EFFECT OF COMBINED APPLICATIONS OF VERMICOMPOST AND FERTILIZERS ON THE YIELD OF SUMMER ONION

BY

MD. ZAHADUL ISLAM

REGISTRATION NO. 00820

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

MASTER OF SCIENCE

IN

SOIL SCIENCE

SEMESTER: JULY-DECEMBER, 2007

Approved by:

(Prof. Dr. Md.Nurul Islam) **Supervisor**	**(Prof. Dr. Sirajul Hoque)** **Co-supervisor**

(Assoc. Prof.A. T. M. Shamsuddoha)
Chairman
Department of Soil Science
Sher-e-Bangla Agricultural University

CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF COMBINED APPLICATIONS OF VERMICOMPOST AND FERTILIZERS ON THE YIELD OF SUMMER ONION" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in SOIL SCIENCE, embodies the result of a piece of bonafide research work carried out by MD. ZAHADUL ISLAM, Registration No. 00820 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 30.12.08

Place: Dhaka, Bangladesh

(Prof. Dr. Md. Nurul Islam)
Supervisor

DEDICATED TO MY BELOVED PARENTS

ACKNOWLEDGEMENTS

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

The author is proud to express his deepest gratitude, deep sense of respect and immense indebtedness to his research supervisor Dr. Md.Nurul Islam, Professor of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207, for his constant supervision, valuable suggestions, scholastic guidance, continuous inspiration, constructive comments, extending generous help and encouragement during his research work and guidance in preparation of manuscript of the thesis.

The author sincerely express his heartiest respect, deepest sence of gratitude and profound appreciation to his co-supervisor Dr. Sirajul Hoque, Professor, Department of Soil, Water and Environment, Dhaka University, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice during the research period and preparing the thesis.

The author would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207 for the valuable teaching, sympathetic co-operation and inspirations throughout the course of this study and research work. The author wish to express his cordial thanks to departmental and field staffs for their active help during the experimental period. Sincere appreciation goes to SAURES for partial financial support to complete the field research.

The author intend to express heartful indebtedness and sincere appreciation to his friends Obaidullah, Delwar, Liton, Nazim, Anowar, Sohel, Tewel, Selina, Kakan and Aminur and also to all other friends for their heartiest assistance in *his research period and tireless effort in completing this thesis writing. The author would like to express cordial thanks to his younger brother Borhan Uddin for his genial help rega*

rding of his tireless effort in completing this thesis.

The author express his supreme gratitude and deepest appreciation to his beloved father, mother and all other members of the family for their ever ending prayer, encouragement, sacrifices and dedicated efforts to educate him to this level.

Place: Dhaka
Dated: 30.12.06

Md. Zahadul Islam
Reg. No.- 00820

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	Agro- Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BRRI	Bangladesh Rice Research Institute
Cm	Centimeter
cv.	Cultivar (s)
DAT	Days After Transplanting
et al.	And others
FAO	Food and Agriculture Organization
G	Gram (s)
Hr	Hour(s)
K_2O	Potassium Oxide
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non significant
P_2O_5	Phosphorus Penta Oxide
S	Sulphur
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
var.	Variety
Wt.	Weight
t ha^{-1}	Ton per hectare
^0C	Degree Centigrade
%	Percentage
MT	Metrric Ton
DMRT	Duncan Multiple Range Test

EFFECT OF COMBINED APPLICATIONS OF VERMICOMPOST AND FERTILIZERS ON THE YIELD OF SUMMER ONION

ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the summer season of 2007 to study the effect of "Combined application of vermicompost and fertilizers (NPKS) on the yield of summer onion". The experimental soil was silty clay loam in texture having pH of 6.0. The treatments were 4 levels of vermicompost viz, V_0 (0 t ha^{-1}), V_1 (1.5 t ha^{-1}), V_2 (3 t ha^{-1}),V_3 (5 t ha^{-1}), and 3 levels of chemical fertilizers, viz. F_0 = No NPKS (0-0-0-0 kg ha^{-1}), F_1 = Half the recommended dose of NPKS (60-22-50-16 kg ha^{-1}), F_2 = Full recommended dose of NPKS (120-44-100-32 kg ha^{-1}) in 12 treatment combinations and 3 replications. The results demonstrated that the increasing doses of vermicompost and chemical fertilizers in combination increased bulb yield of summer onion significantly. The maximum significant bulb yield was obtained with the treatment combinations of V_3F_1 (High vermicompost + Medium NPKS) or V_2F_2 (Medium vermicompost + High NPKS). The highest doses of vermicompost and chemical fertilizers increased N, P, K and S concentrations in summer onion plant and bulb significantly at the hervesting stage. Application of chemical fertilizers failed to increase organic matter content of post harvest soil, whereas vermicompost showed a significant positive effect. Combined application of vermicompost and chemical fertilizers increased the level of NPKS and organic matter status of soil significantly. Application of vermicompost and chemical fertilizers in combination prevents the development of acidity in the postharvest soil.

Chapter 1
Introduction

CHAPTER 1

INTRODUCTION

Onion, the most important bulb crop in Bangladesh is growing during cool winter season. Recently, Bangladesh Agricultural Research Institute (BARI) has released two summer onion varieties for cultivation in Bangladesh. The production of onion bulb is influenced by climate, plant nutrients and many other factors. These play an important role on growth and yield of onion. The appropriate application of compost and various types of fertilizers i.e. NPKS is indispensable to ensure better yield of summer onion. Compost plays a vital role for increasing soil moisture, plant growth and bulb development. The present study has been undertaken to find out the optimum doses of compost and fertilizers i.e. NPKS requirement of summer onion in Bangladesh.

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 has 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.

Introduction of hot and rain tolerant summer onion variety 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, sulphur, zinc and boron for the growth and yield of vegetable crops is well established and plays an important role on onion production.

Several researchers have reported that vermicompost has a higher base exchange capacity and are generally rich in total organic matter. Besides, it contains substances which helps in building soil structure, stimulation of plant growth, particularly that of roots, drilling mud and emulsifiers (Dussere, 1992). Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. Its status in Bangladesh soil is very poor. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. More recently, attention is focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose.

The application of different fertilizers and manures influences the physical and chemical properties of soil and enhance the metabolic activities of soil. The organic and chemical fertilizers are also positively correlated with soil porosity, enzymatic activity and CO_2 production. Organic matter stimulates soil biological activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter (Marinari, *et al.*, 2000).

In Bangladesh, the farmers are using the chemical fertilizers continuously without knowing the actual dose and their residual adverse effects on soil properties. Under these imbalanced conditions various beneficial soil microorganisms are being adversely affected. The soil is loosing its fertility as well as productivity day by day. If this trend continues, crop production will be seriously affected in the long run. On the contrary, if only organic matter is used the soil physical properties will be improved but the nutrient demand of the crop can't be satisfied due to low content of nutrients in organic matter.

So, combined applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients. Information are limited regarding the combined application of organic and inorganic fertilizers with respect to the soil and crops of Bangladesh under the existing agro-climatic conditions which needs to be studied.

Considering the above views the present experiment has been undertaken with the following objectives:-

- To study the effect of combined application of vermicompost and NPKS on the yield of summer onion.
- To know the optimum dose of vermicompost and NPKS on the yield of onion.
- To find out the measures of improving the soil health (physical properties) as continuous application of chemical fertilizers alone deteriorates the soil health.

Chapter 2
Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

2 . 1. Effect and importance of vermicompost on onion and other crops

Vermicomposting is the managed bioconversion of organic materials through earthworm consumption (Blickwedel and Mach, 1983). Vermiculture and vercomposting experiments have been set up in many countries like England, France, Germany, Italy, Israel, USA, Japan, The Philippines, India and other parts of South-East Asia, Australia, Cuba, The Bahamas and many countries in Africa and South America (Edwards and Bohlen, (1996).

When vermin casts have been compared with the surrounding soil it is observed that casts have a high base exchange capacity and are generally rich in total organic matter, total exchangeable bases, phosphorous, exchangeable potassium, manganese and total exchangeable calcium. Vermicompost helps to improve and protect fertility of topsoil and also helps to boost up productivity by 40% with 20 to 60% lower nutrient inputs. It also enhances the quality of end products and thereby creating significant impact on flexibility in marketing as well as increases the storage time. Vermicompost contain 30 to 50% humic substances which help in the stimulation of plant growth, particularly that of roots, drilling mud and emulsifiers (Dussere, 1992).

Chee *et al.* (1998) studied the effect of vermicompost incorporation and arbuscular mycorrhizae inoculation on onion yield and nutrient content in Mexico. Long white onion (*Allium cepa*) was sown in milled, sieved (2 mm mesh) and fumigated (with CH_3Br), temperate soil from Hueyotlipan, Tlax, Mexico, with vermicompost (8 t/ha) made of coffee pulp, with and without arbuscular mycorrhizae inoculation. In general, 120 days after sowing, plant yield and nutrient content increased with applied vermicompost or mycorrhizal inoculation. This nutrient increase was attributed to nutrients supplied by the vermicompost or the establishment of mycorrhizal symbiosis. The combined application of vermicompost and mycorrhizal inoculation slightly decreased arbuscular colonization without affecting yields, but contrarily increased P and K content, demonstrating that simultaneous application of 2 or more biofertilizers is not always profitable.

Reddy and Reddy (2005) conducted a study in Andhra Pradesh, India during 1996-98 to determine the effects of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen (0, 50, 100, 150 and 200 kg/ha) on the growth and yield of onion (cv. N-53) and their residual effect on succeeding radish in an onion-radish (cv. Sel-7) cropping system. The plant height, number of leaves per plant, leaf area, bulb length, diameter and weight and yield of onion increased significantly with increasing levels of vermicompost (from 10 to 30 t/ha) and nitrogen (from 50 to 200 kg/ha). A similar increase in radish yield was also observed due to the residual effect of different levels of vermicompost and nitrogen applied to the preceding crop (onion). Among the various treatment combinations, vermicompost at 30 t/ha + 200 kg N/ha recorded the highest plant height and number of leaves per plant in onion and radish, but was at par with the treatment with vermicompost at 30 t/ha + 150 kg N/ha in terms of bulb length, bulb weight and onion yield.

Rao *et al.* (2000) from a field experiment carried out at the Indian Agricultural Research Institute, New Delhi, India revealed that application of 3 t vermicompost ha^{-1} to chickpea improved dry matter accumulation, grain yield and grain protein content in chickpea, soil N and P and bacterial count, dry fodder yield of succeeding maize, total N and P uptake by the cropping system over no vermicompost.

A study was conducted in India on two wheat cultivars to investigate the effect of chemical fertilizers (NPK fertilizer), and organic manure (vermicompost). Results showed that plant height, dry matter production and grain yield were higher at higher dose of vermicompost. Number of tillers and leaves per plant were very low at early stages of growth and suddenly increased after adding different doses of vermicompost and organic manure (Khandal and Nagendra, 2002).

A field experiment was conducted by Ranwa and Singh (1999) at Hisar, Haryana, India during the winter seasons of 1994-96 to study the effect of integration of nitrogen with vermicompost on wheat crop. The treatment comprised 5 levels of organic manures, viz., no organic manure, farmyard manure at 10 t ha^{-1}, vermicompost at 5, 7.5 and 10 t ha^{-1} and 5 levels of N viz. 0, 50, 100, 150 kg ha^{-1} and recommended fertilizer. They reported that the application of organic manures improved yield attributes and grain, straw and biological yields of wheat. Application of vermicompost at 7.5 or 10 t ha^{-1} resulted in higher yields than 10 t ha^{-1} FYM.

A field experiment was conducted in Orissa, India, during the *kharif* season of 1999 to determine the effect of integrated application of vermicompost and chemical fertilizer on rice cv. Lalat. Yield components were increased by integrated application of vermicompost and chemical fertilizes compared to the other treatments. The highest results in terms of straw and crop yields were obtained with 50% vermicompost + 50% chemical fertilizers (Das *et al.* 2002).
The combined application of organic and inorganic N sustained the productivity. Soil available nutrients like N, P and K increased significantly with the application of various organic sources of nutrients in combination with fertilizers over the fertilizer alone. The highest grain yields of *rabi* sorghum and chickpea were obtained with 50 percent N through green manure plus 50 percent fertilizer N (Tolanur and Badanur, 2003).

Vasanthi and Kumaraswamy (1999) from an experiment with vermicompost and NPK fertilizers showed that the grain yields of rice were significantly higher in the treatments that received vermicompost from any of the 5 to 10 t ha^{-1} organic materials (sugarcane trash, Ipomea, banana peduncle etc) with N, P and K at recommended levels than in the treatment that received N, P and K alone. Organic carbon content and fertility status as reflected by the available status of N, P, and K, micronutrients and CEC were higher and bulk density were lower in the treatments that received vermicompost plus N, P and K than in the treatments with N, P and K alone. It was found that vermicompost at 5 t ha^{-1} would be sufficient for rice crop when applied with recommended levels of N, P and K.

Vermicompost produced higher yield of tomato than the chemical fertilizer treated and control plots. Same margin of production was obtained in snake gourd, bitter gourd and lady's finger. All the plots of lady's finger at one time were completely damaged due to severe virus attack. It was observed that crops grown under chemical fertilizer became yellowish rapidly while crops grown under vermicompost remained green. Germination of different seeds in the vermicomposted plots was higher than the control and chemical fertilizer treated plots (Zahid, 2001).

2. 2. Nutrient status of vermicompost

Vermicompost contains 2.29 folds more organic carbon, 1.76 times total nitrogen, 3.02 folds phosphorous and 1.60 times potassium than normal compost. Earthworms decrease the C: N ratio from 14.21 to 10.11 and an average 56.03% of organic waste can be converted into vermicompost by the activities of earthworms in short time (Sohrab and Sarwar, 2001).
Robinson *et al*. (1992) reported that the nutrients present in vermicompost are readily available and the increase in earthworm populations on application of vermicompost and mulching leads to the easy transfer of nutrient to plants thus providing synchrony in ecosystems.

Kumari and Kumari (2002) from an experiment stated that vermicompost is a potential source of organic manure due to the presence of readily available plant nutrients, growth enhancing substances and number of beneficial microorganisms like N fixing, P solubilising and cellulose decomposing organisms.

Vermicompost contain more organic matter, N, P, S, Ca and Mg. It was shown that worm-worked composts have better texture and soil enhancing properties, hold typically higher percentages of N, P and K (Zahid, 2001).

Harris *et al.* (1990) reported that earthworm excreta is the excellent soil conditioning material with higher water holding capacity and less time for releasing nitrogen into the soil. The nutrient level of the vermicompost was about two times greater than natural compost and the use of vermicompost is important for the farmers to get better quality crop yields.

The organic wastes could be efficiently converted into vermicompost with a recovery of 74.65 - 87% in a composting period of 3 months. Earthworm biomass was doubled irrespective of organic waste used in a period of 2 months. Major nutrients (NPK) and micronutrient (Cu, Zn, Fe and Mn) contents were slightly higher in all the vermicompost samples than in normal compost. Vermicompost had lower C: N ratio and pH than normal compost irrespective of the source of organic waste. Microbial population was considerably higher in vermicompost than in normal compost (Chowdappa *et al.* 1999).

Earthworms influence the changes in various chemical parameters governing the compost maturity of local grass, mango leaves and farm wastes. There was a decrease in C: N ratio, while humic acid, cation exchange capacity and water soluble carbohydrates increased up to 150 days of composting. Compost maturation was achieved up to a period of 120 and 150 days in farm wastes and mango leaves, respectively, while more than 150 days would be required to reach the maturity in case of local grass. Inoculation of earthworms reduced the composting by 13 days (Talaskilkar *et al.* 1999).

Vermicomposting of sugarcane trash individually and in combination with press mud using earthworm *Perionyx excavatus* increased significantly N by 34%, P by 87%, K by 40%, Ca by 64%, Mg by 39% and Mn by 11% over the control compost along with a reduction in C: N (15:1) and C: P (6:1) ratio due to mineralization and combined action of earthworms and microbes (Ramalingam, 1999).

Saerah *et al.* (1996) conducted an experiment on the effect of compost in optimizing the physical condition of sandy soil. Compost at the rates of 0.0, 16.5, 33.0, 49.5 and 66.0 t ha^{-1} was incorporated into the soil and then wheat was grown. The results indicated that the various application rates were significantly correlated with improvement in physical properties of soil as well as straw and grain yields of wheat.

Organic manure influences favorably plant growth and yield through augmentation of beneficial microbial population and their activities such as organic matter decomposition (Gaur *et al.* 1971).

2. 3. Effect and importance of NPKS fertilizers on onion

Green *et al.* (1980) observed that on a nutrient depleted sandy loam soil, optimal level of N, P and K fertilizers 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.

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 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.

Bereniewiez and Nowosiecksi (1986) conducted an experiment and observed that the application of 200 kg N, 200 kg P_2O_5, 200 kg K_2O, 20 kg Mg, 5 kg Mn, 5 kg Zn, 10 kg Cu and 1.5 kg Mo ha^{-1} gave the highest yield of onion. Yields were further increased when organic fertilizer (Lignite or peat) at 100 m^3 ha^{-1} and Ca at 2 t ha^{-1} were applied at the same time.

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.

Hedge (1988) carried out an experiment with cv. Pusa Red 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.

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 throughout 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}.

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}.

Rahim *et al.* (1992) conducted fertilizer trial. Onion sets were planted on 6^{th} 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 rate of N and K gave the maximum yield of 11.11 t ha^{-1} compared with 4.5 t ha^{-1} from control.

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

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

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

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

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}, respectively for the cultivation of BARI peaj-1 at BAU Farm conditions. Islam (1998) found that nitrogen at 120 kg ha^{-1} produced the maximum bulb weight and bulb yield (25.5 t ha^{-1}).

Jiang *et al.* (1998) grew onions supplied with 0, 375, 450 or 525 kg potassium sulfate ha^{-1}. Bulb dimensions increased with increasing rate of fertilizer application and bulb weight increased from 231 g with no fertilizer to 324 g with the highest fertilizer rate. Minimum bulb yield was found (69.4 t ha^{-1}) with no fertilizer and maximum bulb yield (85.3 t ha^{-1}) was found with the higher rate of potassium sulphate. Net benefit increased with increasing rate of potassium fertilizer application.

Rodriguez *et al.* (1999) carried out experiment 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 4 rates of potassium (0, 40, 80 and 120 kg ha^{-1}) during 1995-96 and 1996-97 on growth characters, yield attributes, yield and quality of onion on a sandy loam soil in Madhya Pradesh, India. Application of 80 kg K_2O ha^{-1} significantly increased bulb weight $plant^{-1}$ and horizontal diameter of the bulb.

Singh *et al.* (2000) conducted an experiment at Rajasthan during summer season of 1993-95. Onion cv. N-53 was grown under factorial combinations of 3 levels each of nitrogen (50, 75 and 100 kg N ha^{-1}), phosphate (13.2, 22.0 and 30.8 kg P ha^{-1}) and potash (41.5, 62.2 and 83.0 kg K ha^{-1}). 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 or 150 kg N and K ha^{-1} in Jaipur, Rajasthan, India during the *rabi* seasons of 1998-2000. Yield, fresh weight of bulb, total soluble solids and allyl propyl disulfide content increased, whereas ascorbic acid content decreased with the increase in N and K rates. Rasidpura Local recorded the highest values for the parameters measured except allyl propyl disulfide content which was highest in Nasik Red.

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

Sharma *et al.* (2003) conducted a field experiment in Leo, Himachal Pradesh, India to study the effect of combined use of NPK and farmyard manure (FYM) on yield attributes, yield, nutrient uptake by onion (*Allium cepa*) as well as on build up of available N, P, K during the summer seasons of 1998 and 1999. The treatments involved 3 levels of FYM (0, 10 and 20 t ha^{-1}) and 4 levels of NPK (0, 50, 100 and 150 % of the recommended dose, which was 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 significant improvement in available N, P, and K status of the soil.

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

Singh *et al.* (2003) studied that the effects of K fertilizer (30, 60, 90 or 120 kg ha^{-1}) applied as split dressings (1/2 as basal + 1/2 as top dressing at 45 days after transplanting or DAT or 1/3 as basal + 1/3 top dressing at 45 DAT + 1/3 top dressing at 90 DAT) on the seed yield of onion cv. N-53 at Dhaulakuan, Himachal Pradesh, India during the *rabi* seasons 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.

2. 4. Effect and importance of combind application of NPKS and manure on onion

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

Varu *et al.* (1997) conducted a field experiment at Baroda, Gujarat, India, during *rabi* 1994-95. Onion cultivar Talaja White seedlings, transplanted on 25-26 October 1994, were given the following fertilizer treatments: NPK (100 kg N, 50 kg P_2O_5, 50 kg K_2O/ha); farmyard manure (FYM at 50 t/ha); a concentrated organic manure (Dharatidhara at 4 t/ha); FYM (25 t/ha) + Dharatidhara (2 t/ha); FYM (25 t/ha) + NPK (full rate); FYM (95 t/ha) + NPK (half rate) + Dharatidhara (2 t/ha); and no fertilizer. Data was tabulated on number of leaves/plant, plant height, bulb yield, bulb diameter, bulb weight and bulb volume. The highest bulb yield (32.70 t/ha) was obtained for the FYM + NPK + Dharatidhara treatment. This treatment also gave the highest bulb diameter, weight and volume.

Gupta *et al.* (1999) conducted a field experiment at the Regional Research Station, Carnal during *kharif* 1996, 1997 and 1998 to study the effect of organic manure and inorganic fertilizers on growth, yield and quality of *kharif* onion cv. Agrifound Dark Red. The organic manures evaluated were sunflower cake @ 19 q/ha, poultry manure @ 57 q/ha and FYM @ 143 q/ha and 72 q/ha. The inorganic fertilizers evaluated were urea @ 252 kg/ha, CAN @ 444 kg/ha and ammonium sulfate @ 565 kg/ha. The control plot was maintained without any organic/inorganic fertilizer. The bed size was 3.6 x 1.8 m. The studies revealed that FYM @ 72.0 q/ha along with ammonium sulfate @ 565 kg/ha were effective in increasing the growth, yield and quality contributing characters such as bulb color, compactness, TSS and dry matter and gave the highest net return.

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

Yadav *et al.* (2004) conducted a field experiment in Jaipur, Rajasthan, India during the *rabi* seasons of 1999-2000, 2000-01 and 2001-02 to find out the effects of nitrogen and *Azospirillum brasilense* on the yield of onion cv. RO-1 bulbs. Treatment consisted of four levels of nitrogen (no nitrogen, 50%, 75% and 100% of recommended rate of nitrogen (i.e. 100 kg/ha) and two levels of biofertilizer (with and without *Azospirillum brasilense*). Application of nitrogen fertilizer and biofertilizer had significant independent effects on yield of onion bulbs. Significant and highest yield (336.5 q/ha) was recorded with 100 kg N/ha, which was at par with 75 kg N/ha (328.4 q/ha). The improvement in bulb yield was 14.1 and 11.4%, respectively, over the control treatment (without nitrogen application). *Azospirillum* inoculation recorded a higher bulb yield of onion (323.7 q/ha) over the control (310.9 q/ha). A slight increase in available nitrogen content in soil was observed with increasing nitrogen rate in all the samplings. With the application of *Azospirillum*, an increasing trend of available nitrogen content of soil for all the samplings was found and a significant difference was noticed in the 2nd sampling of third year and 3rd sampling of first year only, and the increase in available nitrogen was 10.97 and 11.14 kg/ha, respectively. Treatment with 100 kg N/ha + *Azospirillum brasilense* inoculation recorded the highest net profit per hectare (Rs. 32 791.95) which was at par with 75 kg N/ha + *Azospirillum brasilense* (Rs. 31 287.95).

Gunjan *et al.* (2005) conducted a field experiment on a sandy loam soil in Jobner, Rajasthan, India during the *rabi* season of 1999-2000 to study the effect of 4 levels of N (25, 50, 75 and 100 kg ha^{-1}) and 2 sources of biofertilizer, i.e. *Azotobacter* (A_1) and *Azospirillum* (A_2) as seedling dipping, seed and soil treatments, on yield and quality of onion bulb (A. cepa). The application of N at 100 kg ha^{-1} significantly increased bulb yield and quality attributes. The treatment combination $N_4A_1S_2$ (100 kg N ha^{-1}+*Azotobacter* as seedling dipping) gave the highest bulb yield and fresh weight of bulb, followed at par by $N_3A_1S_2$ (75 Kg N ha^{-1}+*Azotobacter* as seedling dipping). A higher benefit: cost ratio (2.26:1) was recorded with the treatment combination of $N_3A_1S_2$ compared to $N_4A_1S_2$, with a lower benefit:cost ratio (2.24:1) due to additional cost of urea and non significant difference between these 2 treatments regarding yield of bulbs. Thus, the treatment combination $N_3A_1S_2$ was the best.

Yadav *et al.* (2005) studied the effects of N fertilizer (50, 75 or 100% of the recommended N rate of 100 kg/ha) with or without inoculation of *Azospirillum* in Durgapura, Jaipur, Rajasthan, India, during the *rabi* of 1999-2000, 2000-01 and 2001-02. N was applied in 3 equal splits at 30-day intervals starting at 20 days after transplanting. Before sowing, seeds were treated with *Azospirillum* at 500 g/ha. Seedlings were dipped for 15 minutes in *Azospirillum* slurry (1 kg *Azospirillum* dissolved in 50 liters of water/ha). Before transplanting, *Azospirillum* (2 kg/ha) was mixed with farmyard manure and incorporated into the soil. Pooled data showed that bulb yields were highest with N at 75 (328.4 quintal/ha) and 100 kg/ha (336.5 quintal/ha); under these treatments, bulb yields increased by 11.4 and 14.1%, respectively, over the control. The inoculation of *Azospirillum* resulted in a higher bulb yield (323.7 quintal/ha) over the control (310.9 quintal/ha). The available N in the soil slightly increased with the increase in the N rate. A significant increase in available N was observed during the first sampling of the second year, and during the second sampling of the second and third years. *Azospirillum* inoculation increased the available N during the second sampling of the third year, and during the third sampling of the first year. The highest net profits were obtained with *Azospirillum* combined with N at 100 (32792 rupees/ha) or 75 kg/ha (31 288 rupees/ha). [1 quintal=100 kg]

Devi *et al.* (2003) studied the effects of inorganic fertilizers and biofertilizers on the yield of A. cepa var. aggregatum in Imphal, Manipur, India during the *rabi* season of 2000/2002. The treatments consisted of 90 kg N + 60 kg P/ha; 90 kg N + 45 kg P or 90 kg N + 30 kg P/ha + *Phosphatika*; 75 kg N + 60 kg P, 60 kg N 60 kg P or 45 kg N + 60 kg P/ha + *Azospirillum*; 75 kg N + 45 kg P, 75 kg N + 30 kg P, 60 kg N + 45 kg P, 60 kg N + 30 kg P, 45 kg N + 45 kg P or 45 kg N + 30 kg P/ha + *Azospirillum* + *Phosphatika*. P fertilizer and half of the N fertilizer were applied as basal. The remaining N was applied as top dressing at 30 days after planting. *Azospirillum* and *Phosphatika* (2 kg/ha each) were applied as bulb treatments. The application of biofertilizers along with inorganic fertilizers gave higher yields than the inorganic fertilizers alone. The highest yield (163.41 quintal/ha) and net return (85 807 rupees/ha) were obtained with 75 kg N + 45 kg P/ha + *Azospirillum* + *Phosphatika.*

Yadav *et al.* (2001) conducted an experiment in a randomized block design at Research Farm of Agricultural Research Station, Durgapura (Jaipur), Rajasthan, India during *rabi* season of 2000-01 to determine the effect of NICAST (OM) in comparison to the recommended dose of manure and fertilizers in onion cv. Ro-1. The treatments used in the experiment were: (T_1) recommended farmyard manure (FYM) (30 tones/ha); (T_2) recommended NPK (100 : 50 : 100 kg/ha); (T_3) recommended FYM + recommended NPK; (T_4) NICAST (250 kg/ha); (T_5) NICAST 250 + recommended NPK; (T_6) NICAST (500 kg/ha); (T_7) NICAST 500 + recommended NPK; (T_8) NICAST (750 kg/ha); (T_9) NICAST 750 + recommended NPK; and (T_{10}) recommended vermicompost (15 tones/ha) + recommended NPK. Out of the 10 treatments, the performance of the individual treatment revealed that treatment T_3 gave the highest significant bulb yield (370.37 q/ha) which was at par with treatment T_9

(367.41 q/ha) bulb yield with maximum net return (Rs. 47132.0) and highest benefit: cost ratio (2.79) registered.

Nasreen *et al.* (2002) conducted a study on a silty clay loam of Grey Terrace soil at Joydebpur, Gazipur during 2000-2001 and 2001-2002. Effect of sulphur fertilizer (0, 20, 40 and 60 kg/ha) was assessed on dry matter production, yield attributes and yield of two onion varieties (BARI Piaz-1 and Taherpuri). The results indicated that dry matter was higher in Taherpuri at all growth stages. Variety Taherpuri also gave higher bulb yield. Application of 40 kg S per hectare produced tallest plant, maximum leaves per plant and highest amount of dry matter. The partitioning of dry matter into leaves accumulated more from 45 to 75 DAT for both the varieties which influenced the subsequent crop growth. There was a close relationship between dry matter and bulb yield. Diameter of bulb, single bulb weight and yield were significantly increased with application up to 40 kg per hectare and beyond this a negative response of sulphur was recorded. However, economic optimum doses of sulphur were worked out to be 36 and 39 kg per hectare giving onion yield 13.48 and 15.79 tons per hectare for BARI Piaz-1 and Taherpuri, respectively in prevailing agro-climatic conditions.

Mandira *et al.*(2003) used different levels of nitrogen (at 0, 100, 150 and 200 kg/ha) and potassium (0, 75 and 150 kg/ha) as soil application to study their effect on the growth, yield and yield attributes of onion cv. N-53 in a study conducted in Tripura, India during *rabi* 2001. Nitrogen at 150 kg/ha, potassium at 75 kg/ha and their combination recorded the best performance in terms of yield and growth. All other treatments and their combinations were superior compared to the control.

Qureshi *et al.* (2003) studied the effects of Nitro gold (slow-release, granulated ammonium sulfate), and of standard N sources like urea and ammonium sulfate, on the yield and quality of onion in Maharashtra, India during the *rabi* season of 1999/2000. These fertilizers were applied with diammonium phosphate (DAP) or single super phosphate (SSP). The treatments consisted of urea + SSP, Nitro gold + SSP, Nitro gold (60% of the recommended rate or RR) + SSP, ammonium sulfate (RR) + SSP, urea + DAP, Nitro gold + DAP, Nitro gold (60% RR) + DAP, and ammonium sulfate (RR) + DAP. N was applied as basal (50%), and at 30 (25%) and 60 (25%) days after transplanting. Urea + SSP were the most effective in the enhancement of the number of leaves. The application of Nitro gold (RR) along with DAP significantly improved bulb polar diameter. The highest yields of grade A and B bulbs were obtained with Nitrogold and urea. On the other hand, the highest total marketable yield was obtained with Nitrogold + SSP. The N fertilizers did not significantly affect plant height, and the neck size and total soluble solid content of bulbs.

Sumantra and Tiwari (1997) incorporated $CaSO_4$ (8, 16 or 24 kg/ha), elemental sulphur (2, 4 or 6 kg/ha), single super phosphate (16.7, 25 or 50 kg/ha) or $(NH_4)_2SO_4$ (8, 16, 24 kg/ha) into the soil (sandy loam, pH 6.8) on the day of onion seedling transplanting (23 January 1991) at Pantnagar, Uttar Pradesh, India. Observations on plant growth were made at 70 and 100 days after transplanting (DAT), while bulb characteristics and yield were recorded at harvest. Sulfur fertilizers significantly increased all vegetative growth parameters compared to the control except number of leaves/plant at 70 DAT. Application of $CaSO_4$ at 24 kg/ha gave the highest values for the following characteristics: number, length, fresh weight and dry weight of leaves; number, length and fresh weight of roots; length, diameter, fresh weight, dry weight and volume of bulbs. All fertilizer sources and application rates significantly increased the bulb yield at harvest compared to the control, but the highest yield was again obtained after application of $CaSO_4$ at 24 kg/ha.

Shamima *et al.* (2005) conducted field experiments in Gazipur, Bangladesh, during the 1995/96, 1996/97 and 1997/98 *rabi* seasons to determine the yield, content and uptake of onion cv. Faridpuri, when applied with sulfur (S) at 0, 15, 30, 45, 60, 75 and 90 kg/ha. The S content, uptake and yield of onion significantly responded to the different S fertilizer applications. S content in leaves at 45 days after transplanting (DAT) and in bulbs at 110 DAT was the highest. S content in the leaves decreased with advancement in crop age. The uptake of S into the leaves increased up to 75 DAT while bulb uptake continued to increase up to 110 DAT in all treatments. Increasing S levels up to 45 kg/ha increased the S content, uptake throughout the season and also produced the highest bulb yield. Zero kg S/ha produced the lowest bulb yield and S uptake by the plant.

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.

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. They also reported in another trial (1983) that P and K at higher rate improved the storage quality of onion.

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}).

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.

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 N, 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.

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.

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.

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.

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

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

Sing and Mohanty (1998) studied on the growth and yield of onion in Orissa, India, in 1995-96 and 1996-97. Nitrogen (80, 120 or 160 kg ha^{-1}), K_2O (80, 100 or 120 kg ha^{-1}) and P_2O_5 (60 kg ha^{-1}) were applied in a randomized block to give a total of 9 treatments. With the increasing N level plant height became increased in both years. Nitrogen and K at 160 and 80 kg ha^{-1}, respectively (160:80 NK) resulted in the maximum plant height and 120:80 NK produced the minimum plant height. Bulb 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}.

Subbiah (1994) conducted field experiments with chilli [Capsicum sp.] (Co.1) and bellary onion (NP.53) at the University Orchard, Tamil Nadu Agricultural University, Coimbatore, during Sep.-Oct. 1987 and June-July 1989, respectively. The soil, a vertisol, was low in available N (75-107 kg/ha) and P (2.8-3.5 kg/ha), and high in available K (280-300 kg/ha). Seeds were treated with *Azospirillum brasilense* (50-100 g/100 g) and sown in nursery beds which had been inoculated with VAM fungi {*Glomus faciculatum* (*G. fasciculatum*)} at 1kg/ha and *A. brasilense* at 2 kg/ha. Seedlings (45 days old) from beds inoculated with the biofertilizers, or from untreated beds, were transplanted onto ridges and received fertilizer treatments comprising 50, 75 or 100% of the recommended N dose + 100% of the recommended dose of P (as superphosphate). Data on the yields of dry chilli pods and onion bulbs and on N, P and K uptake showed no significant effects on yields. Application of biofertilizers had some significant effects on nutrient uptake.

Halder *et al.* (1998) in a field experiment on onion at Mymensingh in 1989, applied N fertilizer at 0, 70, 80 and 90 kgN/ha and P fertilizer at 0, 50, 60 and 70 kg P_2O_5/ha. N application improved dry matter production and contributed to maximum uptake of nutrient elements from soil. But application of P alone at higher rates gave no better results than with N. N applied at 90 kg/ha gave the highest response in respect of nutrient uptake and bulb dry matter content. Combined application of N and P at higher rates also produced excellent performance. Correlation studies indicated that fresh yield, dry matter content and removal of nutrient elements were significantly related to N fertilizer application.

Rostamfrodi *et al.* (1999) investigated the effects of 0, 40, 80, 120, 160 or 200 kg N/ha applied as urea on the accumulation of nitrates, phosphorus and potassium in bulbs and leaves of onion cultivars Sefide Kashan, Toupaz and Ghermez Azarshahr in field and laboratory experiments at Tehran. The nitrate contents of the bulbs increased by up to 93% as N rate was increased from 0 to 160 kg/ha. Nitrate accumulation was lower in leaves than in the bulbs. Increasing the N rate decreased the P content of bulbs and leaves, but had an insignificant effect on K content. Nitrate accumulation capacity differed between *cultivars*. It was highest in Sefide Kashan (62.6 mg/kg fresh weight), and lowest in Ghermez Azarshahr (56.3 mg/kg fresh weight). Sefide Kashan has also higher P and K contents than the other cultivars. Soil analysis after harvest showed that increasing the N fertilizer rate increased soil-available P. Inversely; N application resulted in greater K absorption by plants. It can be concluded that application of 80-120 kg N/ha in the from of urea would not lead to nitrate accumulation in onion bulbs.

Guo-Xi Sheng *et at.* (1999) showed that the application of K fertilizer (0-240 kg/ha) increased the onion yield and economic efficiency of production. Onion volatile compound content increased with K rate. Low rates of K increased the sugar content of onions, high rates decreased it.

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

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

Geetha *et al.* (2000) conducted a field experiment in Andhra Pradesh, India, during the *rabi* season of 1994-95 to study the effects of farmyard manure (FYM at 0.0, 12.5, and 25.0 t/ha) and K fertilizer (0, 50, 100, and 200 kg/ha as muriate of potash) on the yield and nutrition of onion cv. Nasik Red grown on Alfisol with medium K content. FYM and K fertilizers significantly increased the shoot and bulb yields of onion. FYM at 25 t/ha and 200 kg K/ha, individually or in combination, gave the highest dry matter production, K content, K uptake, and bulb yields. However, 12.5 and 25.0 t FYM/ha were equally effective in increasing the total K uptake when applied with 200 kg K/ha. Soil analysis after harvest indicated that the water-soluble, fixed, and non-exchangeable K decreased while the exchangeable K increased with the increase in FYM and K rate.

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

Rahayu *et al.* (2002) studied the effect of *kascing* organic fertilization and it's reducement in using urea dosage on the growth and yield of Welsh Onion (Allium fistulosum L.). The experiment was conducted from March until May 2002, in Mulyoagung, Dau, Malang with Alluvial soil type. Five levels of kascing organic fertilization, K_0 = common kascing fertilizer, K_1 = 3 ton/ha, K_2 = 6 ton/ha, K_3 = 9 ton/ha, and five levels of urea fertilizer, N_0 = common urea fertilizer, N_1 = 75 kg/ha, N_2 = 150 kg/ha, N_3 = 300 kg/ha were arranged in a Randomized Block Design with three replications. This observation result showed that there was an interaction between kascing organic fertilization and urea fertilization on the growth of plant height at 51 DAP (Days After Planting), leaf width at 51 DAP and tiller number at 58 DAP. The result showed that no interaction between kascing organic fertilization and urea fertilization on fresh weight per plant, fresh weight per square and dry weight per plant.

Jablonska *et al.* (2002) studied the effect of green manures with papilionaceous plants on the yield of white cabbage and onion. The catch crop intended for green manure were sown at the turn of March and April and ploughed down in the first ten days of June. In the first year after ploughing-down of green manures, white cabbage, and in the second onion were cultivated. The greatest amount of organic matter and macroelements were supplied to soil with field pea. In the cultivation of cabbage the mixture of vetch and field pea showed the highest yield-stimulating value. Onion cultivation following the ploughing-down of the examined catch crops caused an increase in yields in comparison with the growth after farmyard manure and without organic fertilization.

From the above reviews, it is observed that organic manures such as vermicompost and fertilizers (NPKS) played a vital role on the growth and yield for successful onion cultivation. India cultivates onion successfully during summer season. There are great possibilities of growing onion in Bangladesh during *kharif* season to meet up the demand. Research in various aspects along with mass selection for adaptation of onion cultivars in *kharif* season is necessary.

Chapter 3
Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

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

3.1 Location

The research work relating to the study of the effect of combined application of vermicompost and NPKS fertilizers on the yield of summer onion was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka 1207 during the summer season of 2007. The location of the experimental site is shown in Figure 1.

3.2 Soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the General soil type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters. Some initial physical and chemical characteristics of the soil are presented in Table 3.1.

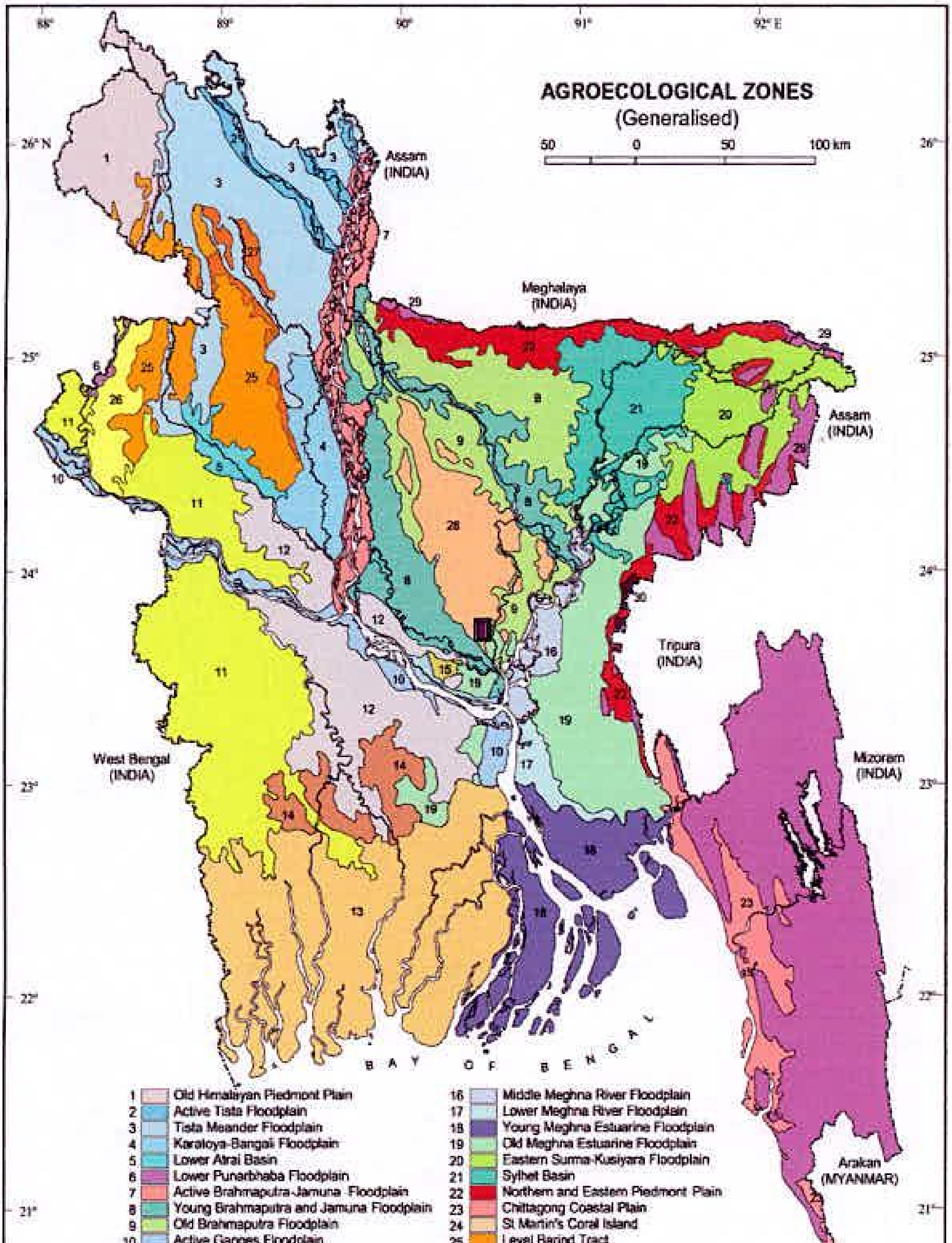


Fig 3.1 Map showing the experimental site under study

Source: BBS 2004.

Table 3.1 Some initial characteristics of the experimental soil

1.pH		6.0
2. Particle-size analysis of soil	Sand	30.65
	Silt	38.19
	Clay	31.16
3. Textural class		Silty clay loam
4. Total N (%)		0.078
5. Organic matter (%)		0.88
6. Phosphorous (%)		0.0015
7. Potassium (%)		0.0053
8. Sulphur (%)		0.0017

3.3 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. 3.2-3.6.

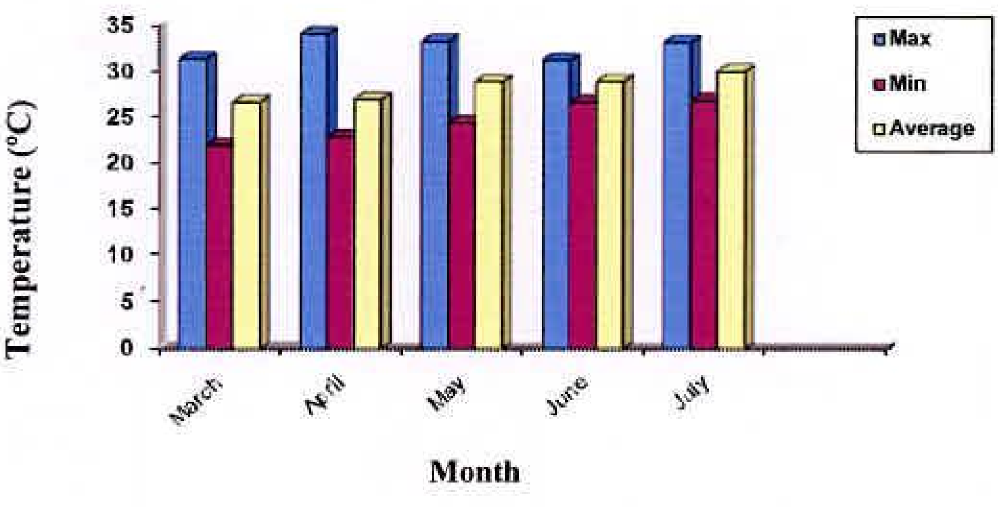


Fig 3.2 Monthly average maximum and minimum air temperature (°C) of the experimental site during the growing period (March to July, 2007).

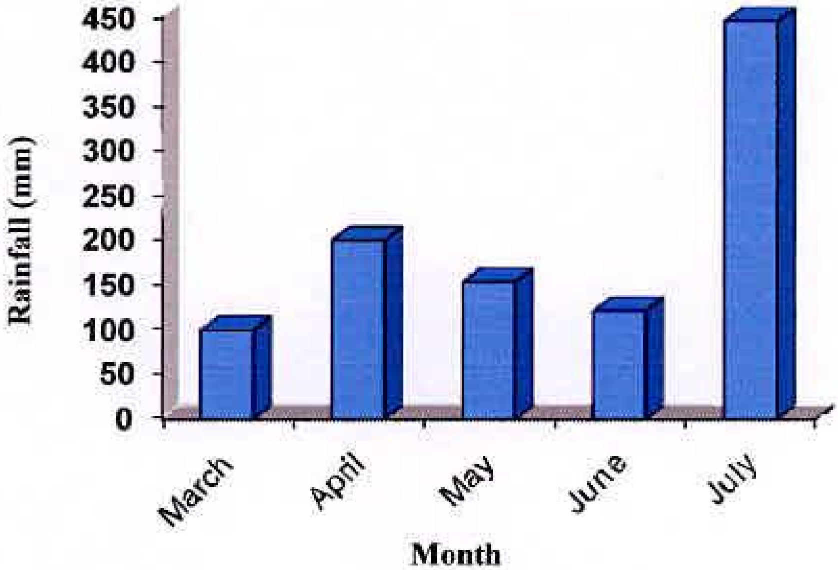


Fig 3.3 Monthly total rainfall (mm) of the experimental site during the growing period (March to July, 2007).

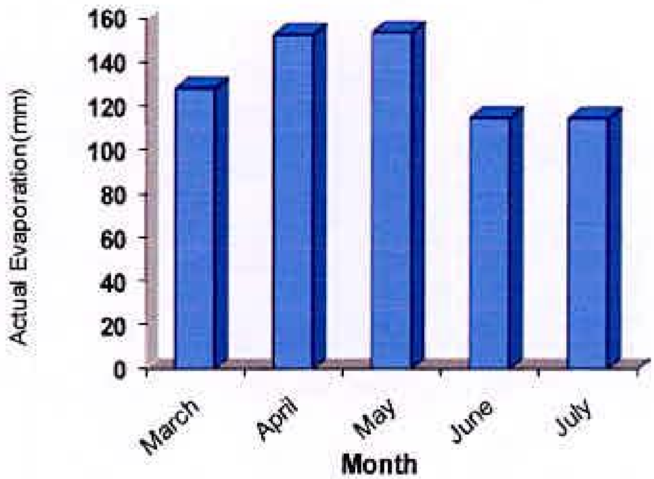


Fig 3.4 Monthly average actual Evaporation (mm) of the experimental site during the growing period (March to July, 2007).

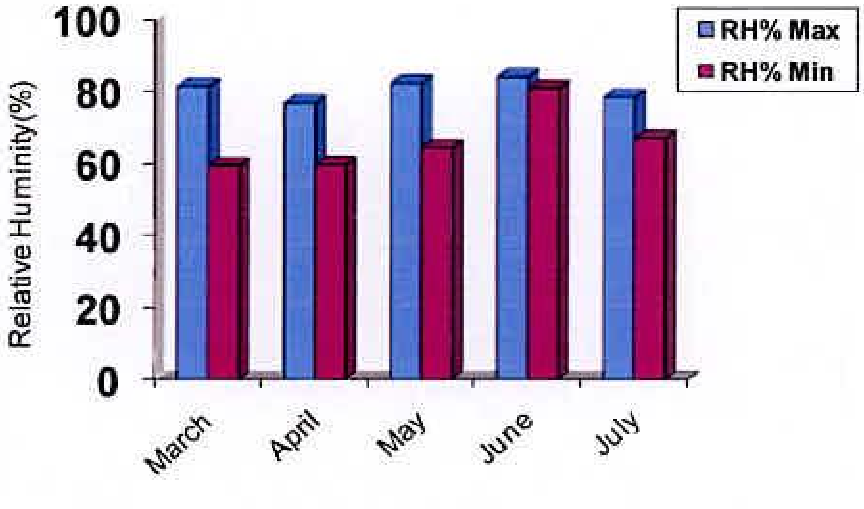


Fig 3.5 Monthly average maximum and minimum relative humidity (%) of the experimental site during the growing period (March to July, 2007).

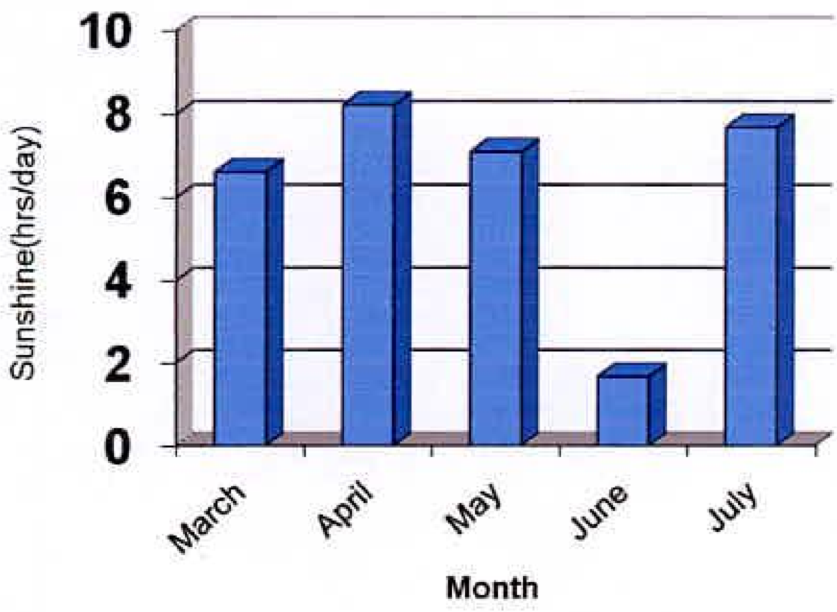


Fig 3.6 Monthly average sunshine (hrs/day) of the experimental site during the growing period (March to July, 2007).

3.4 Onion variety

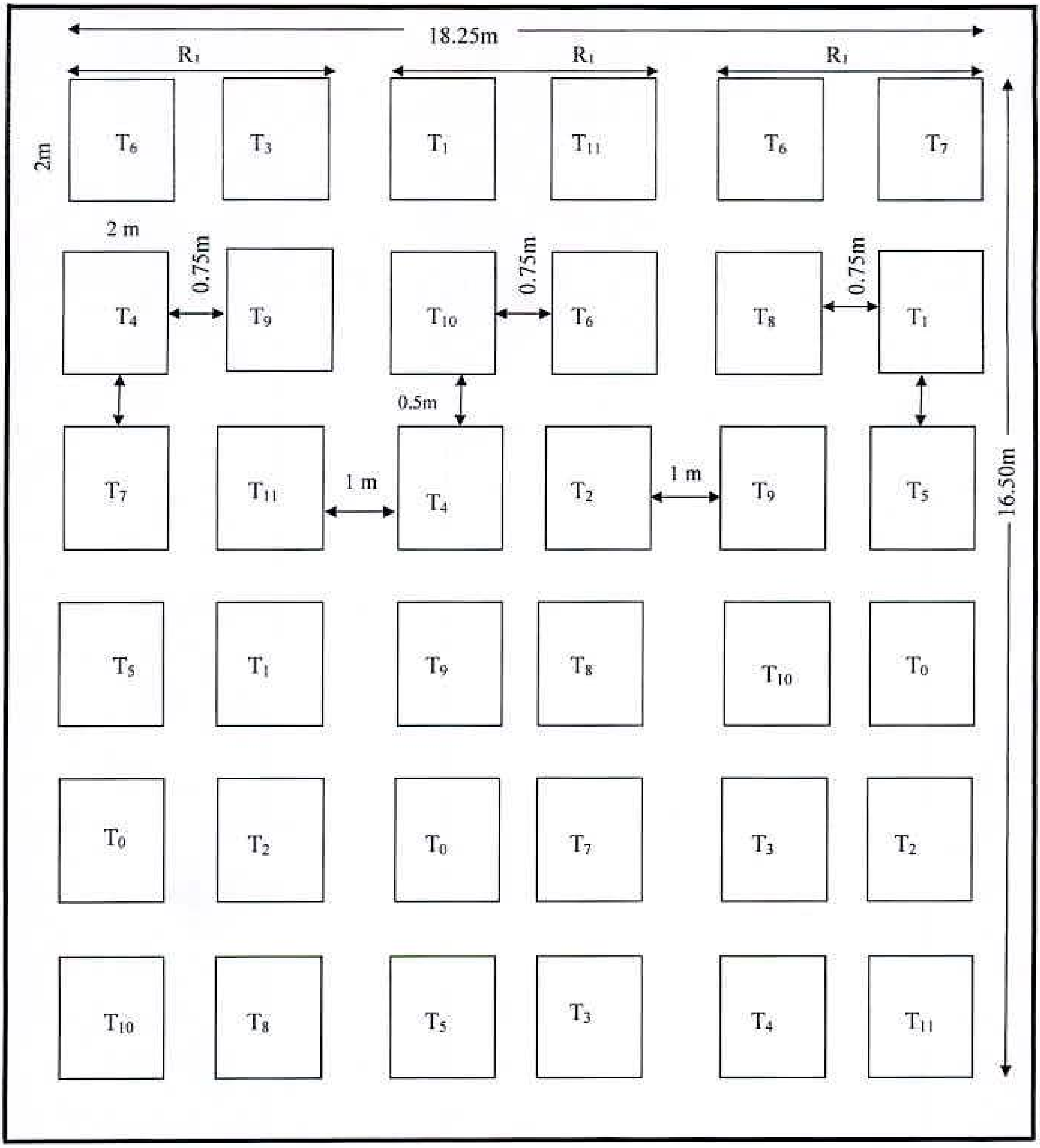
An approved summer onion variety released by National Seed Board as BARI Peaj-2 was selected for the present study. This variety was released in 2000. The variety produces plants 50-55 cm tall with 9-10 leaves $plant^{-1}$. The diameter of bulb is 4-5 cm; the bulbs are highly pungent with pinkish red 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} (Anon., 2000). The germination percentage of the seed was 85.

3.5 Land preparation

The experimental plot was opened in the month of April 2007 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 soil for transplanting the seedlings.

3.6 Design and layout of the experiment

The experiment was laid out in a two factor Randomized Complete Block Design with three replications. The total number of plots was 36, each measuring 2m × 2m. The treatment combination of the experiment was assigned at random into 12 plots of each at 3 replications. The distance maintained between two plots was 75 cm and between blocks was 150 cm. The layout of the experiment is presented in Figure 3.7.



Plot size : 2 m × 2 m (4 m^2)

Plot to plot distance :0.75 m

Block to block distance :1.0 m

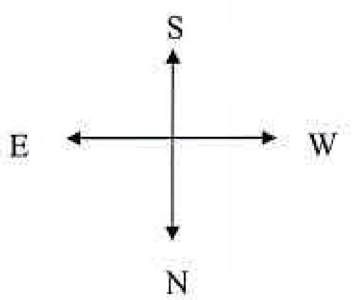


Figure 3.7. Layout of the experimental field.

3.7 Treatment of the experiment

The experiment consists of 2 Factors i.e. vermicompost and fertilizer. Fertilizer has three levels, and vermicompost have four levels. Details of factors and their combinations are presented below:

Factor A: Vermicompost

V_0 = 0 t ha^{-1} (No vermicompost)
V_1 = 1.5 t ha^{-1} (Low vermicompost)
V_2 = 3 t ha^{-1} (Medium vermicompost)
V_3 = 5 t ha^{-1} (High vermicompost)

Factor B: Fertilizer

F_0 = 0 kg N ha^{-1} + 0 kg P ha^{-1} + 0 kg K ha^{-1} + 0 kg S ha^{-1} (No NPKS)
F_1 = 60 kg N ha^{-1} + 22 kg P ha^{-1} + 50 kg K ha^{-1} + 16 kg S ha^{-1} (Half RDF, NPKS)
F_2 = 120 kg N ha^{-1} + 44 kg P ha^{-1} + 100 kg K ha^{-1} + 32 kg S ha^{-1} (Full RDF, NPKS)

Treatment combinations:

T_0 = (V_0F_0) = Control (No vermicompost + No NPKS)
T_1 = (V_0F_1) = (No vermicompost + Half RDF, NPKS)
T_2 = (V_0F_2) = (No vermicompost +Full RDF, NPKS)
T_3 = (V_1F_0) = (Low vermicompost + No NPKS)
T_4 = (V_2F_0) = (Medium vermicompost + No NPKS)
T_5 = (V_3F_0) = (High vermicompost + No NPKS)
T_6 = (V_1F_1) = (Low vermicompost + Half RDF, NPKS)
T_7 = (V_1F_2) = (Low vermicompost + Full RDF, NPKS)
T_8 = (V_2F_1) = (Medium vermicompost + Half RDF, NPKS)
T_9 = (V_2F_2) = (Medium vermicompost + Full RDF, NPKS)
T_{10} = (V_3F_1) = (High vermicompost + Half RDF, NPKS)
T_{11} = (V_3F_2) = (High vermicompost + Full RDF, NPKS)

*** RDF= Recommended dose of fertilizers**

3.8 Raising of seedlings

Seeds were soaked overnight (twelve hours) in water and allowed to sprout in a piece of moist cloth keeping in the sunshade for two days.

3.9 Seed sowing

The first date of seed sowing was 19th March 2007. The sprouted seeds (3-4 in number) were sown directly in the raised seedbed for raising seedling which will be transplanted. The young seedlings were exposed to dew by night and mid 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 healthy seedling in right place.

3.10 Rates of vermicompost

No vermicompost	: 0 ton/ha.
Low vermicompost	: 1.5 ton/ha.
Medium vermicompost	: 3.0 ton/ha.
High vermicompost	: 5.0 ton/ha.

3.11 Rates of fertilizer

N (Urea) : 0, 60 and 120 kg N/ha (Half and full BARI recommended dose)
P (T S P) : 0, 22 and 44 kg P/ha (Half and full BARI recommended dose)
K (M P) : 0, 50 and 100 kg K/ha (Half and full BARI recommended dose)
S (Gypsum) : 0, 16 and 32 kg S/ha (Half and full BARI recommended dose).

3.12 Application of fertilizers and manure

The entire required quantity of vermicompost, 50% of the required amount of N (Urea) and K (MP), full doses of P (TSP) and S (Gypsum) were applied during final land preparation. Rest of the N (urea) were applied in two equal installments and the remaining K (MP) were applied in one installment as top dressing.

3.13 Transplanting of seedlings

Healthy and disease free uniform sized 35 days old seedlings were uprooted from the seedbeds and transplanted in the main field with the line to line of spacing 25 cm and plant to plant spacing of 10 cm in the afternoon on 22th April 2007. 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 filling.

3.14 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.

3.15 Gap filling

Damaged / dead seedlings were replaced by healthy plant within one week of transplantation.

3.16 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.

3.17 Irrigation and drainage

Irrigation was given 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.

3.18 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.

3.19 Harvesting

The crops were harvested on 23^{rd} July, 2007 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.

3.20 Collection of soil sample

Post hervest composite soil samples were collected from each plot at 0 to 15 cm depth.The samples were air-dried ground and sieved through 2 mm (10 mesh) sieve and kept for analysis.

3.21 Collection of plant sample

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

3.22 Collection of onion bulb sample

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

3.23 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 the border effect was avoided for the highest precision.

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

3.23.1 Plant height (cm)

The height of the selected six plants in each plot was measured after 50 days of 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 six plants were taken.

3.23.2 Number of leaves per plant

The number of leaves per plant from five selected plants from each plot were counted after 50 DAT and the average of five plants was taken as the number of leaves per plant.

3.23.3 Leaf length (cm)

The length of leaf was measured with a centimeter scale from pseudo stem to the tip of the leaf from five selected plants from each plot at 90 DAT and their average was recorded

3.23.4 Length of bulb per plant (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 from each plot and their average was taken.

3.23.5 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.

3.23.6 Diameter of bulb (cm)

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

3.23.7 Yield of bulb

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

3.24 Post harvest soil sampling

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

3.25 Analysis of soil samples

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

3.25.1 Soil Analysis

3.25.1.1 Physical analysis of soil

3.25.1.1.1 Particle size analysis

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

3.25.2 Chemical analysis of soil

3.25.2.1 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).

3.25.2.2 Organic carbon (%)

Organic carbon in soil was estimated by wet oxidation method described by Black (1965).

3.25.2.3 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).

3.25.2.4 Available phosphorus

Available phosphorus was extracted from the soil sample with 0.5 M $NaHCO_3$ at P^H 8.5 folloing the method described by Olsen *et al* (1954). The phosphorus in the extract was then determined by developing blue colour using ascorbic acid. The absorbance of the molybdophosphate blue colour was measured at 660 nm wave length by spectrophotometer.

3.25.2.5 Exchangeable potassium

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

3.25.2.6 Available sulphur

Available sulphur in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution. The S content in the extract was determined turbidimetrically by spectrophotometer at 420 nm wavelength.

3.26 Chemical analysis of plant samples

3.26.1 Preparation of plant samples

Five selected plants per plot were collected randomly immediately after harvest of the crop. The bulbs and leaves of the selected plants were cleaned and dried in an over at 70^0C for 72 hours. The dried samples were then ground with a grinding mill. The prepared samples were kept in a dessicator for analysis.

3.26.2 Digestion of plant samples with sulphuric acid

For N determination an amount of 0.2g plant sample was taken into a 100 ml kjeldahl flask. An amount of 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$:Se = 100:10:1), 2ml 30% H_2O_2 and 3ml conc. H_2SO_4 were added into the flask. The flask was swirled and allowed to stand for about 10 minutes, followed by heating at 200^0C. 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.

3.26.3 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 rising slowly to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6ml of 6N HCl were added to it. The contents of the flask were heated until they became clear and colourless. This digest was used for determining P, K and S.

3.26.4 Determination of elements in the digest

Nitrogen and Phosphorus contents in the digests were determined by similar method as described in soil analysis.

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

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

3.27 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 for the interpretation of results.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The results on different yield attributes, yield and nutrient concentrations in the plants and availability of different nutrients in the soil after harvest of summer onion are presented in this chapter.

4.1 Plant height

4.1.1 Effect of vermicompost on the plant height of summer onion.

The effects of vermicompost on the plant height of summer onion are presented in (Table 4.1 and appendix Fig. 1). Significant variation was observed on the plant height of summer onion when the field was incorporated with different doses of vermicompost. Among the different doses of vermicompost, V_3 (5 t ha^{-1}) showed the highest plant height (34.41 cm) and it was closely followed by (32.80 cm) V_2 (3 t ha^{-1}) treatment. On the other hand, the lowest plant height (25.83 cm) was observed in the V_0 treatment where no vermicompost was applied. Vermicompost might have increased the soil moisture content, soil porosity and other plant growth enhancing characters and for that reason increasing dose of vermicompost increased plant height. Similar result was reported by Rao *et al.* (2000), Nasiruddin *et al.* (1993) found that the increasing soil organic matter content through the application of vermicompost in summer onion increased plant height.

Table 4.1 Effect of vermicompost on the growth parameters of summer onion.

Vermicompost	Plant height (cm)	Leaf plant^{-1} (no.)	Leaf length (cm)
V_0	25.83 c	5.22	17.85 c
V_1	31.21 b	6.11	20.82 b
V_2	32.80 ab	6.88	21.72 ab
V_3	34.41 a	6.44	22.97 a
Level of Significance	**0.01**	**NS**	**0.01**

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

4.1.2 Effect of chemical fertilizers on the plant height of summer onion.

Summer onion plants showed significant variation in respect of plant height when fertilizers in different doses were applied (Table 4.2 and appendix Fig. 2). Among the different fertilizer doses, F_2 (High NPKS) showed the highest plant height (34.13 cm), which was statistically identical with the fertilizer dose F_1 (Medium NPKS). On the contrary, the lowest plant height (27.12 cm) was observed in the tratment where no fertilizer was applied.

Table 4.2 Effect of NPKS fertilizers on the growth parameters of summer onion.

NPKS Fertilizer	Plant height (cm)	Leaf plant^{1} (no.)	Leaf length (cm)
F_0	27.12 b	6.08	18.94 b
F_1	31.94 a	6.08	21.49 a
F_2	34.13 a	6.33	22.09 a
Level of Significance	**0.01**	**NS**	**0.01**

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

4.1.3 Combined effect of vermicompost and chemical fertilizers on the plant height of summer onion

Combined application of different doses of vermicompost and fertilizers had significant effect on the plant height of summer onion (Table 4.3 and Appendix Figure 3). The lowest plant height (23.22 cm) was observed in the treatment combination of V_0F_0 (No vermicompost and No NPKS). On the other hand, the highest plant height (37.61 cm) was recorded with V_3F_2 (High vermicompost + High NPKS).

Table 4.3 Combined effect of vermicompost and different doses of chemical fertilizers (NPKS) on the growth parameters of summer onion.

Vermicompost × NPKS Fertilizers	Plant height (cm)	Leaf plant^{-1} (no.)	Leaf length (cm)
V_0F_0	23.22 e	5.000 b	17.10 f
V_0F_1	25.17 e	5.667 ab	17.95 ef
V_0F_2	29.10 d	5.000 b	18.50 e
V_1F_0	27.64 d	6.333 ab	18.90 e
V_1F_1	32.10 c	6.333 ab	21.60 bc
V_1F_2	33.90 bc	5.667 ab	21.95 b
V_2F_0	28.20 d	6.333 ab	19.25 de
V_2F_1	34.30 bc	7.000 ab	22.10 b
V_2F_2	35.90 ab	7.333 a	23.80 a
V_3F_0	29.43 d	6.667 ab	20.50 cd
V_3F_1	36.20 ab	5.333 ab	24.30 a
V_3F_2	37.61 a	7.333 a	24.10 a
Level of Significance	0.05	0.05	0.01

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

4.2 Leaf plant^{-1}

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

No significant variation was observed in leaf plant^{-1} of summer onion when different doses of vermicompost were applied (Table 4.1 and Appendix Figure 4). The highest leaf plant^{-1} (6.44) was recorded in V_3 (5 t ha^{-1}), which was statistically similar with the other doses of vermicompost application. The lowest leaf plant^{-1} (5.22) was recorded in the V_0 treatment where no vermicompost was applied. Similar result was reported by Nasiruddin *et al.* (1993). The increased leaf plant^{-1} might be due to favorable effects of vermicompost on the vegetative growth and accumulation of materials that helped proper growth and development of the summer onion bulb.

4.2.2 Effect of chemical fertilizers on the leaf plant^{-1} of summer onion.

Different doses of chemical fertilizers showed significant variations in respect of leaf plant^{-1} (Table 4.2 and Appendix Figure 5). Among the different doses of fertilizers, F_2 (High NPKS) showed the highest leaf plant^{-1} (6.33), which was statistically similar with the different fertilizer dose. On the contrary, the lowest leaf plant^{-1} (6.08) was observed with F_0, where no fertilizer was applied.

4.2.3 Combined effect of vermicompost and chemical fertilizers on the leaf plant^{-1} of summer onion.

The combined effect of different doses of vermicompost and fertilizer on leaf plant^{-1} of summer onion was significant (Table 4.3 and Appendix Figure 6). But the highest leaf plant^{-1} (7.33) was recorded with the treatment combination of V_3F_2 (high vermicompost + High NPKS). On the other hand, the lowest leaf plant^{-1} (5.00) was found in V_0F_0 treatment (No vermicompost and No NPKS).

4.3 Leaf length (cm)

4.3.1 Effect of vermicompost on the leaf length of summer onion.

Different doses of vermicompost showed a statistically significant variation of leaf length (Table 4.1 and Appendix Figure 7). Among the different doses of vermicompost the highest leaf length (22.97 cm) was observed in V_3 (5 t ha^{-1}), which was statistically identical (21.72 cm) with V_2 (3 t ha^{-1}). The lowest leaf length (17.85 cm) was recorded in the V_0 treatment where no vermicompost was applied. Probably vermicompost supplied the necessary requirements for the proper vegetative growth that helped in obtaining the highest leaf length of summer onion.

4.3.2 Effect of chemical fertilizers on the leaf length of summer onion.

Application of fertilizers at different doses showed a significant variation on the leaf length of summer onion (Table 4.2 and Appendix Figure 8). Among the different fertilizer doses, F_2 (High NPKS) showed the highest leaf length (22.09 cm), which was closely followed (21.49 cm) by the fertilizer dose F_1 (Medium NPKS). On the other hand, the lowest leaf length (18.94 cm) was recorded with F_0 treatment where no fertilizer was applied.

4.3.3 Combined effect of vermicompost and chemical fertilizers on the leaf length (cm) of summer onion.

Combined effects of different doses of vermicompost and fertilizers on leaf length showed a statistically significant variation (Table 4.3 and Appendix Figure 9). The highest leaf length (24.30 cm) was recorded in the treatment combination of V_3F_1 (High vermicompost + Medium NPKS) and V_3F_2 (High vermicompost + High NPKS), which was statistically identical with the treatment combination of V_2F_2 (Medium vermicompost + High NPKS). On the other hand, the lowest leaf length (17.10 cm) was found in V_0F_0.

4.4 Yield and yield contributing characters

4.4.1 Diameter of bulb per plant (cm)

4.4.1.1 Effect of vermicompost on the diameter of summer onion bulb per plant.

Significant variation in diameter of bulb per plant of summer onion was observed with different doses of vermicompost (Table 4.4 and Appendix Figure 10). Among the different doses of vermicompost V_3 (5 t ha^{-1}) showed the highest diameter of bulb per plant (3.18 cm), which was statistically identical with the treatment V_2 (3 t ha^{-1}). On the other hand, the lowest diameter of bulb per plant (2.60 cm) was observed in the V_0 treatment, where no vermicompost was applied and it was closely followed (2.77 cm) by the V_1 (1.5 t ha^{-1}) treatment.

Table 4.4 Effect of vermicompost on the yield contributing characters and the yield of summer onion.

Vermicompost	Diameter of bulb $plant^{-1}$ (cm)	Length of bulb $plant^{-1}$ (cm)	Weight of single bulb (gm)	Yield of bulb (t/ha^{-1})
V_0	2.60 b	2.43	17.19 b	6.957 b
V_1	2.76 b	2.54	23.78 a	9.513 a
V_2	3.13 a	2.59	25.91 a	10.32 a
V_3	3.18a	2.59	25.55 a	10.22 a
Level of Significance	0.01	NS	0.05	0.01

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

4.4.1.2 Effect of chemical fertilizers on the diameter of summer onion bulb per plant.

Diameter of bulb per plant showed significant variation when different doses of fertilizers were applied (Table 4.5 and Appendix Figure 11). Among the different combinations of fertilizer doses, F_3 (High NPKS) showed the highest diameter of bulb per plant (3.14 cm), which was closely followed (3.13 cm) by the fertilizer dose F_1 (Medium NPKS). The lowest diameter of bulb per plant (2.64 cm) was observed with F_0 where no fertilizer was applied. Similar result was reported by Baloch *et al.* (1991).

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

NPKS Fertilizer	Diameter of bulb plant^{-1} (cm)	Length of bulb plant^{-1} (cm)	Weight of single bulb (gm)	Yield of bulb (t ha^{-1})
F_0	2.64 b	2.44	18.22 b	7.255 b
F_1	3.13 a	2.58	25.44 a	10.18 a
F_2	3.14 a	2.58	26.20 a	10.32 a
Level of Significance	0.01	NS	0.05	0.01

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

4.4.1.3 Combined effect of vermicompost and chemical fertilizers on the diameter of summer onion bulb per plant.

Combined effect of different doses of vermicompost and fertilizer showed a statistically significant effect on the diameter of bulb per plant of summer onion (Table 4.6 and Appendix Figure 12). The lowest diameter of bulb per plant (2.51 cm) was observed in the treatment combination of V_0F_0 (No vermicompost and No NPKS).

Table 4.6 Combined effect of vermicompost and different doses of chemical fertilizers (NPKS) on the yield contributing characters of summer onion.

Vermicompost × NPKS Fertilizer	Diameter of bulb $plant^{-1}$ (cm)	Length of bulb $plant^{-1}$ (cm)	Weight of single bulb (g)	Yield of bulb ($t\ ha^{-1}$)
V_0F_0	2.517 f	2.390	14.50 e	5.800 e
V_0F_1	2.600 f	2.430	18.10 de	7.250 d
V_0F_2	2.700 f	2.470	21.12 cd	7.820 d
V_1F_0	2.660 f	2.450	18.35 de	7.340 d
V_1F_1	2.980 de	2.560	25.10 bc	10.04 c
V_1F_2	2.980 de	2.620	27.90 ab	11.16 bc
V_2F_0	2.607 f	2.460	19.78 d	7.780 d
V_2F_1	3.300 bc	2.647	28.40 ab	11.36 bc
V_2F_2	3.490 ab	2.683	29.55 ab	11.82 ab
V_3F_0	2.783 ef	2.490	20.25 d	8.100 d
V_3F_1	3.640 a	2.710	30.15 a	12.06 a
V_3F_2	3.120 cd	2.580	26.25 ab	10.50 bc
Level of Significance	**0.01**	**NS**	**0.01**	**0.01**

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

On the other hand, the highest diameter of bulb per plant (3.64 cm) was recorded with V_3F_1 (High vermicompost + Medium NPKS), which was statistically identical with the treatment combinations of V_2F_1 (Medium vermicompost + Medium NPKS).

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

4.4.2.1 Effect of vermicompost on the bulb length of summer onion plant.

There was no significant variation in the length of bulb plant^{-1} (cm) in summer onion when different doses of vermicompost were applied (Table 4.4 and Appendix Figure 13). The highest length of bulb plant^{-1} (2.59 cm) was recorded both in V_2 (3 t ha^{-1}) and V_3 (5 t ha^{-1}) treatments. The lowest length of bulb plant^{-1} (2.43 cm) was recorded in the V_0 treatment where no vermicompost was applied.

4.4.2.2 Effect of chemical fertilizers on the bulb length of summer onion plant.

Different doses of chemical fertilizers showed non significant variations in respect of length of bulb plant^{-1} (Table 4.5 and Appendix Figure 14). Among the different doses of fertilizers, both F_1 (low NPKS) and F_2 (High NPKS) showed the highest length of bulb plant^{-1} (2.58 cm). On the contrary, the lowest the length of bulb plant^{-1} (2.44 cm) was observed with F_0, where no fertilizer was applied.

4.4.2.3 Combined effect of vermicompost and chemical fertilizers on the bulb length of summer onion plant.

The combined effect of different doses of vermicompost and fertilizer on the length of bulb plant^{-1} of summer onion was not significant (Table 4.6 and Appendix Figure 15). However, the highest length of bulb plant^{-1} (2.71 cm) was recorded with the treatment combination of V_3F_1 (High vermicompost + Medium NPKS). On the other hand, the lowest length of bulb plant^{-1} (2.39 cm) was found in V_0F_0 treatment (No vermicompost and No NPKS).

4.4.3 Weight of single bulb (g)

4.4.3.1 Effect of vermicompost on the weight of single bulb of summer onion.

Significant variation was observed on the weight of single bulb of summer onion when different doses of vermicompost were applied (Table 4.4 and Appendix Figure 16). The highest weight of single bulb (25.55 g) was recorded in V_3 (5 t ha^{-1}), which was statistically similar with V_1 (1.5 t ha^{-1}) and V_2 (3 t ha^{-1}). The lowest weight of single bulb (17.91 g) was recorded in the V_0 treatment where no vermicompost was applied. Similar result was reported by Baloch *et al.* (1991). They found maximum bulb yield (22.66 t ha^{-1}) with the application of 125 kg N + 75 kg K_2O ha^{-1}. The highest 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}.

4.4.3.2 Effect of chemical fertilizers on the weight of single bulb of summer onion.

Different doses of chemical fertilizers showed significant variations in respect of the weight of single bulb (Table 4.5 and Appendix Figure 17). Among the different doses of fertilizers, F_2 (High NPKS) showed the highest weight of single bulb (26.20 g), which was statistically identical (25.44 g) with the fertilizer dose of F_1(Medium NPKS). On the contrary, the lowest weight of single bulb (18.22 g) was observed with F_0, where no fertilizer was applied.

4.4.3.3 Combined effect of vermicompost and chemical fertilizers on the weight of single bulb of summer onion.

The combined effect of different doses of vermicompost and fertilizer on the weight of single bulb of summer onion was statistically significant (Table 4.6 and Appendix Figure 18). The highest weight of single bulb (30.15 g) was recorded with the treatment combination of V_3F_1 (High vermicompost + Medium NPKS), which was statistically identical (29.55 g) with V_2F_2 (Medium vermicompost + High NPKS), V_2F_1 (Medium vermicompost + Medium NPKS), V_1F_2 (Low vermicompost + High NPKS) and V_3F_2 (High vermicompost + High NPKS) treatments. On the other hand, the lowest weight of single bulb (14.50 g) was found in V_0F_0 treatment (No vermicompost and No NPKS).

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

4.4.4.1 Effect of vermicompost on the yield of summer onion bulb.

Significant variation was observed on the yield of bulb of summer onion when different doses of vermicompost were applied (Table 4.4 and Appendix Figure 19). The highest yield of bulb (10.32 t/ha^{-1}) was recorded in V_2 (3 t ha^{-1}), which was statistically similar with V_1 (1.5 t ha^{-1}) and V_3 (5 t ha^{-1}). The lowest yield of bulb (6.96 t/ha^{-1}) was recorded in the V_0 treatment where no vermicompost was applied.

4.4.4.2 Effect of chemical fertilizers on the yield of summer onion bulb.

Different doses of chemical fertilizers showed significant variations in respect of yield of bulb (Table 4.5 and Appendix Figure 20). Among the different doses of fertilizers, F_2 (High NPKS) showed the highest yield of bulb (10.32 t/ha^{-1}), which was statistically identical (10.18 g) with the fertilizer dose of F_1(Medium NPKS). On the contrary, the lowest yield of bulb (7.25 t/ha^{-1}) was observed with $F_{0,}$ where no fertilizer was applied.

4.4.4.3 Combined effect of vermicompost and chemical fertilizers on the yield of summer onion bulb.

The combined effect of different doses of vermicompost and fertilizer on the yield of bulb of summer onion was significant (Table 4.6 and Appendix Figure 21). The highest yield of bulb (12.06 t/ha^{-1}) was recorded with the treatment combination of V_3F_1 (High vermicompost + Medium NPKS), which was statistically identical (11.82 t/ha^{-1}) with the fertilizer dose of V_2F_1 (Medium vermicompost + Medium NPKS). On the other hand, the lowest yield of bulb

(5.800 t/ha^{-1}) was found in V_0F_0 treatment (No vermicompost and No NPK). Similar result was reported by Sharma *et al.* (2003).They found that maximum bulb yield was recorded in the case of 100 % NPKS along with 20 t FYM ha^{-1} (19.87 t ha^{-1}) was at par with 150 % NPKS 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}.

4.5 Effect of vermicompost on nitrogen concentrations in plant and bulb of summer onion.

4.5.1 Effect of vermicompost on the nitrogen content in summer onion plant.

Application of vermicompost showed significant variation in the nitrogen concentration in onion plant (Table 4.7). The highest nitrogen concentration in plant (2.156%) was recorded in V_3 (5 t ha^{-1}), which was statistically significant with V_2 (3 t ha^{-1}). On the other hand, the lowest nitrogen concentration in plant (1.647%) was recorded in the V_0 treatment where no vermicompost was applied.

Table 4.7 Effect of vermicompost on the nitrogen concentration in summer onion plant bulb.

Vermicompost	N concentration (%)	
	Plant	Bulb
V_0	1.647 c	2.39 b
V_1	1.910 b	2.55 ab
V_2	2.083 a	2.61 ab
V_3	2.156 a	2.68 a
Level of Significance	0.01	0.01

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

4.5.2 Effect of vermicompost on the nitrogen content in the bulb of summer onion.

The highest significant nitrogen concentration in onion bulb (2.68%) was recorded in V_3 (5 t ha^{-1}), which showed similar result with V_2 (3 t ha^{-1}) and V_1 (1.5 t ha^{-1}) treatments (Table 4.7). The lowest nitrogen concentration in onion bulb (2.39 %) was recorded in the V_0 treatment where no vermicompost was applied.

4.6 Effect of chemical fertilizers on nitrogen concentrations in plant and bulb of summer onion.

4.6.1 Effect of chemical fertilizers on the nitrogen content in summer onion plant.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the nitrogen concentration in plant (Table 4.8). The highest nitrogen concentration among different doses of chemical fertilizers was obserd with F_2 (2.10%) in plant, which was similar to F_1 (2.06 %). The lowest nitrogen concentration (1.68%) in plant was observed in F_0 treatment where no fertilizer was applied.

Table 4.8 Effect of chemical fertilizers on the nitrogen concentrations in plant and bulb of summer onion.

Fertilizers	N concentration (%)	
	Plant	Bulb
F_0	1.681 b	2.37 b
F_1	2.062 a	2.62 ab
F_2	2.104 a	2.68 a
Level of Significance	**0.01**	**0.01**

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

4.6.2 Effect of chemical fertilizers on the nitrogen content in summer onion bulb.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the nitrogen concentration in bulb (Table 4.8). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest nitrogen concentration (2.68 %) in bulb, which was statistically similar to F_1 (2.62 %). The lowest nitrogen concentration (2.37 %) in the onion bulb was observed in the treatment where no fertilizer was applied.

4.7 Combined effect of chemical fertilizers on the nitrogen concentrations in plant and bulb of summer onion.

4.7.1 Combined effect of vermicompost and chemical fertilizers on the nitrogen content in summer onion plant.

Significant effect of combined application of different doses of vermicompost and fertilizers on the nitrogen concentration was observed in the plant of summer onion (Table 4.9 and Appendix Figure 22). The highest concentration of nitrogen in the plant (2.28%) was recorded with the highest dose of vermicompost and fertilizers (V_3F_2). This may be due to the higher supply and subsequent assimilation of this element in the plant. On the other hand, the lowest nitrogen concentration (1.28%) in plant was found in V_0F_0 (No vermicompost+ No NPKS) treatment.

Table 4.9 Combined effects of vermicompost and chemical fertilizers on the nitrogen concentrations in plant and bulb of summer onion.

Vermicompost × NPKS Fertilizers	N concentration (%)	
	Plant	Bulb
V_0F_0	1.284 f	2.369 d
V_0F_1	1.828 d	2.386 d
V_0F_2	1.828 d	2.440 cd
V_1F_0	1.509 e	2.358 d
V_1F_1	2.100 b	2.620 bc
V_1F_2	2.120 b	2.680 ab
V_2F_0	1.949 c	2.359 d
V_2F_1	2.117 b	2.722 ab
V_2F_2	2.184 ab	2.755 ab
V_3F_0	1.982 c	2.402 d
V_3F_1	2.201 ab	2.789 ab
V_3F_2	2.284 a	2.856 a
Level of Significance	**0.01**	**0.01**

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

4.7.2 Combined effect of vermicompost and chemical fertilizers on the nitrogen content in summer onion bulb.

Significant effect of combined application of different doses of vermicompost and fertilizers on the nitrogen concentration was observed in bulb of summer onion (Table 4.9 and Appendix Figure 22). The highest concentration of nitrogen in the bulb (2.856 %) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS), which was similar to V_3F_1, V_2F_2, V_2F_1 and V_1F_2. On the other hand, the lowest nitrogen concentration (2.369 %) in bulb was found in V_1F_0 (low vermicompost + No NPKS) which was statistically similar with V_0F_0, V_0F_1, V_2F_0 and V_3F_0.

4.8 Effect of vermicompost on phosphorous concentrations in plant and bulb of summer onion.

4.8.1 Effect of vermicompost on the phosphorus content in summer onion plant.

The highest significant phosphorus concentration in plant (0.067 %) was recorded in V_3 (5 t ha^{-1}), which was statistically similar with V_2 (3 t ha^{-1}) and V_1(1.5 t ha^{-1}) treatments (Table 4.10). On the other hand, the lowest phosphorus concentration in plant (0.045 %) was recorded in the V_0 treatment where no vermicompost was applied.

Table 4.10 Effect of vermicompost on the phosphorous concentration in the plant and bulb of summer onion.

Vermicompost	P concentration (%)	
	Plant	Bulb
V_0	0.045 b	0.067 c
V_1	0.054 ab	0.072 bc
V_2	0.062 ab	0.075 ab
V_3	0.067 a	0.080 a
Level of Significance	**0.01**	**0.01**

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

4.8.2 Effect of vermicompost on the phosphorus content in summer onion bulb.

Statistically significant variation was observed in phosphorus concentration in the bulb of summer onion with different doses of vermicompost (Table 4.10). The highest phosphorus concentration in onion bulb (0.080 %) among different doses of vermicompost was recorded in V_3 (5 t ha^{-1}), which was statistically similar with V_2 (3 t ha^{-1}). On the other hand, the lowest phosphorus concentration in bulb (0.067 %) was recorded in the V_0 treatment where no vermicompost was applied.

4.9 Effect of chemical fertilizers on the phosphorous concentrations in the plant and bulb of summer onion.

4.9.1 Effect of chemical fertilizers on the phosphorus content in summer onion plant.

The effect of different doses of chemical fertilizers showed a statistically insignificant variation in the phosphorus concentration in plant of summer onion (Table 4.11). The highest phosphorus concentration among different doses of chemical fertilizers (0.066 %) in plant was obtained with F_2 which was similar to other treatments . The lowest phosphorus concentration (0.045 %) in plant was observed in the treatment where no chemical fertilizers were applied (F_0).

Table 4.11 Effect of chemical fertilizers on the phosphorous concentrations in plant and bulb of summer onion.

Fertilizers	P concentration (%)	
	Plant	Bulb
F_0	0.045	0.067 b
F_1	0.061	0.076 a
F_2	0.066	0.078 a
Level of Significance	**NS**	**0.01**

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

4.9.2 Effect of chemical fertilizers on the phosphorus content in summer onion bulb.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the phosphorus concentration in summer onion bulb (Table 4.11). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest phosphorus concentration (0.078 %) in the onion bulb, which was similar to F_1 (0.076 %). The lowest phosphorus concentration (0.067 %) in onion bulb was observed in the F_0 treatment.

4.10 Combined effect of vermicompost and chemical fertilizers on phosphorous concentrations in the plant and bulb of summer onion.

4.10.1 Combined effect of vermicompost and chemical fertilizers on the phosphorus content in plant of summer onion.

Significant effect of combined application of different doses of vermicompost and fertilizers on the phosphorus concentration was observed in plant of summer onion (Table 4.12 and Appendix Figure 23). The highest concentration of phosphorus in the plant (0.078 %) was recorded with the highest dose of vermicompost and fertilizers which may be due to the higher supply and subsequent assimilation of this element in the plant. On the other hand, the lowest phosphorus concentration (0.0406 %) in plant was found in V_0F_0 (No vermicompost+ No NPKS) treatment.

Table 4.12 Combined effect of vermicompost and chemical fertilizers on the phosphorous concentrations in the plant and bulb of summer onion.

Vermicompost × NPKS Fertilizers	P concentration (%)	
	Plant	Bulb
V_0F_0	0.04067 f	0.064 g
V_0F_1	0.04400 f	0.068 fg
V_0F_2	0.05300 ef	0.071 ef
V_1F_0	0.04300 f	0.067 fg
V_1F_1	0.05800 de	0.075 cd
V_1F_2	0.06300 bc	0.076 cd
V_2F_0	0.04967 de	0.068 fg
V_2F_1	0.06800 ab	0.078 bc
V_2F_2	0.07100 ab	0.080 bc
V_3F_0	0.04900 ef	0.070 ef
V_3F_1	0.07600 ab	0.083 ab
V_3F_2	0.07800 a	0.088 a
Level of Significance	**0.05**	**0.01**

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

4.10.2 Combined effect of vermicompost and chemical fertilizers on the phosphorus content in the bulb of summer onion.

Significant effect of combined application of different doses of vermicompost and fertilizers on the phosphorus concentration was observed in the bulb of summer onion (Table 4.12 and Appendix Figure 23). The highest concentration of phosphorus in the bulb (0.088 %) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS) which was similar with V_3F_1. On the other hand, the lowest phosphorus concentration in the bulb (0.064 %) was found in V_0F_0 (No vermicompost+ No NPKS) V_0F_1 treatment.

4.11 Effect of vermicompost on the potassium concentrations in the plant and bulb of summer onion.

4.11.1 Effect of vermicompost on the potassium content in summer onion plant.

A statistically significant variation was observed in potassium concentration in plant of summer onion with different doses of vermicompost (Table 4.13). Among the different doses of vermicompost the highest potassium concentration in plant (0.574 %) was recorded in V_3 (5 t ha^{-1}), which was statistically similar with V_2 (3 t ha^{-1}) and V_1 (1.5 t ha^{-1}) treatments. On the other hand, the lowest potassium concentration in plant (0.461 %) was recorded in the V_0 treatment where no vermicompost was applied.

Table 4.13 Effect of vermicompost on the potassium concentration in plant and bulb of summer onion.

Vermicompost	K concentration (%)	
	Plant	Bulb
V_0	0.461 b	0.446
V_1	0.511 ab	0.505
V_2	0.539 a	0.530
V_3	0.574 a	0.544
Level of Significance	0.01	NS

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

4.11.2 Effect of vermicompost on the potassium content in summer onion bulb.

A statistically insignificant variation was observed in potassium concentration in bulb of summer onion with different doses of vermicompost (Table 4.13). The highest potassium concentration among the different doses of vermicompost (0.544 %) was recorded in V_3 (5 t ha^{-1}) in bulb, which was statistically similar with V_2 (3 t ha^{-1}) and V_1 (1.5 t ha^{-1}) treatments. On the other hand, the lowest potassium concentration in onion bulb (0.446 %) was recorded in the V_0 treatment where no vermicompost was applied.

4.12 Effect of chemical fertilizers on potassium concentrations in the plant and bulb of summer onion.

4.12.1 Effect of chemical fertilizers on the potassium content in summer onion plant.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the potassium concentration in summer onion plant (Table 4.14). The highest potassium concentration among the different doses of chemical fertilizers (0.568 %) was recorded with F_2 treatment in plant, which was similar to F_1 (0.552 %). The lowest potassium concentration (0.442 %) in plant was observed in the fertilizer combination F_0 where no fertilizer was applied.

Table 4.14 Effect of chemical fertilizers on potassium concentrations in plant and bulb of summer onion.

Fertilizers	K concentration (%)	
	Plant	Bulb
F_0	0.442 b	0.511
F_1	0.552 a	0.560
F_2	0.568 a	0.450
Level of Significance	**0.01**	**NS**

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

4.12.2 Effect of chemical fertilizers on the potassium content in summer onion bulb.

Statistically similar values of potassium content in the onion bulb were recorded with all the doses of fertilizer treatments (Table 4.14).

4.13 Combined effect of vermicompost and chemical fertilizers on potassium concentrations in plant and bulb of summer onion.

4.13.1 Combined effect of vermicompost and chemical fertilizers on the potassium content in summer onion plant.

Significant effect of combined application of different doses of vermicompost and fertilizers on the potassium concentration was observed in plant of summer onion (Table 4.15 and Appendix Figure 24). The highest concentration of potassium in the plant (0.63 %) was recorded with the highest dose of vermicompost and fertilizers V_3F_2 which may be due to the higher supply and subsequent assimilation of this element in the plant. On the other hand, the lowest potassium concentration (0.42 %) in plant was found in V_0F_0 (No vermicompost+ No NPKS) treatment.

Table 4.15 Combined effect of vermicompost and chemical fertilizers on the otassium concentrations in plant and bulb of summer onion.

Treatments	K concentration (%)	
	Plant	Bulb
V_0F_0	0.42 f	0.437 cd
V_0F_1	0.47 ef	0.485 cd
V_0F_2	0.49 de	0.414 d
V_1F_0	0.44 ef	0.538 bc
V_1F_1	0.53 cd	0.574 ab
V_1F_2	0.55 c	0.422 cd
V_2F_0	0.45 ef	0.539 bc
V_2F_1	0.57 bc	0.571 ab
V_2F_2	0.59 bc	0.482 cd
V_3F_0	0.46 ef	0.543 bc
V_3F_1	0.62 ab	0.604 a
V_3F_2	0.63 a	0.477 cd
Level of Significance	0.01	0.01

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

4.13.2 Combined effect of vermicompost and chemical fertilizers on the potassium content in summer onion bulb.

Significant effect of combined application of different doses of vermicompost and fertilizers on the potassium concentration was observed in the bulb of summer onion (Table 4.15 and Appendix Figure 24). The highest concentration of potassium in the bulb (0.064 %) was recorded in the treatment combination of V_3F_1 (High vermicompost + medium NPKS) in bulb, which was similar to V_1F_1, and V_2F_1. On the other hand, the lowest potassium concentration (0.42 %) in bulb was found in V_1F_2 (low vermicompost+ No NPKS) treatment.

4.14 Effect of vermicompost on the sulphur concentrations in plant and bulb of summer onion.

4.14.1 Effect of vermicompost on the sulphur content in summer onion plant.

A statistically significant variation was observed in sulphur concentration in plant of summer onion with different doses of vermicompost (Table 4.16). Among the different doses of vermicompost the highest sulphur concentration in plant (0.25 %) was recorded in V_3 (5 t ha^{-1}) treatment, which was statistically similar with V_2 (3 t ha^{-1}) and V_1 (1.5 t ha^{-1}) treatments. On the other hand, the lowest sulphur concentration in plant (0.182 %) was recorded in the V_0 treatment where no vermicompost was applied.

Table 4.16 Effect of vermicompost on the sulphur content in plant and bulb of summer onion.

Vermicompost	S concentration (%)	
	Plant	Bulb
V_0	0.182 b	0.19 c
V_1	0.21 ab	0.21 b
V_2	0.23 ab	0.23 a
V_3	0.25 a	0.25 a
Level of Significance	**0.05**	**0.01**

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

4.14.2 Effect of vermicompost on the sulphur content in the bulb of summer onion.

A statistically significant variation was observed in sulphur concentration in bulb of summer onion with different doses of vermicompost (Table 4.16). The highest sulphur concentration(0.25 %) among different doses of vermicompost was recorded with V_3 (5 t ha^{-1}) in bulb, which was statistically similar with V_2 (3 t ha^{-1}) treatment. On the other hand, the lowest sulphur concentration in bulb (0.19 %) was recorded in the V_0 treatment where no vermicompost was applied.

4.15 Effect of chemical fertilizers on sulphur concentrations in the plant and bulb of summer onion.

4.15.1 Effect of chemical fertilizers on the sulphur content in summer onion plant.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the sulphur concentration in plant of summer onion (Table 4.17). The highest sulphur concentration in plant among different doses of chemical fertilizers (0.24 %) was recorded with F_2, which was statistically similar with F_1 (0.23 %). The lowest sulphur concentration (0.17 %) in plant was observed in the treatment where no fertilizer was applied.

Table 4.17 Effect of chemical fertilizers on sulphur concentrations in plant and bulb of summer onion.

Fertilizers	S concentration (%)	
	Plant	Bulb
F_0	0.17 b	0.18 b
F_1	0.23 ab	0.24 a
F_2	0.24 a	0.25 a
Level of Significance	0.01	0.01

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

4.15.2 Effect of chemical fertilizers on the sulphur content in summer onion bulb.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the sulphur concentration in bulb of summer onion (Table 4.17). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest sulphur concentration (0.25 %) in bulb, which was statistically similar with F_1 (0.24 %). The lowest sulphur concentration (0.18 %) in bulb was observed in the fertilizer combination F_0 where no fertilizer was applied.

4.16 Combined effect of vermicompost and chemical fertilizers on sulphur concentrations in the plant and bulb of summer onion.

4.16.1 Combined effect of vermicompost and chemical fertilizers on sulphur content in summer onion plant.

Significant effect of combined application of different doses of vermicompost and fertilizers on the sulphur concentration was observed in plant of summer onion (Table 4.18 and Appendix Figure 25). The highest concentration of sulphur in the plant (0.29 %) was recorded with the highest dose of vermicompost and fertilizers which may be due to the higher supply and subsequent assimilation of this element in the plant and which was similar to V_3F_1 (0.27 %). On the other hand, the lowest sulphur concentration (0.16 %) in plant was found in V_0F_0 (No vermicompost+ No NPKS) treatment.

Table 4.18 Combined effect of vermicompost and chemical fertilizers on the sulphur concentrations in the plant and bulb of summer onion.

Treatments	S concentration (%)	
	Plant	Bulb
V_0F_0	0.160 d	0.171 g
V_0F_1	0.187 cd	0.193 ef
V_0F_2	0.200 cd	0.210 de
V_1F_0	0.171 d	0.180 fg
V_1F_1	0.215 bc	0.224 cd
V_1F_2	0.244 ab	0.231 c
V_2F_0	0.180 d	0.185 fg
V_2F_1	0.259 ab	0.251 b
V_2F_2	0.265 ab	0.261 b
V_3F_0	0.189 cd	0.195 ef
V_3F_1	0.276 a	0.278 a
V_3F_2	0.290 a	0.280 a
Level of Significance	**0.01**	**0.01**

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

4.16.2 Combined effect of vermicompost and chemical fertilizers on sulphur content in summer onion bulb.

Significant effect of combined application of different doses of vermicompost and fertilizers on the sulphur concentration was observed in bulb of summer onion (Table 4.18 and Appendix Figure 25). The highest concentration of sulphur in the bulb (0.28 %) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS) which was statistically similar with V_3F_1. On the other hand, the lowest sulphur concentration (0.17 %) in bulb was found in V_0F_0 (No vermicompost+ No NPKS) treatment.

4.17 Effect of vermicompost and NPKS fertilizers on the organic carbon, nutrient status of the postharvest soil and pH of summer onion field.

Table 4.19 Effect of vermicompost on the organic carbon, total N, available P, available K, available S content and pH of the postharvest soil.

Vermicompost	Org. Carb %	Total N %	Avail. P %	Avail. K %	Avail. S %	Soil pH
V_0	1.046	0.074 b	0.0013 d	0.098 c	0.0017 c	5.40 b
V_1	0.971	0.084 ab	0.0017 c	0.136 b	0.0018 bc	5.45 b
V_2	1.117	0.088 ab	0.0020 b	0.150 b	0.0019 b	6.05 a
V_3	1.193	0.096 a	0.0022 a	0.199 a	0.0022 a	6.13 a
Level of Significance	**NS**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**

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

4.17.1 Effect of vermicompost on the organic carbon, nutrient status of the postharvest soil and pH of summer onion field.

4.17.1.1 Effect of vermicompost on the organic carbon content in the postharvest soil of summer onion field.

A statistically insignificant variation was observed in organic carbon content of the postharvest soil of summer onion field with different doses of vermicompost (Table 4.19). Considering the different doses of vermicompost the highest organic carbon content (1.193 %) was recorded in V_3 (5 t ha^{-1}) treatment which was similar with the other treatmeants. The lowest organic carbon content in soil (0.971%) was recorded in the V_1 treatment where low vermicompost was applied. Application of vermicompost at higher doses increased the organic carbon content in the postharvest soil of the onion field.

4.17.1.2 Effect of vermicompost on the nitrogen content in the postharvest soil of summer onion field.

A statistically significant variation was observed in nitrogen concentration in postharvest soil of summer onion with different doses of vermicompost (Table 4.19). Considering the different doses of vermicompost the highest nitrogen concentration in soil (0.096 %) was recorded in V_3 (5 t ha^{-1}), which was statistically significant with V_2 (3 t ha^{-1}) and V_1 (1.5 t ha^{-1}). On the other hand, the lowest nitrogen concentration in soil (0.074%) was recorded in the V_0 treatment where no vermicompost was applied.

4.17.1.3 Effect of vermicompost on the phosphorus content in the postharvest soil of summer onion field.

A statistically significant variation was observed in phosphorus concentration in soil of summer onion field with different doses of vermicompost (Table 4.19). Considering the different doses of vermicompost the highest phosphorus concentration in soil (0.0022%) was recorded in V_3 (5 t ha^{-1}), which was significantly higher than V_2 (3 t ha^{-1}). On the other hand, the lowest phosphorus concentration in soil (0.0013%) was recorded in the V_0 treatment where no vermicompost was applied.

4.17.1.4 Effect of vermicompost on the potassium content in the postharvest soil of summer onion field.

A statistically significant variation was observed in potassium concentration in soil of summer onion with different doses of vermicompost (Table 4.19). Considering the different doses of vermicompost the highest potassium concentration in soil (0.199 %) was recorded in V_3 (5 t ha^{-1}), which was significantly differed with V_2 (3 t ha^{-1}) and V_1 (1.5 t ha^{-1}). On the other hand, the lowest potassium concentration in soil (0.098 %) was recorded in the V_0 treatment where no vermicompost was applied.

4.17.1.5 Effect of vermicompost on the sulphur content in the postharvest soil of summer onion field.

A statistically significant variation was observed in sulphur concentration in the postharvest soil of summer onion with different doses of vermicompost (Table 4.19). Considering the different doses of vermicompost the highest sulphur concentration in soil (0.0022 %) was recorded in V_3 (5 t ha^{-1}) treatment. On the other hand, the lowest sulphur concentration in soil (0.0017 %) was recorded in the V_0 treatment where no vermicompost was applied.

4.17.1.6 Effect of vermicompost on the pH in the postharvest soil of summer onion field.

A statistically significant variation was observed in the soil pH of the postharvest soil of summer onion field with different doses of vermicompost (Table 4.19). Considering the different doses of vermicompost the highest pH 6.13 in the postharvest soil was recorded in V_3 (5 t ha^{-1}) which was similar to the V_2 (3 t ha^{-1}) treatmeant. On the other hand, the lowest pH in postharvest soil (5.40) was recorded in the V_0 treatment where no vermicompost was applied and which was similar to the V_1 (1.5 t ha^{-1}) treatmeant.

4.17.2 Effect of chemical fertilizers on the organic carbon, nutrient status of the postharvest soil and pH of summer onion field.

4.17.2.1 Effect of chemical fertilizers on the organic carbon content in the postharvest soil of summer onion field.

The effect of different doses of chemical fertilizers showed a statistically insignificant variation in the organic carbon content in the postharvest soil of summer onion field (Table 4.20). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest organic carbon content (1.166%) which was statistically similar to the other treatments. The lowest organic carbon content (0.9459%) was observed in the treatmeant where no fertilizer was applied (F_0).

4.17.2.2 Effect of chemical fertilizers on the nitrogen content in the postharvest soil of summer onion field.

The effect of different doses of chemical fertilizers showed a statistically insignificant variation in the nitrogen concentration in postharvest soil (Table 4.20). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest nitrogen concentration (0.087 %) in soil, which was similar to the other treatments. The lowest nitrogen concentration (0.080 %) in soil was observed in the treatment where no fertilizer was applied (F_0).

Table 4.20 Effect of chemical fertilizers on the organic carbon, total N, available P, available K, available S content and P^H of the postharvest soil.

Fertilizers	Org. Carb %	Total N %	Avail. P %	Avail. K %	Avail. S %	Soil pH
F_0	0.945	0.081	0.0012 c	0.511	0.0015 b	5.10 b
F_1	1.133	0.089	0.0020 b	0.560	0.0020 a	5.59 b
F_2	1.166	0.087	0.0021 a	0.450	0.0021 a	6.17 a
Level of Significance	NS	NS	0.01	NS	0.01	0.05

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

4.17.2.3 Effect of chemical fertilizers on the phosphorus content in the postharvest soil of summer onion field.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the phosphorus concentration in the soil of summer onion field (Table 4.20). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest phosphorus concentration (0.0021 %), which statistically differed from other treatments. The lowest phosphorus concentration (0.0012 %) in soil was observed in the treatment where no fertilizer was applied (F_0).

4.17.2.4 Effect of chemical fertilizers on the potassium content in the postharvest soil of summer onion field.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the potassium concentration in soil of summer onion field (Table 4.20). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest potassium concentration (0.185 %) in soil. The lowest potassium concentration (0.092 %) in soil was observed in the fertilizer combination F_0 where no fertilizer was applied.

4.17.2.5 Effect of chemical fertilizers on the sulphur content in the postharvest soil of summer onion field.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the sulphur concentration in soil of summer onion field (Table 4.20). Among the different combinations of fertilizer doses, F_2 (High NPKS) showed the highest sulphur concentration (0.0021 %) in soil, which was statistically similar with F_2 (Medium NPKS). The lowest sulphur concentration (0.0015 %) in soil was observed in the treatment where no fertilizer was applied.

4.17.2.6 Effect of chemical fertilizers on the pH in the postharvest soil of summer onion field.

The effect of different doses of chemical fertilizers showed a statistically significant variation in the pH of the postharvest soil of summer onion field (Table 4.20). Among the different doses of fertilizer dose, F_2 (High NPKS) showed the highest value of soil pH (6.17). The lowest pH in the soil (5.10) was observed in the treatment where no fertilizer was applied and which was similar to the fertilizer dose of F_1.

4.17.3 Combined effect of vermicompost and NPKS fertilizers on the organic carbon, nutrient status of the postharvest soil and pH of summer onion field.

4.17.3.1 Combined effect of vermicompost and NPKS fertilizers on the organic carbon content in the postharvest soil of summer onion field.

Significant effect of combined application of different doses of vermicompost and fertilizer on the the organic carbon content in the postharvest soil of summer onion field (Table 4.21). The highest organic carbon content (1.273 %) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS) in soil which was similar to the other treatmeants except V_1F_0. On the other hand, the lowest carbon content (0.6947 %) in soil was found in V_1F_0 treatment. Organic carbon content in the postharvest soil showed increase when vermicompost and chemical fertilizers at higher doses were added in the soil.

4.17.3.2 Combined effect of vermicompost and chemical fertilizers on the nitrogen content in the postharvest soil of summer onion field.

Significant effect of combined application of different doses of vermicompost and fertilizer on the nitrogen concentration was observed in postharvest soil of summer onion (Table 4.21). The highest nitrogen concentration (0.106 %) was recorded in the treatment combination with V_3F_2 (High vermicompost + High NPKS) treatment. On the other hand, the lowest nitrogen concentration (0.06 %) in soil was found in V_0F_2 (No vermicompost+ High NPKS) treatment.

Table 4.21 Combined effect of vermicompost and NPKS fertilizers on the organic carbon, total N, available P, available K, available S contents and P^H of the postharvest soil.

Vermicompost × NPKS Fertilizers	Org. Carb %	Total N %	Avail. P %	Avail. K %	Avail. S %	Soil pH
V_0F_0	0.986 a	0.077 c	0.0010 h	0.070 i	.0015 g	5.35 e
V_0F_1	1.065 a	0.085 bc	0.0013 g	0.100 g	.0017 f	5.42 d
V_0F_2	1.087 a	0.060 d	0.0015 f	0.123 f	.0019 e	5.94 d
V_1F_0	0.947 b	0.080 bc	0.0012 g	0.082 hi	0.0014 g	5.60 c
V_1F_1	1.101 a	0.085 bc	0.0019 e	0.151 e	0.0019 de	5.78 c
V_1F_2	1.119 a	0.087 bc	0.0021 d	0.174 d	0.0020 de	5.90 b
V_2F_0	1.031 a	0.083 bc	0.0013 g	0.093 gh	0.0015 fg	5.46 c
V_2F_1	1.135 a	0.088 bc	0.0022 c	0.165 de	0.0021 cd	6.15 b
V_2F_2	1.184 a	0.094 ab	0.0024 b	0.192 c	0.0022 bc	6.18 b
V_3F_0	1.072 a	0.084 bc	0.0015 f	0.123 f	0.0017 f	5.97 ab
V_3F_1	1.233 a	0.097 ab	0.0024 b	0.221 b	0.0024 ab	6.19 ab
V_3F_2	1.273 a	0.106 a	0.0026 a	0.252 a	0.0025 a	6.30 a
Level of Significance	NS	0.01	0.01	0.01	0.01	0.05

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

4.17.3.3 Combined effect of vermicompost and chemical fertilizers on the phosphorus content in the postharvest soil of summer onion field.

Significant effect of combined application of different doses of vermicompost and fertilizers on the phosphorus concentration was observed in soil of summer onion field (Table 4.21). The highest phosphorus concentration (0.0026 %) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS) in the postharvest soil. On the other hand, the lowest phosphorus concentration (0.0010 %) in soil was found in V_0F_0 (No vermicompost+ High NPKS) treatment.

4.17.3.4 Combined effect of vermicompost and chemical fertilizers on the potassium content in the postharvest soil of summer onion field.

Significant effect of combined application of different doses of vermicompost and fertilizers on the potassium concentration was observed in soil of summer onion (Table 4.21). The highest potassium concentration (0.252 %) in soil was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS). On the other hand, the lowest potassium concentration (0.070 %) in the postharvest soil was found in V_0F_0 treatment.

4.17.3.5 Combined effect of vermicompost and chemical fertilizers on sulphur content in the postharvest soil of summer onion field.

Significant effect of combined application of different doses of vermicompost and fertilizers on the sulphur concentration was observed in soil of summer onion (Table 4.21). The highest sulphur concentration (0.0025 %) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS) in soil, which was similar to V_3F_1 (0.0024 %). On the other hand, the lowest sulphur concentration (0.0015%) in soil was found in V_0F_0 (No vermicompost+ No NPKS) treatment.

4.17.3.6 Combined effect of vermicompost and NPKS fertilizers on the pH in the postharvest soil of summer onion field.

Significant effect of combined applications of different doses of vermicompost and fertilizers on the pH of postharvest soil was observed in the field of summer onion crop (Table 4.21). The highest value of soil pH (6.30) was recorded in the treatment combination of V_3F_2 (High vermicompost + High NPKS) in soil which was similar to the V_3F_1(High vermicompost + Medium NPKS) and V_2F_2 (Medium vermicompost + High NPKS). On the other hand, the lowest value of soil pH (5.35) was found in V_0F_0 (No vermicompost + No NPKS). Combined application of vermicompost and fertilizers at high doses showed increase pH of the postharvest soil.

Chapter 5
Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Sher-e-Bangla Agricultural University Farm Dhaka 1207 (Tejgaon series under AEZ No.28) during the summer season of 2007 to study the effect of "Combined application of vermicompost and NPKS on the yield of summer onion".The soil was silty clay loam in texture having pH 6.0 and organic matter content of 0.88%. Randomized complete block design was followed with 12 treatments having unit plot size of 2m x 2m ($4m^2$) avd replicated thrice. The treatments were V_0F_0 Control (No vermicompost + No NPKS), V_0F_1 (No vermicompost + Medium NPKS), V_0F_2 (No vermicompost + High NPKS), V_1F_0 (Low vermicompost + No NPKS), V_1F_1 (Low vermicompost + Medium NPKS), V_1F_2 (Low vermicompost + High NPKS), V_2F_0 (Medium vermicompost + No NPKS), V_2F_1 (Medium vermicompost + Medium NPKS), V_2F_2 (Medium vermicompost + High NPKS), V_3F_0 (High vermicompost + No NPKS) and V_3F_1 (High vermicompost + Medium NPKS), V_3F_2 (High vermicompost + High NPKS).

Nitrogen from urea, P from TSP, K from Muriate of potash and S from Gypsum were used. Three rates of each of NPK and S were be used. The rates of N were be 0, 60 kg N ha^{-1} (Half of the recommended dose) and 120 kg N ha^{-1} (Full of the recommended dose). The rates of P were be zero, 22 kg P ha^{-1} (Half of the recommended dose) and 44 kg P ha^{-1}(Full of the recommended dose).The rates K were be zero, 50 kg K ha^{-1} (Half of the recommended dose) and 100 kg K ha^{-1}(Full of the recommended dose). The rates of S were be zero, 16 kg S ha^{-1} (Half of the recommended dose) and 32 kg S ha^{-1}(Full of the recommended dose). The rates of vermicompost were be 0, 1.5, 3 and 5 t ha^{-1}.
Summer onion seeds were sown on 19th March 2007, transplanted date of seedlings was 22nd April 2007 and the crop was harvested on 23rd July 2007. The data were collected plot wise for plant height (cm), leaf length (cm),

number of leaves per plant, diameter of bulb per plant (cm), length of bulb per plant (cm), weight of single bulb, yield of bulb per hectare (t) . The post harvest soil samples were analyzed for pH, organic carbon, N, P, K and S contents. All the data were statistically analyzed following F-test and the mean comparison was made by DMRT at 5% level. The results of the experiment are stated below.

Significant variation was observed in the yield of summer onion bulb when different doses of vermicompost were applied. The highest yield of bulb (10.32 t/ha^{-1}) was recorded in V_2 (3 t ha^{-1}), which was statistically similar with V_1 (1.5 t ha^{-1}) and V_3 (5 t ha^{-1}). The lowest yield of bulb (6.96 t/ha^{-1}) was recorded in the V_0 treatment where no vermicompost was applied.

Different doses of chemical fertilizers showed significant variations in respect of yield of onion bulb. Among the different doses of fertilizers, F_2 (High NPKS) showed the highest yield of bulb (10.32 t/ha^{-1}), which was statistically identical (10.18 g) with the fertilizer dose F_1 (Medium NPKS). On the contrary, the lowest yield of bulb (7.25 t/ha^{-1}) was observed with $F_{0,}$ where no fertilizer was applied.

The combined effect of different doses of vermicompost and fertilizers on the yield of summer onion bulb was significant. The highest yield of bulb (12.06 t/ha^{-1}) was recorded with the treatment combination of V_3F_1 (High vermicompost + Medium NPKS), which was statistically identical (11.82 t/ha^{-1}) with the fertilizer dose V_2F_2 (Medium vermicompost + High NPKS). The lowest yield of bulb (5.800 t/ha^{-1}) was found in V_0F_0 treatment (No vermicompost and No NPK).

The N, P, K and S contents in onion plant, bulb and postharvest soil of summer onion were influenced significantly by the application of vermicompost and chemical fertilizers.

The highest N, P, K and S contents in the onion plant were recorded in V_3F_2 (High vermicompost + High NPKS) treatment. The lowest N, P, K and S contents in plant was obtained with V_0F_0 treatment.

The highest N, P, K and S contents in onion bulb was recorded with V_3F_2 treatment. The lowest N, P, K and S contents in onion bulb was obtained with V_0F_0 treatment.

The N, P, K and S contents in the postharvest soil showed increase with increases doses of vermicompost and fertilizers. The highest N, P, K and S contents in postharvest soil was recorded in V_3F_2 (High vermicompost + High NPKS) treatment.

The organic carbon content in the postharvest soil showed increase when vermicompost and fertilizers were applied at higher combinations. The highest and the lowest organic carbon content in the postharvested soil were recorded with the V_3F_2 and V_0F_0 treatments, respectivelly.

Application of vermicompost and chemical fertilizers showed significant changes in the pH of the postharvest soil. Vermicompost and chemical fertilizers at this higher combination showed increase the pH of the postharvest soil. On the other hand, the control treatment V_0F_0 showed a decrease in the pH of the postharvest soil.

Based on the results of the present study, the following conclusions may be drawn:-

- ❖ The combined application of vermicompost and chemical fertilizers (NPKS) showed higher yield of summer onion than their individual applications.

- ❖ Organic carbon content in the post harvest soil showed increase with combined application of vermicompost and chemical fertilizers which will help to maintain the fertility status of the soil and improve the physical properties of the soil.

- ❖ Combined application of vermicompost and chemical fertilizers check the development of acidity in the soil.

However, to reach a specific conclusion and recommendation, more research work on yield of summer onion should be done in different Agro-ecological zones of Bangladesh.

References

CHAPTER 6

REFERENCE

Amin, M.R. (1985). Effect of potash and nitrogen on the growth and yield of onion (*Allium cepa L.*). M. Sc. (Ag) Thesis. Dept. of Hort. B.AU. Pp.15-16.

Anon. (2000). Production technology of onion BARI Peaj-2 and 3 (in Bengali) leaflet. Spices Research Centre, BARI, Bogra. pp. 1-4.

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

Baloch, M.A., Baloch, A. F., Baloch, G., Ansari, A.H. and Qayyum, S.M (1991). Growth and yield response of onion to different nitrogen and potassium fertilizer combination levels. *Sarhad J. Agri.*, **7(2)**: 63-66.

BBS (2004). Yearbook of Agricultural Statistics of Bangladesh. 1999. (14^{th} Ed.) Bangladesh Bureau of Statistics. Statistics Division. Ministry of Planning, Govt. of the Peoples Republic of Bangladesh. Dhaka. P. 70.

Bereniewiez, A. and Nowosiecksi, O. (1986). Effect of increasing rate of mineral fertilizer with simultaneous application of organic fertilizers and liming on vegetable yield and soil salinity. Biuletyn Warzywniczy. **26(2)**:41-62.

Black, C.A. (1965). Methods of Soil Analysis, Part I and part II, *Am. Soc. Agron. Inc. Madison*, Wisconsin, USA. pp. 1149-1178.

Blickwedel, P. and Mach, R. 1983. Treatment of wastes using earthworms. *Biocycle.* **24** (1): 40-42.

Brewster, L. J. (1994). Onion and other Vegetable Alliums. CAB International, UK. p.5.

Chee, L. C., Garcia, C., Ferrera, R. And Cerrato, R. (1998). Onion biofertilization with vermicompost and arbuscular mycorrhizae. Universidad Autonoma Chapingo, 56230 Chapingo, Mexico. Annual International Meeting, Orlando, Florida, USA, 12-16-July.

Chowdappa, P., Biddappa, C. C. and Syjatha, S. (1999). Efficient recycling of organic waste in Arecanut (*Areca catechw*) and coco (*Thedroma cacao*) plantation through vermicomposting. *Indian J. Agril. Sci.* **96 (8)**: 563-566.

Das, P. K., Jen, M. K. and Sahoo, K. C. (2002). Effect of integrated application of vermicompost and chemical fertilizer on growth and yield of paddy in red soil of South Eastern Ghat Zone of Orissa. Environment and Ecology. **20 (1)**: 13-15.

Day, P.R. 1965. Particle fractionation and particle size analysis. In methods of soil analysis, Part-1,C.A. Black, (ed), American Society of Agronomy, Inc., Madison, Wisconsir, USA. pp.548-577.

Deho, N. A., Wagan, M. R., Baloach, M. K., Rajpar, I. and Keerio, M. I. (2002). NPK trial on onion (*Allium cepa L.*). Department of Horticulture, Faculty of Crop Production, Sindh Agriculture University, Tando Jam, Sindh, Pakistan. *Pakistan J. Applied Sci.* **2(8)**: 820-821.

Devi, A. K. B., Limi, A. and Singh, N. G. (2003). Effects of inorganic and biofertilizers on bulb yield and economics of multiplier onion (*Allium cepa L.* var. aggregatum Don). College of Agriculture, Central Agricultural University, Imphal, Manipur - 795 004, India. News Letter National Horticultural Researc and Development Foundation. **23(3)**: 1-3.

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

Duque, M. C. M., Perdomo, G. C. E. and Jaramillo, V.J. (1989). Studies on the growth and nitrogen, phosphorus and potassium uptake in onion, *Allium cepa L.*, cultivar Ocanera. Acta Agronomica, Universidad Nacional de Colombia. **39(3-4)**:45-53.

Dusserre, C. (1992). On the effect of earthworm on the chemical condition of soil. *Landw J. B. Schweiz.* **16**: 75-78.

Edwards, C. A. and Bohlen, P. J. (1996). Biology and Ecology of Earthworms. Capman and Hall, London.

FAO. (2003a). Yearbook. Food and Agricultural Organization of the United Nations, Rome, Italy. 57:154.

FAO. (2003b). Yearbook. Food and Agricultural Organization of the United Nations, Rome, Italy. 55:153.

FAO. (2003c). Yearbook. Food and Agricultural Organization of the United Nations, Rome, Italy. 57:133.

Gaur, A. C., Sadasivam, K. V., Vimal, O. P. and Mathur, R. S. (1971). A study of the decomposition of organic matter in and alluvial soil, CO_2 evolution , microbiological and chemical transformations. Plant and Soil. **35**: 17-28.

Geetha, K., Raju, A. S., Rao, P. C. and Reddy, M. S. (2000). Effect of individual and combined application of FYM and potash fertilizer on yield and potash nutrition of onion in Alfisol. Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, Hyderabad 30, *India. J. Res. ANGRAU.* **29(4)**: 34-39.

Geetha, K., Raju, A. S., Rao, P. C. and Reddy, M. S. (1999). Effect of individual and combined application of FYM and potash fertilizer on yield and potash nutrition of onion in Alfisol. Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, Hyderabad 30, *India. J. Res. ANGRAU.* **29(4)**: 34-39.

Green, D. J., Cleaver, T. J. Turner, M. K., Niendorf, K.B. and Vimal, S. M. H. (1980). Comparison of the effect of potassium content and quality of 22 different vegetables and Agril. Crops. *J. Agril. Sci.* **19**: 441.

Gunjan, A., Paliwal, R. and Sarolia, D.K. (2005). Effect of nitrogen and bio-fertilizer on yield and quality of rabi onion (*Allium cepa L*) cv. Puna Red. Department of Horticulture, S K N College of Agriculture, Jobner-303 329, India. *J. Agric. Sci. Digest.* **25(2)**: 124-126

Guptta, G. S. S. and Gaffar, M. A. (1981). Effect of row spacing and different combinations of NPK fertilizer on the yield of onion. Bangladesh Hort., **8(2)**: 8-12.

Gupta, R. P., Sharma,V. P., Singh, D. K. and Srivastava, K. J. (1999). Effect of organic manures and inorganic fertilizers on growth, yield and quality of onion variety Agrifound Dark Red. Regional Research Station Salaru, Karnal (Haryana), India. News Letter National Horticultural Research and Development-Foundation. **19(2/3)**: 7-11.

Guo Xi Sheng, Li Cai,Y. and Wen Jun, W. (1999). The effect of K fertilizer on the yield, qualities and nutrient uptake of onion. Soil and Fertilizer Institute, Anhui Academy of Agricultural Sciences, Hefei 230031, China. China Vegetables. **(2)**: 12-14.

Halder, N K., Zaman, M W U., Chowdhury, M M U., Ullah, M H., and Nag, B. L. (1998). Effect of nitrogen and phosphorus on the uptake of different nutrient elements by onion bulb. Department of Soil Science (Agril. Chemistry), BAU, Mymensingh. *Bangladesh J. of Sci.* Ind. Res. **33(3)**: 404-408.

Harris, G. (1990). Use of earthworm biotechnology for the management of effluents from intensively housed livestock. Out look on Agriculture, **180 (2)**: 72-76.

Harun or Rashid, A. R. M. (1998). Effect of NPKS on the growth and yield of onion at different plant spacing. MS thesis, Dept. Hort., Bangladesh Agril.Univ. Mymensingh. 72p.

Hedge, D. M. (1988). Effect of irrigation and nitrtogen fertilization on yield, quality, nutrient uptake and water use of onion (*Allium cepa L.*). *Singapore J. Primary Ind.* **16(2)**:111-123.

Jablonska C. R., Rosa, R. and Zaniewicz B. A. (2002). Fertilization value of papilionaceous plants in the cultivation of white cabbage and onion. Pt. 1. Yield. University of Podlasie, Siedlce (Poland). Dept. of Vegetable Crops.

Jackson, M. L. (1958). Soil Chemical Analysis. Cinstable and co. ltd. London.

Jiang, Q., Zhang, H. A., Jiang, Q. S. and Zhang, H. L. (1998). Application of potassium fertilizer in onion production. China-Vegetables. Liangshan Agricultural Bureau, Liangshan, Shandong 272600, China. No. 4, 38.

Jitendra, S., Dhankhar, B. S. and Sing, j. (1991). Effect of nitrogen, potash and zinc on storage loss of onion Bulbs (*Allium cepa L.*). Vegetable Science, **18(1)**:16-23.

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

Khandal, D. K. and Nagendra, B. B. N. (2002). Effect of vermicompost of Eichhrnia on two cultivars of wheat. *J. Eco Physiol.* **5(3-4)**: 143-148.

Kumari, M. S., Kumari and S. K. U. (2002). Effect of vermicompost enriched with rockphosphate on growth and yield of cowpea (*Vigna unguiculata* L. Walp). *J. Ind. Soc. Soil Sci.* **50 (2)**: 223-224.

Madan, S. P. S. and J.S. Sandhu. (1985). Influence of nitrogen, phosphorus and potash levels on the growth, bulb yield and dry matter production of white onion variety Punjab-48. Punjab Vegetable Growers, **20**: 17-24.

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

Marinari, S., Masciandaro, G., Cenccanti, B. and Grego, S. (2000). Influence of organic and organic fertilizers on soil biological and physical properties. Bioresource Technology. **72(1)**: 9-17.

Miah, M. M. U. (1994). Prospects and problem of organic farming in Bangladesh. Paper presented at the workshop on integrated Nutrient Management for sustainable Agriculture held at SRDI, Dhaka, June 26-28.

Mohanty, B.K. and Das, J.N. (2001). Response of *rabi* onion cv. *Nasik Red* to nitrogen and potassium fertilization. Vegetable-Science. University of Agriculture and Technology, Regional Research Station, Bhawanipatna 766 001, Orissa, India. **28**: 1, 40-42; 5 ref.

Mossa, j. S. (1985). Onion adiabetic drug. International *J. Crude Drug Res*, **23:3**:137-145.

Nagaich, K. N., Trivedi, S. K., Rajesh, L. and Lekhi, R. (1998). Effect of sulphur and potassium fertilization in onion (*Allium cepa* L.). South-Indian-Horticulture. **46 (3-6)**:266-271.

Nagaich, K. N., Trivedi, S. K., Rajesh, L. and Lekhi, R. (1999). Effect of sulphur and potassium fertilization in onion (*Allium cepa* L.). *Horticultural J.* **12(1)**: 25-31.

Nasreen, S. and Hossain, A. K. M. (2000). Influence of chemical fertilizes and organic manure on the growth and yield of onion. *Bangladesh J. Agril. Res*. **25(2)**: 221-231.

Nasreen, S., Farid, A. T. M. (2002). Dry matter production and yield of onion as influenced by sulphur fertilization. Bangladesh Agricultural Research Inst., Gazipur (Bangladesh). *Division of Soil Sci. J. Agri. Res. (Pakistan)*. (Jul-Dec 2002). v. 40(3-4) p. 205-214.

Nasiruddin, K. M., Mondal, M. F., Farooque, A. M. and Baten, M. A. (1993). Effect of potassium and sulphur on growth and yield of onion. *Bangladesh J. Agril. Sci.* **20(1)**:35-40.

Olsen, S.R.; Cole, C.V.; Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Agric. Circ. p. 929.

Pandey, U. B., Singh, R. Kumar, A. and Raychaudhury, S.P. (1990). Response of different levels of N, P, K on the yield and quality of *kharif* onion. Recent Advances in Medicinal, Aromatic and spice Crops. **1**:231-34.

Patil, P. Y., Mahopkar, V.K. and Patil, V.K. (1983). Effect of nitrogen, phosphorus and potash on growth and yield of onion. J. Maharashtara Agric. Univ. **8 (1)**: 41-43.

Qiao, H., Wang, X., Ai Feng, Z. and Zhong Lan, G. (2005). Effects of decreasing chemical fertilizer application and applying organic fertilizer on yield and quality of welsh onion. Shanghai Key Lab of Protected Horticultural Technology, Environmental Sciences Research Institute, Shanghai Academy of Agricultural Sciences, Shanghai 201106, China. Acta-Agriculturae-Shanghai. **21(2)**: 49-52.

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

Rao, K. R. Rao, P. A. and Rao, K. T. (2000). Influence of organic manure and fertilizers on the incidence of groundnut leafminer. Approacrema Modicella Dev Annals of Plant Protection Sciences. **9 (1)**: 12-15.

Rahayu, L. S. I., Aini, N. and Santoso, M. (2002). Effect of kascing organic and urea fertilizers on the growth and yield of onion (*Allium fistulosum* L.) var.seagon. Universitas Brawijaya, Malang (Indonesia). Fakultas Pertanian Agrivita (Indonesia). **24(1)**: p. 44-50.

Rahim, M. A., Husain, A. and Siddique, M.A. (1992). Production of bulb and storage ability of three cultivars of onion. Punjab Veg. Grower, **17-18**:13-20.

Ramalingam, R. (1999). Vermicomposting of crop residue sugarcane trash using an Indian epigeic earthworm, *Perionyx encavatus. J. Experimental Zoology, India.* **4 (2)**: 267-272.

Ranwa, R. S. and Singh, K. P. (1999). Effect of integrated nutrient management with vermicompost on productivity of wheat. *Indian J. Agron.* **44 (3)**: 554-559.

Reddy, K C. and Reddy, K. M. (2005). Differential levels of vermicompost and nitrogen on growth and yield in onion (*Allium cepa* L.) - radish (*Raphanus sativus* L.) cropping system. Department of Horticulture, College of Agriculture, Rajendranagar, Hyderabad - 500 030, Andhra Pradesh, India. *J. Res. ANGRAU.* **33(1)**: 11-17.

Rizk, F. A. 1997. Productivity of onin plant (*Allium cepa* L.) as affected by method of planting and NPK application. *Egyptian J. Hort*., **24**(2): 219-238.

Robinson, C. H., Ineson, P., Piearce, T. G. and Rowland, A. P. (1992). Nitrogen mobilization by earthworm in limed peat soils under Picea sitchensis, *J. Applied Ecol.* **29**: 226-237.

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

Rudolph, M. (1986). Effect of mineral fertilization on seed yield and quality in onions (*Allium cepa* L.). Archiv fur Gartenbau. **34(5)**: 263-271.

Rostamfrodi, B., Kashi, A., Babalar, M. and Lesani, H. (1999). Effects of different amounts of urea on the nitrate accumulation and changes in phosphorus and potassium contents of leaves and bulbs of onion cultivars (*Allium cepa* L.).Faculty of Agriculture, University of Tehran, Karaj, Iran. *Iranian J. Agric. Sci.* 1999. **30(3)**: 487-493.

Saerah, R. E. A., Magid, H. M. A., Abdel, S. I. and Rabie, R. K. (1996). Optimizing physical properties of a sandy soil for higher productivity using town refuse compost in Saudi Arabia. *J. Arid. Environ.* **29 (2)**: 253-262

Saimbhi, M.S., Gill, B.S. and Sandhu, K. S. (1987). Fertilizer requirement of processing onion (*Allium cepa* L.) cv. Punjab-48. *J. Res., Punjab Agric. Univ.*, **24(3)**: 407-410.

Satyanarayana, V. and Arora, P. N. (1984). Effect of fertilizer on potato and their residual effect on succeding onion. *Indian J. Agon.*,**29 (3)**: 309-311.

Shamima, N. and Huq, S. M. I. (2005). Effect of sulphur fertilization on yield, sulphur content and uptake by onion. Division of Soil Science, BARI, Joydebpur, Gazipur - 1701, Bangladesh. *Indian J. Agric. Res.* **39(2)**: 122-127.

Sharma, R. P., Datt, N. and Sharma, P. K. (2003). Combined application of nitrogen, phosphorus, potassium and farmyard manure in onion (*Allium cepa*) under high hills, dry temperate conditions of north-western Himalayas. *Indian J. Agril. Sci.* **73(4)**: 225-227.

Singh, J. and Dhankhar, B. S. (1988). Effect of nitrogen, potash and zinc on growth, yield and quality of onion. *Indian Agric.*, **32 (3)**: 163-170.

Singh, T. Singh, S. B. and Singh, B.N. (1989). Effect of nitrogen, potassium and green manuring on growth and yield of rainy season onion (*Allium cepa* L.*). Narindra Deva J. Agric. Res.*, **4(1)**: 57-60.

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

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

Singh, A.K., Akhilesh, S. and Singh, A. (2003). Seed production of onion as influenced by potassium and its method of application. *Indian J. Horticulture*. **60(3)**: 287-289.

Sohrab, A. and Sarwar, J. M. (2001). Production of vermicompost and its use in upland and horticulture crops. Project Report of Rajshahi University.

Subbiah, K. (1994). Effect of N, P and biofertilizers on yield and nutrient uptake in chilli and bellary onion. Horticultural Research Station, Thadiyankudisai, India. Madras Agric. **J. 81(5)**: 277-279.

Sumantra, K. And Tiwari, R. S. (1997). Dept. of Vegetable Science, G.B. Pant Univ. of Agriculture and Technology, Pantnagar, Dist. Nainital-263 145 (U.P.), India. Recent-Horticulture. 1997/1998; **4**: 138-139.

Talashilkar, S. C., Bhangaraath, P. P. and Mehta, V. B. 1999. Change in chemical properties during composting of organic residues as influenced by earthworm activity.

Tolanur, S. I. And Badanur, V. P. (2003). Effect of integrated use of organic manure, green manure and fertilizer nitrogen on sustaining productivity of Rabi sorghum-chickpea system and fertility of a verisol. *J. Indian Soc. Soil Sci.*, **51 (1)**: 41-44.

Ullah, M. M. (2003). Nutrien management in summer onion. Ph.D. Thesis. Dept. of Soil Science. BSMRAU. pp.150.

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

Varu, D. K., Vhora, P. H. and Kikani, K. P. (1997). Effect of organic and inorganic fertilizers on onion. R & D Department, LMP, Gujarat Agro Exports Limited, Baroda, *India. Gujarat Agric. Univ. Res. J.* **22(2)**: 116-118.

Vasanthi, D. and Kumaraswamy, K. (1999). Effect of vermicompost to improve soil fertility and rice yield. *J. Ind. Soc. Soil Sci.* **47 (2)**: 268-272.

Vohora, S. B., Rizmana and Khan, J. A. (1974). Medicinal uses of common Indian vegetables. Planta Medica, **23(4)**:381-393.

Yadav, V. S. and Yadav,B. D. (2001). Effect of NICAST (organic manure) in comparison to recommended doses of manure and fertilizers in onion. Department of Horticulture, Agricultural Research Station, Durgapura, Jaipur - 18, India. South-Indian-Horticulture. **49**: 160-161.

Yadav, R. L., Sen N. L., Fageria M. S. and Dhaka R. S. (2002). Effect of nitrogen and potassium fertilization on quality bulb production of onion. *Haryana J. Hort. Sci.* **31**: 3-4, 297-298; 3.

Yadav, B. D., Khandelwal, R. B. and Sharma, Y. K. (2004). Use of bio-fertilizer (*Azospirillum*) in onion. Department of Horticulture, Agricultural Research Station, Durgapura, Jaipur 302 018, India. Haryana *J. Hort. Sci.* **33(3/4)**: 281-283.

Yadav, B D., Khandelwal, R. B. and Sharma, Y. K. (2005). Use of biofertilizer (*Azospirillum*) in onion. Department of Horticulture, Agricultural Research Station, Durgapura, Jaipur 302 018, India. Indian J. Hort. **62(2)**: 168-170.

Yawalkar, K. S. (1985).Vegetable Cropsin India. Agril. Horticultural Publishing House, Nagpur.288-563.

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

Zahid, H. M. (2001). Production of vermicompost and its use in upland and horticultural crops. Annual Report of Bangladesh Agricultural Research Council, Framegate, Dhaka.

APPENDICES

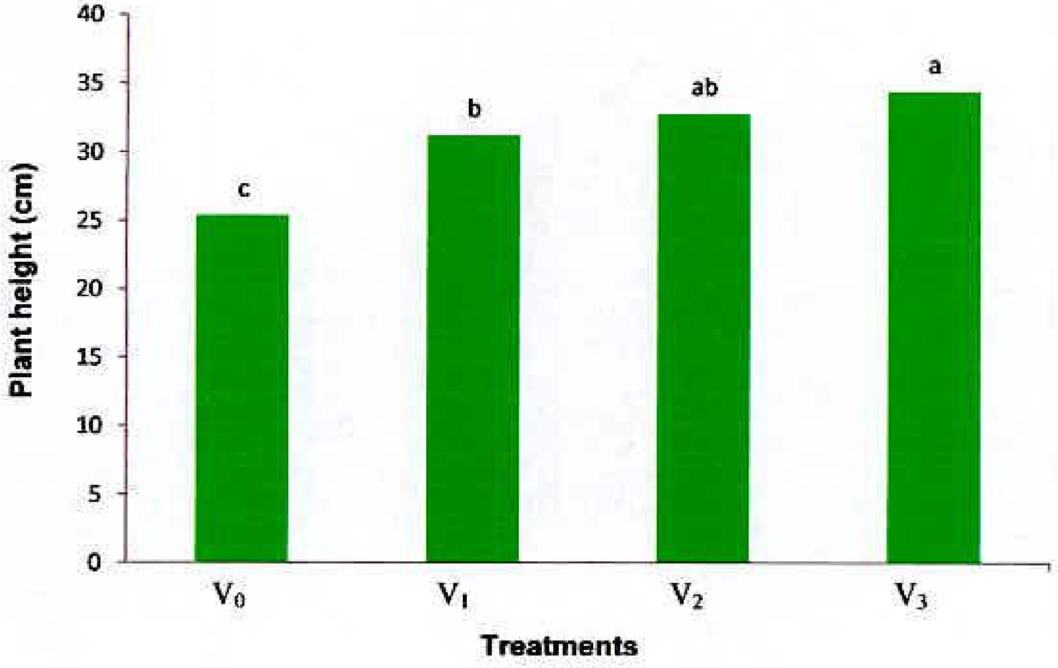


Fig. 1 Effect of vermicompost on the plant height of summer onion.

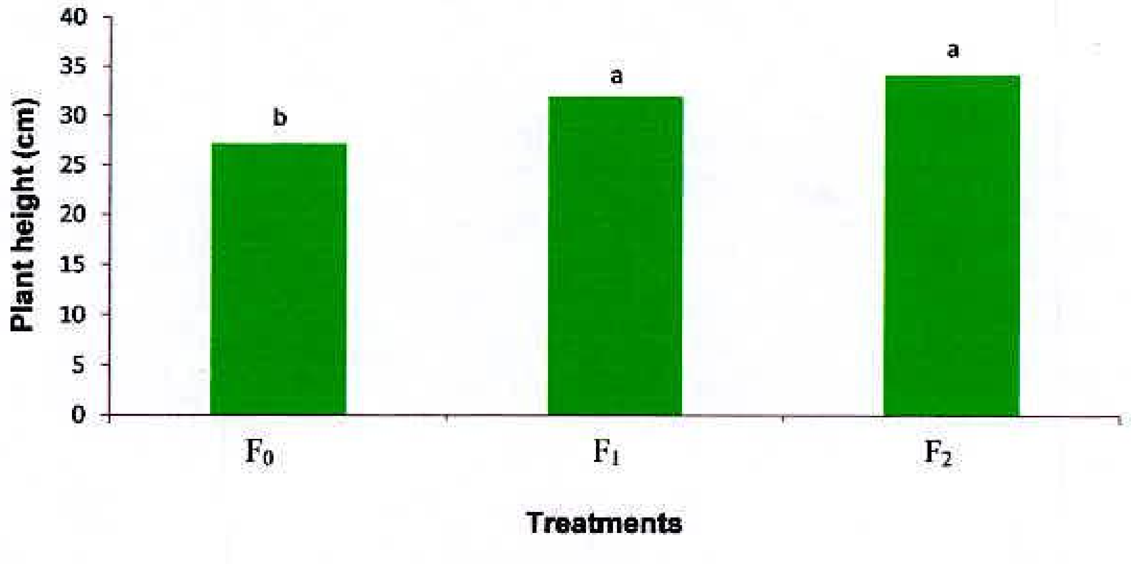


Fig. 2 Effect of chemical fertilizers on the plant height of summer onion.

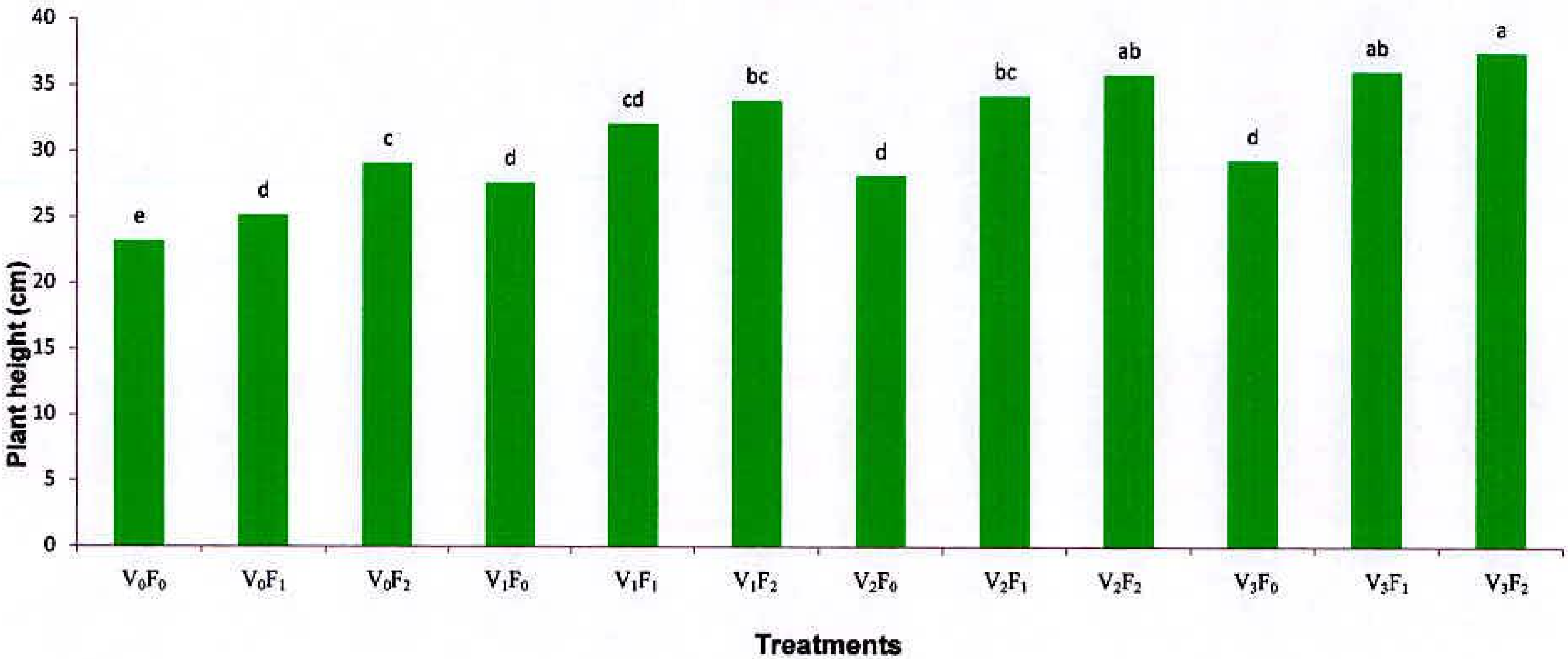


Fig. 3 Combined effect of vermicompost and different doses of chemical fertilizers (NPKS) on the plant height of summer onion.

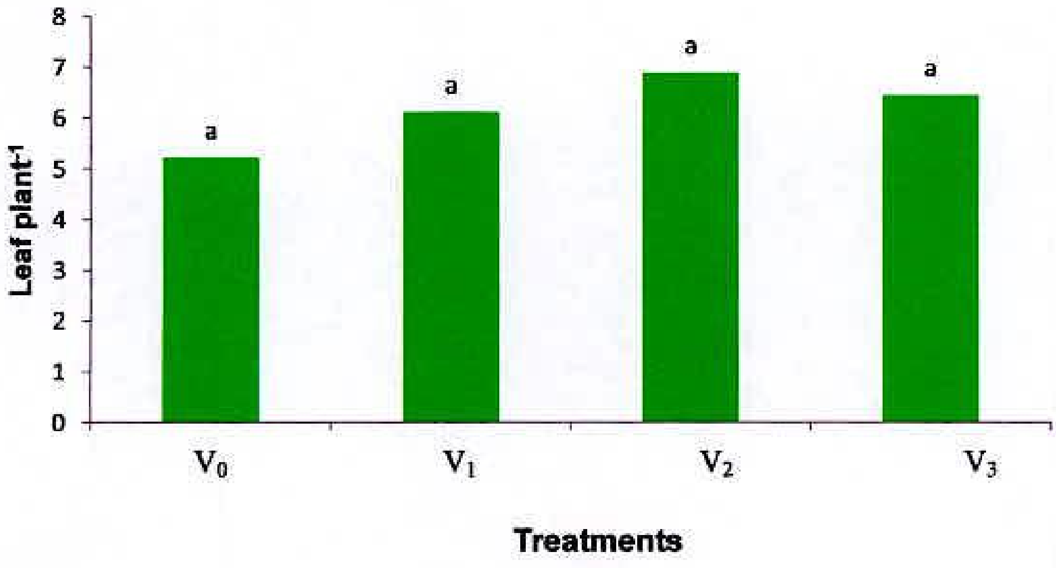


Fig. 4 Effect of different doses of vermicompost on the leaf plant^{-1} of summer onion.

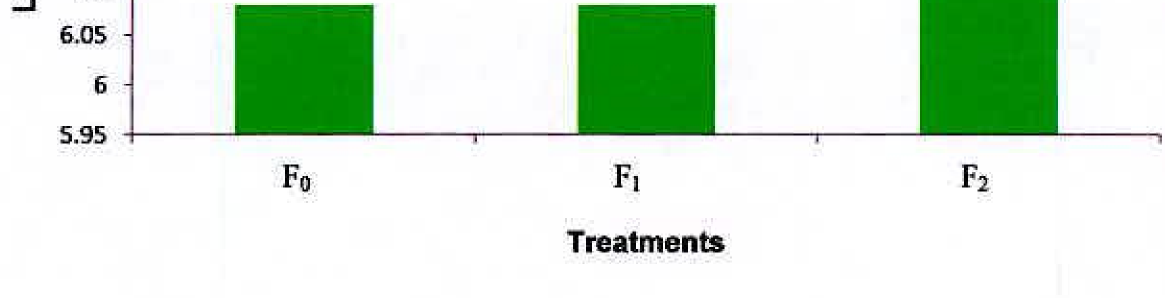


Fig. 5 Effect of different doses of chemical fertilizers on the leaf plant^{-1} of summer onion.

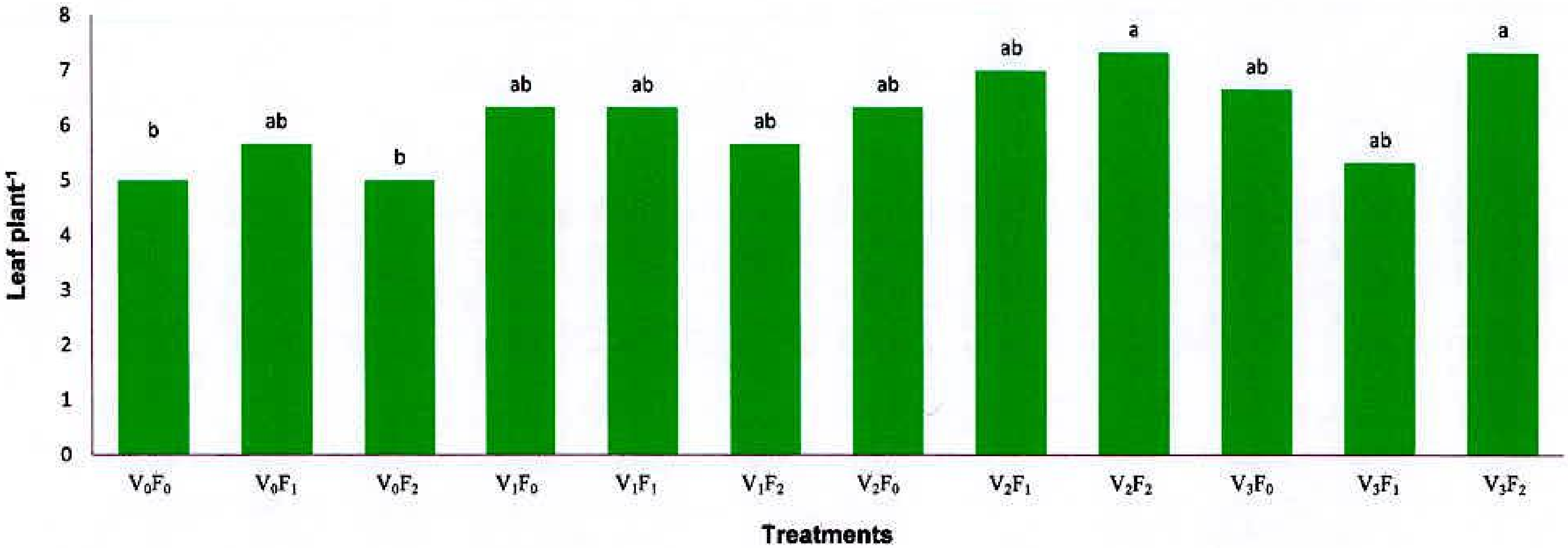


Fig. 6 Combined effect of different doses vermicompost and chemical fertilizers (NPKS) on the leaf plant^{-1} of summer onion.

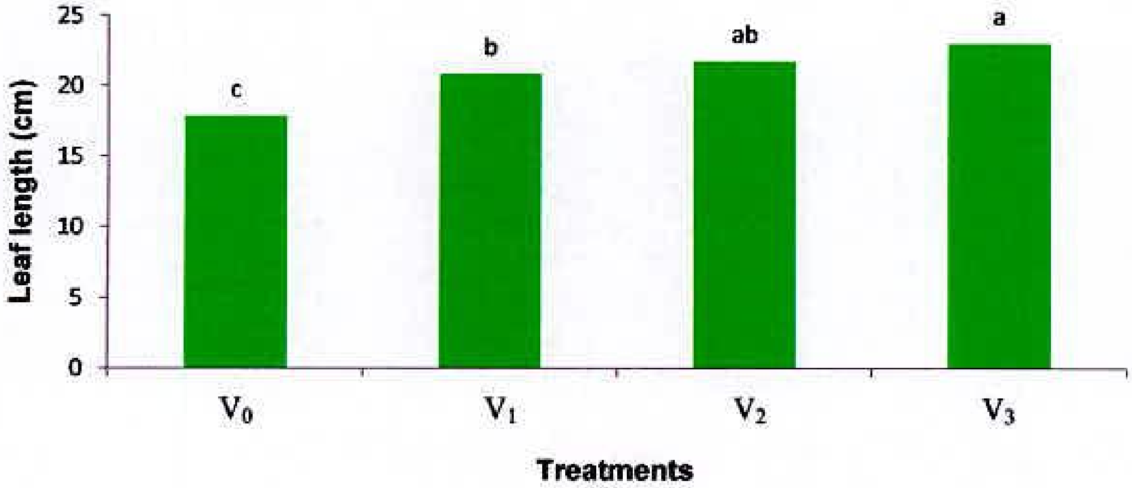


Fig. 7 Effect of different doses of vermicompost on the leaf length of summer onion.

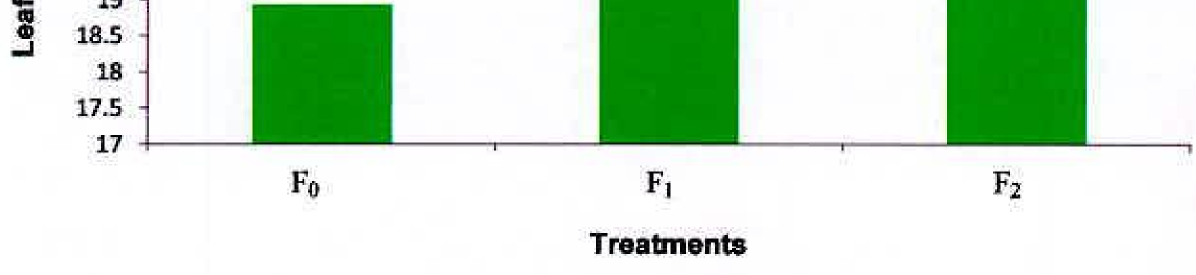


Fig. 8 Effect of different doses of chemical fertilizers (NPKS) on the leaf length of summer onion.

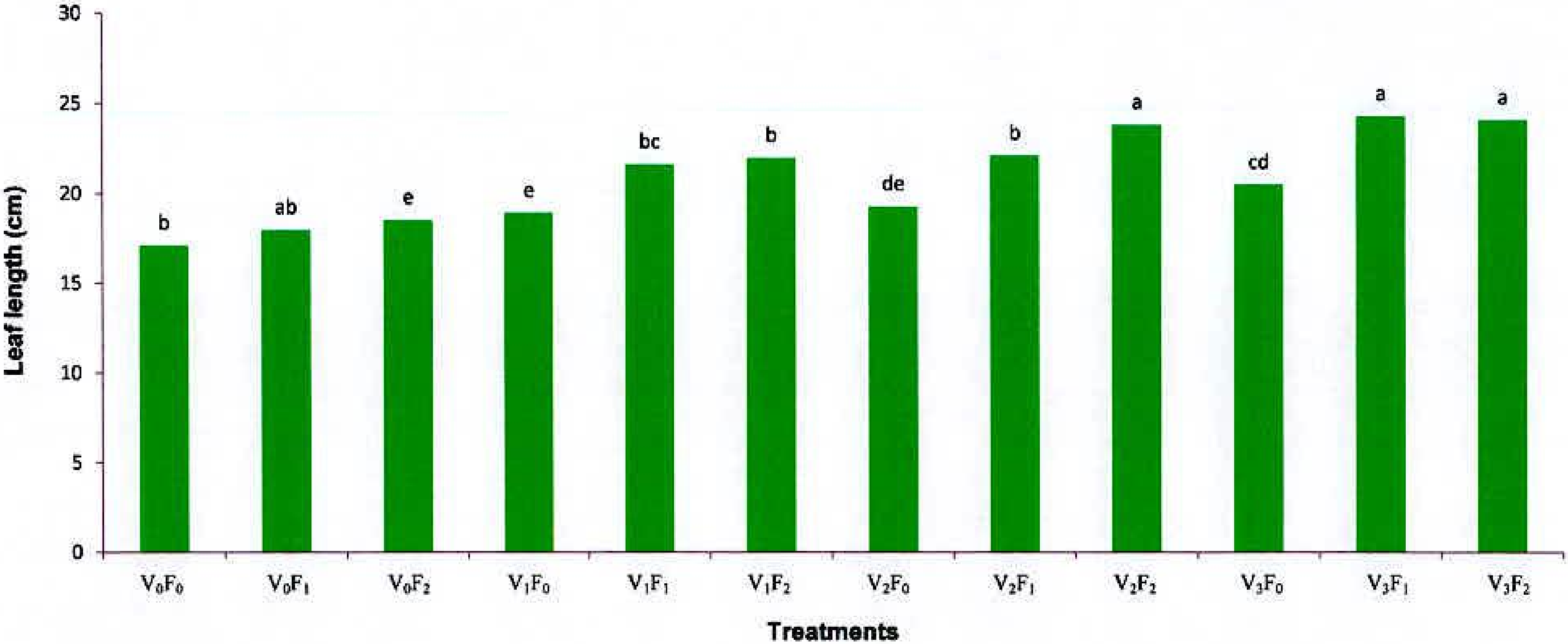


Fig. 9 Combined effect of different doses of vermicompost and chemical fertilizers (NPKS) on the leaf length of summer onion.

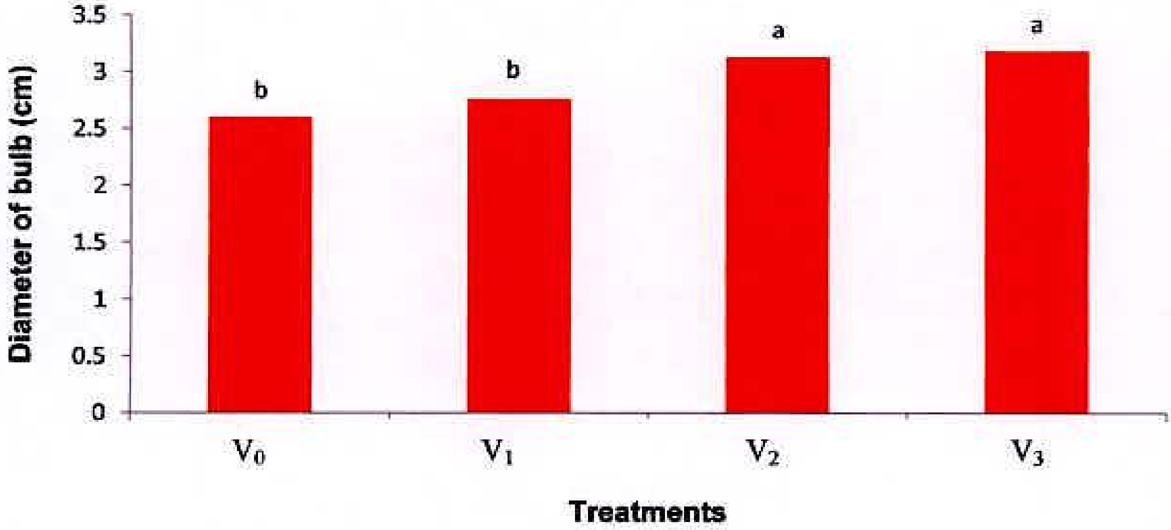


Fig.10 Effect of different doses vermicompost on the diameter of bulb per plant.

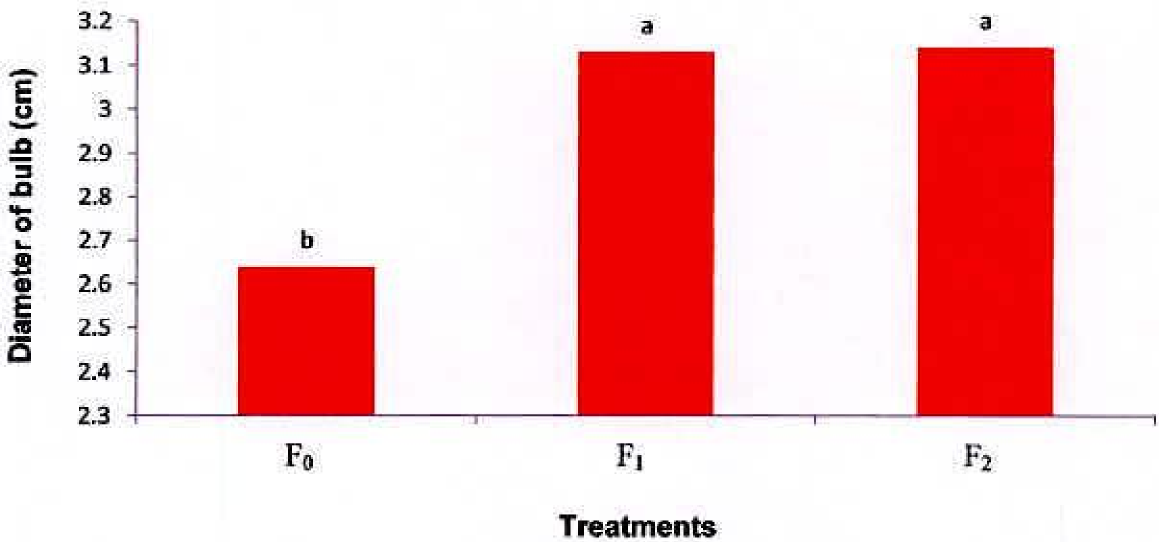


Fig. 11 Effect of different doses chemical fertilizers (NPKS) on the diameter of bulb per plant.

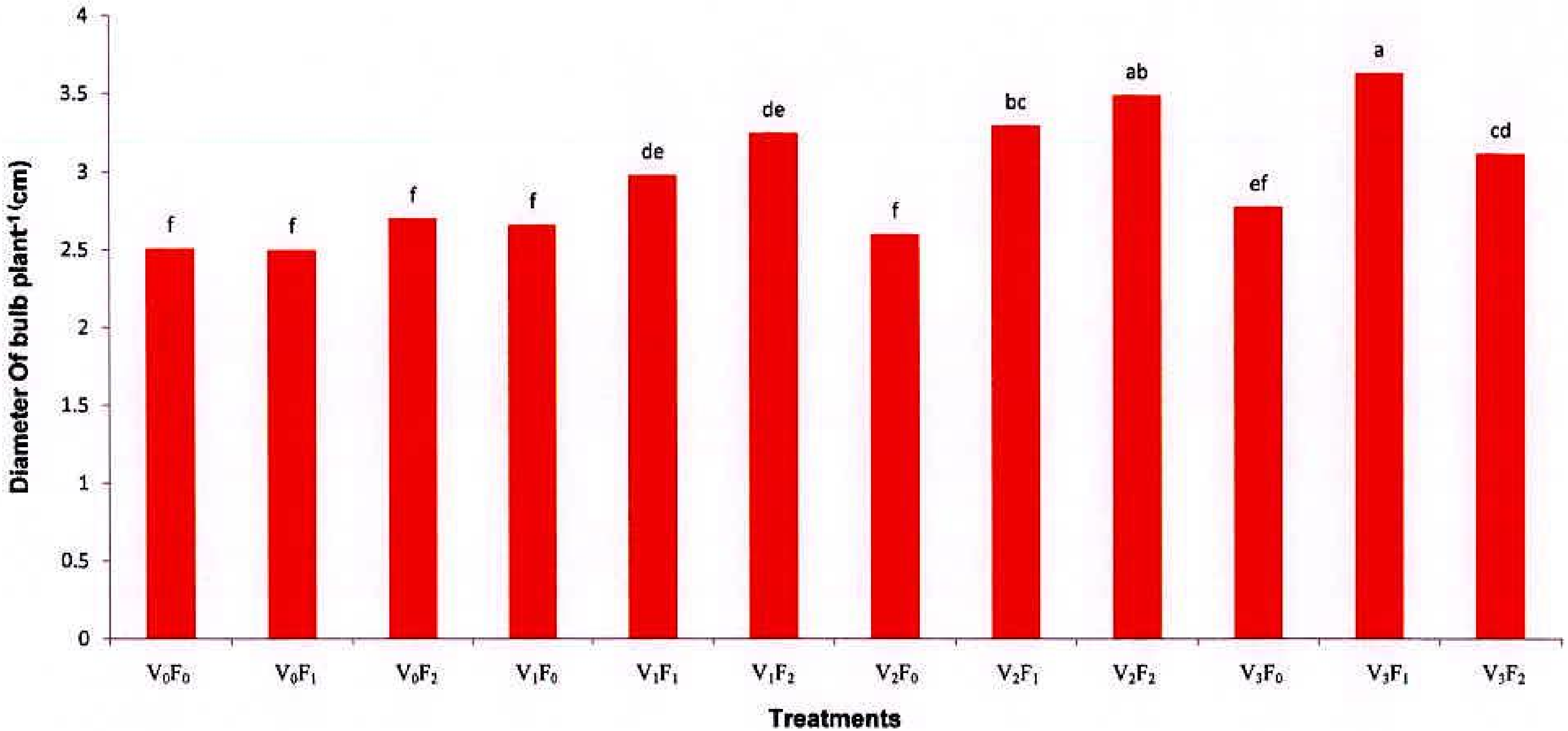


Fig. 12 Combined effect of different doses vermicompost and of chemical fertilizers (NPKS) on the diameter of bulb per plant.

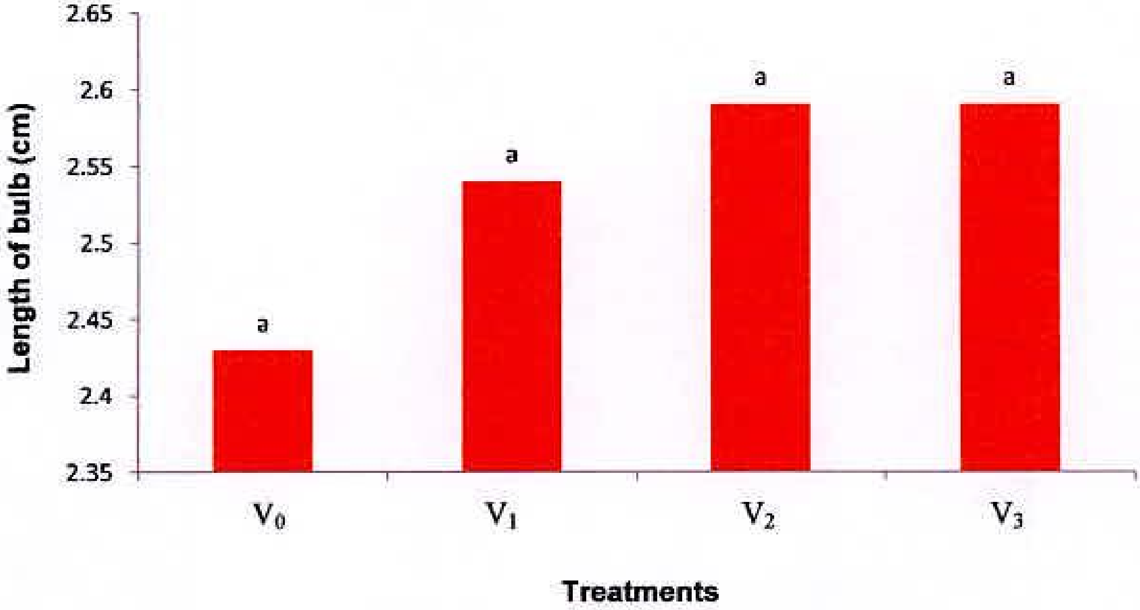


Fig. 13 Effect of different doses vermicompost on the Length of bulb of summer onion.

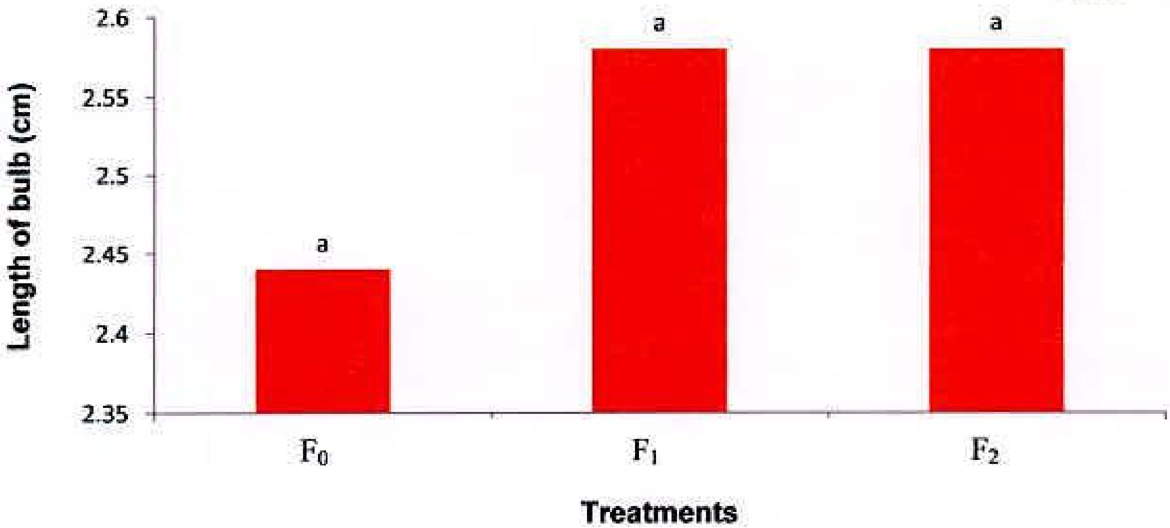


Fig. 14 Effect of different doses chemical fertilizers (NPKS) on the Length of bulb of summer onion.

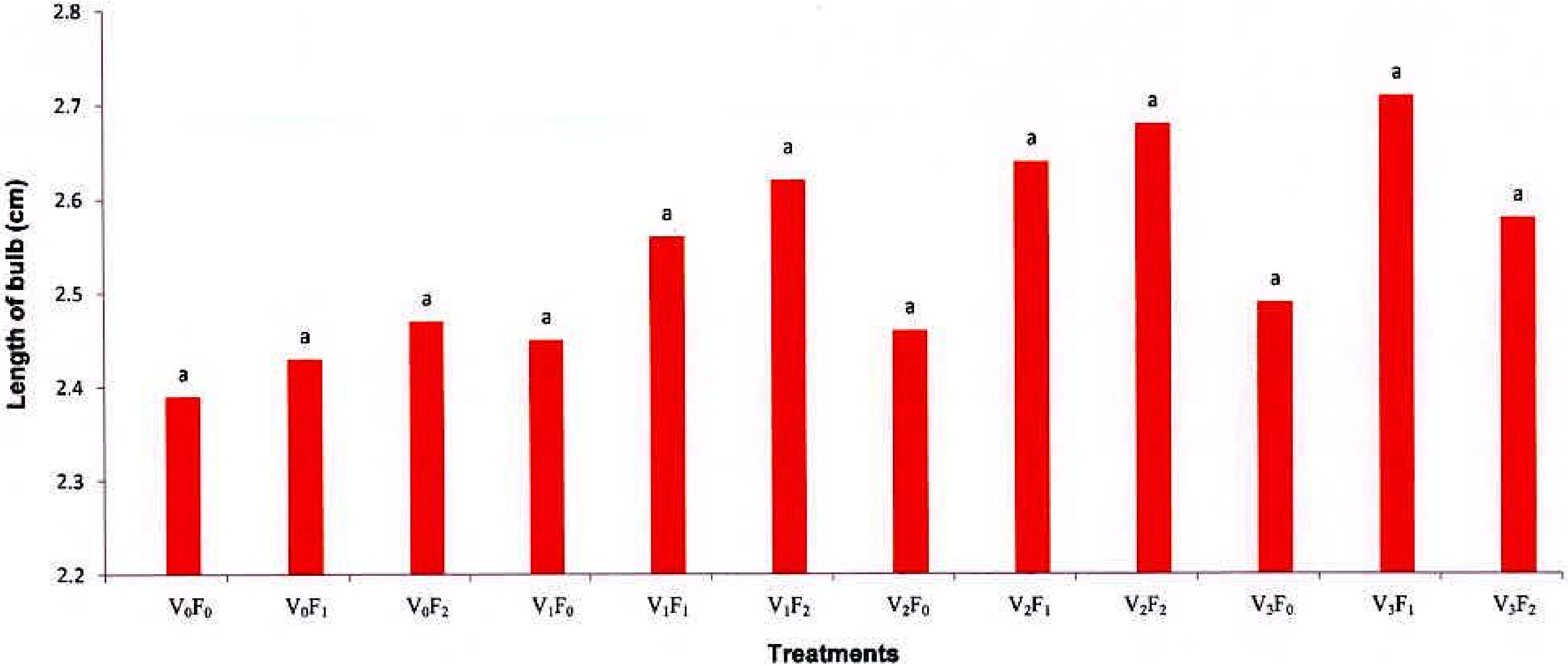


Fig. 15 Combined effect of different doses vermicompost and chemical fertilizers (NPKS) on the Length of bulb of summer onion.

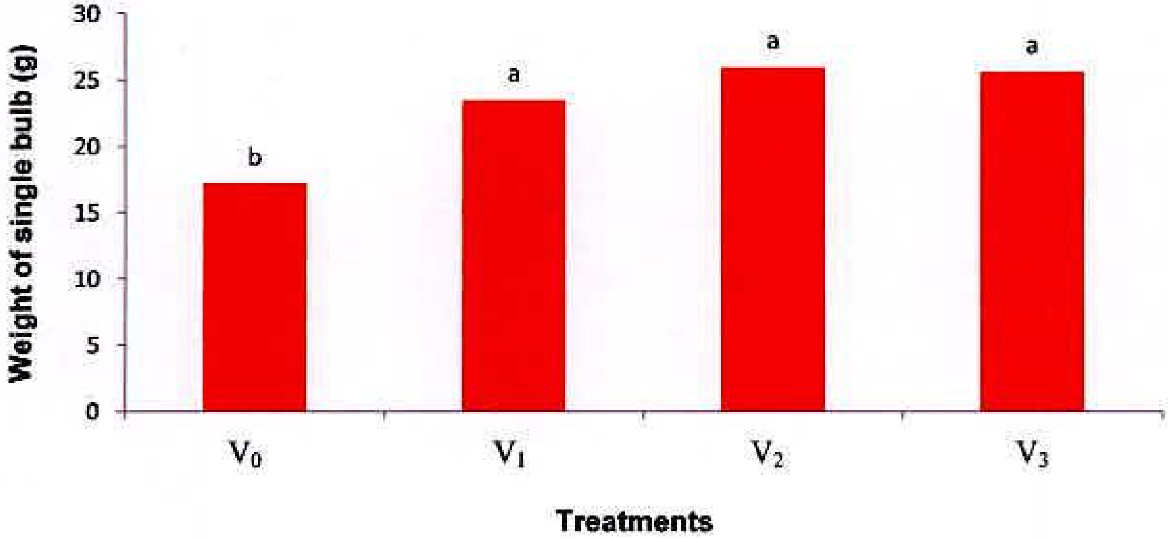


Fig. 16 Effect of different doses of vermicompost on the weight of single bulb of summer onion.

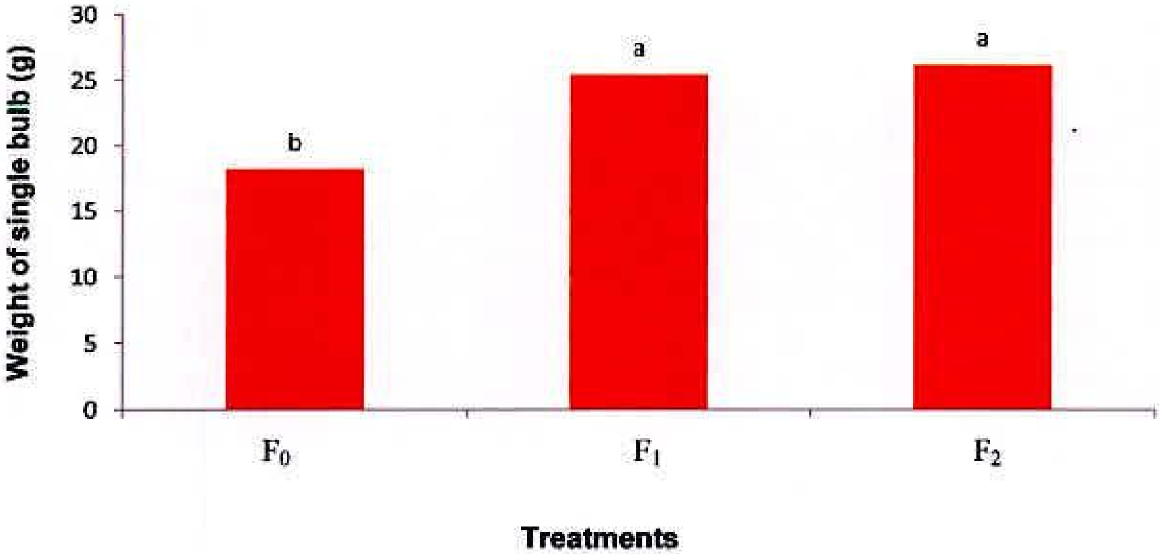


Fig. 17 Effect of different doses of chemical fertilizers (NPKS) on the weight of single bulb of summer onion.

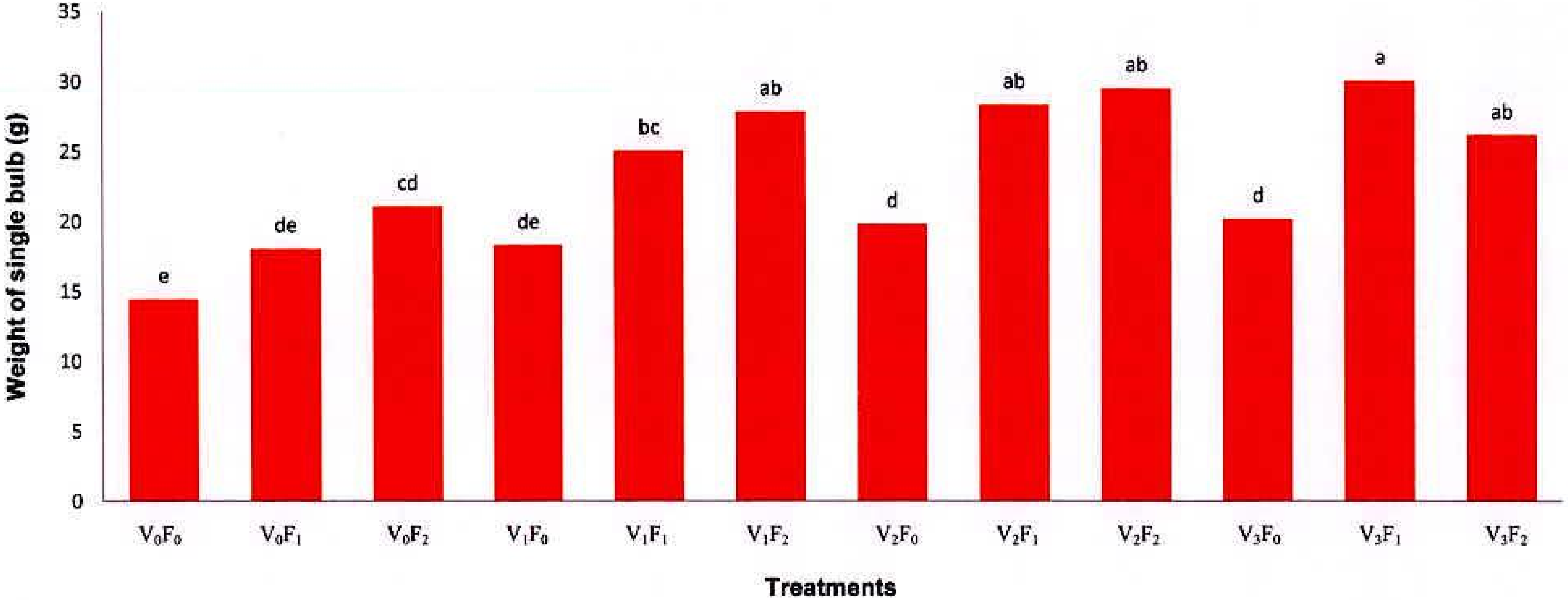


Fig. 18 Combined effect of vermicompost and different doses of chemical fertilizers (NPKS) on the weight of single bulb of summer onion.

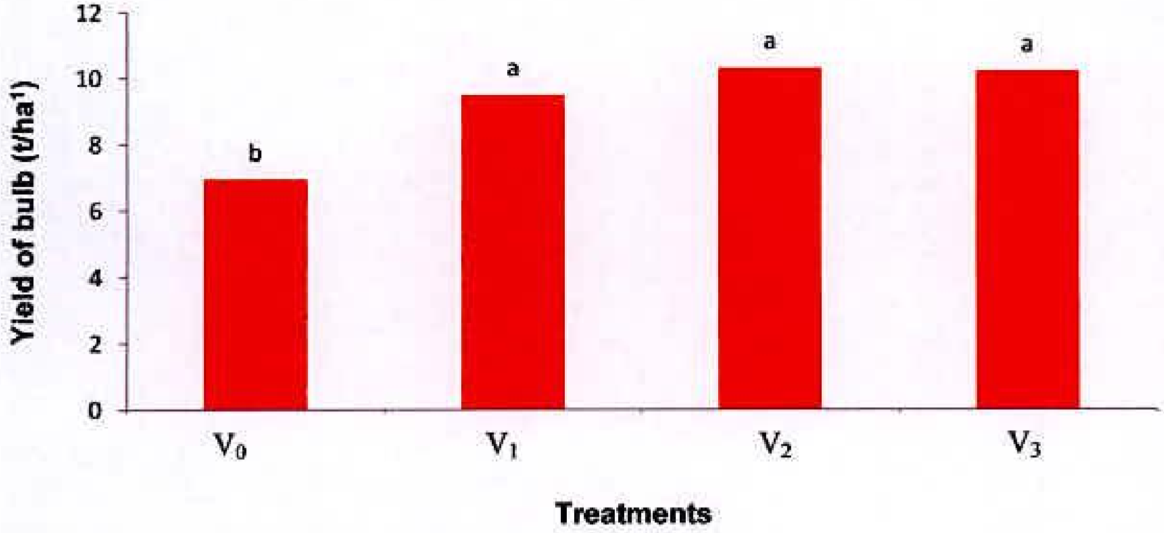


Fig. 19 Effect of different doses vermicompost on the yield of bulb of summer onion.

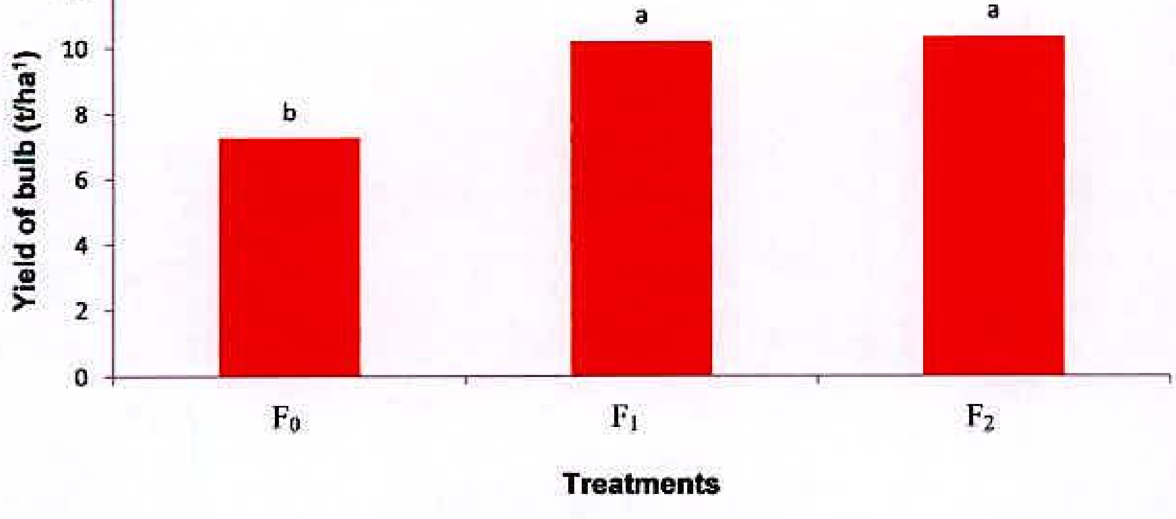


Fig. 20 Effect of different doses chemical fertilizers (NPKS) on the yield of bulb of summer onion.

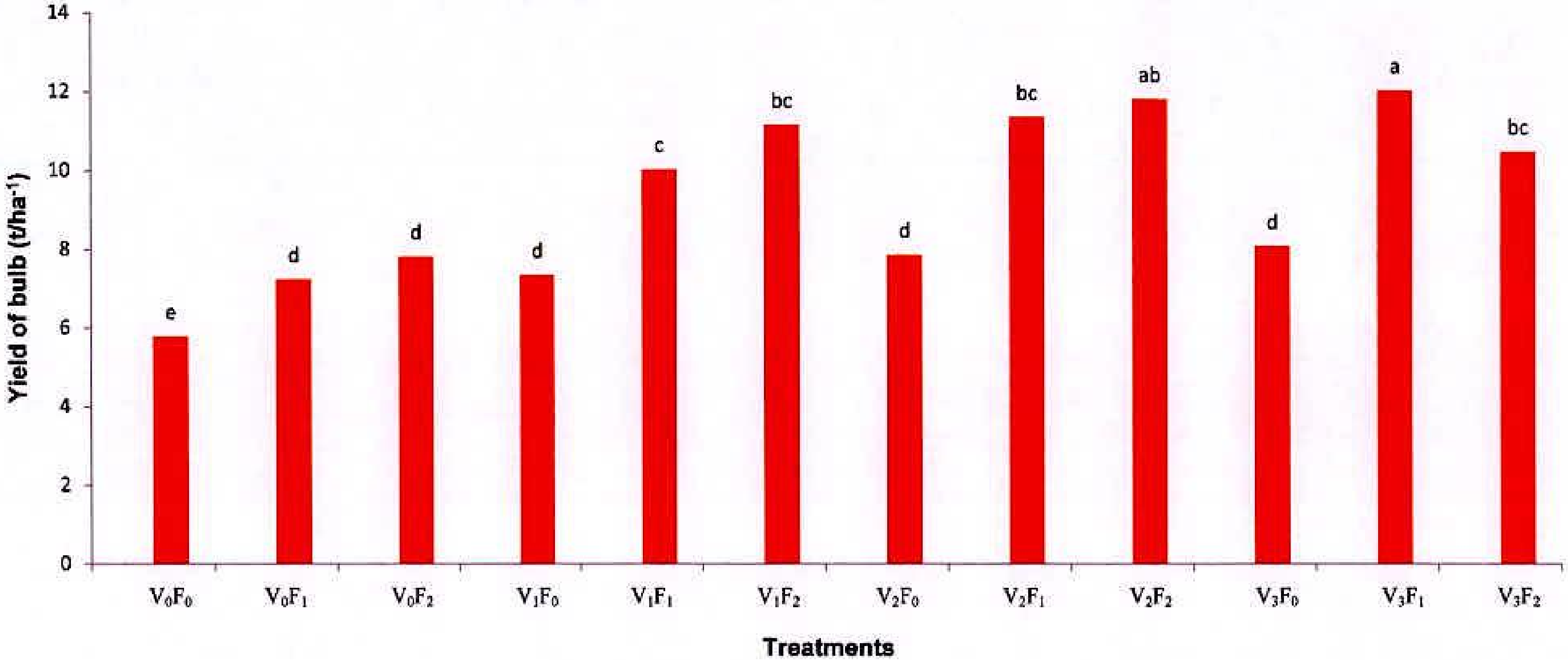


Fig. 21 Combined effect of different doses vermicompost and chemical fertilizers (NPKS) on the yield of bulb of summer onion.

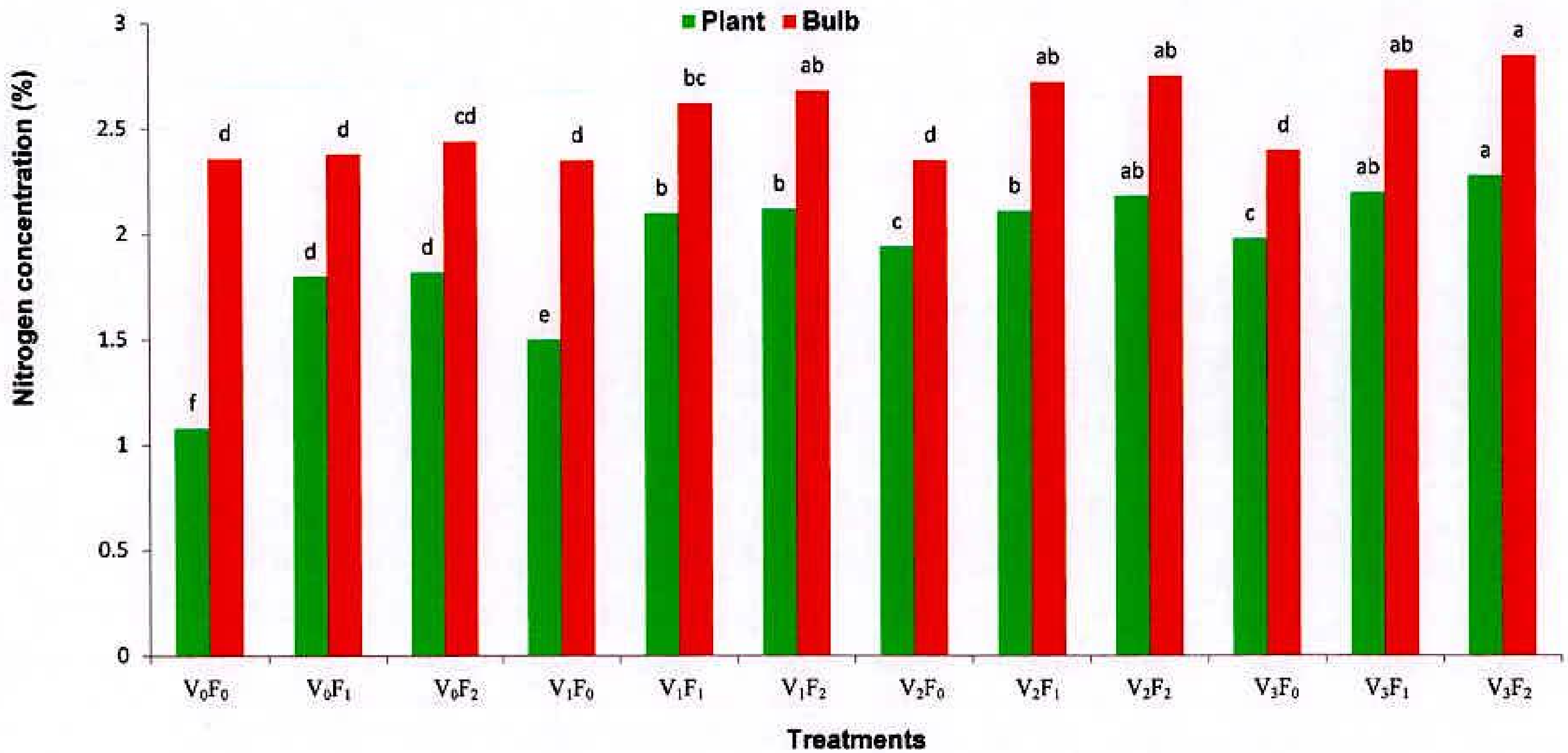


Fig. 22 Combined effect of different doses of vermicompost and chemical fertilizer on the nitrogen content in onion plant and bulb.

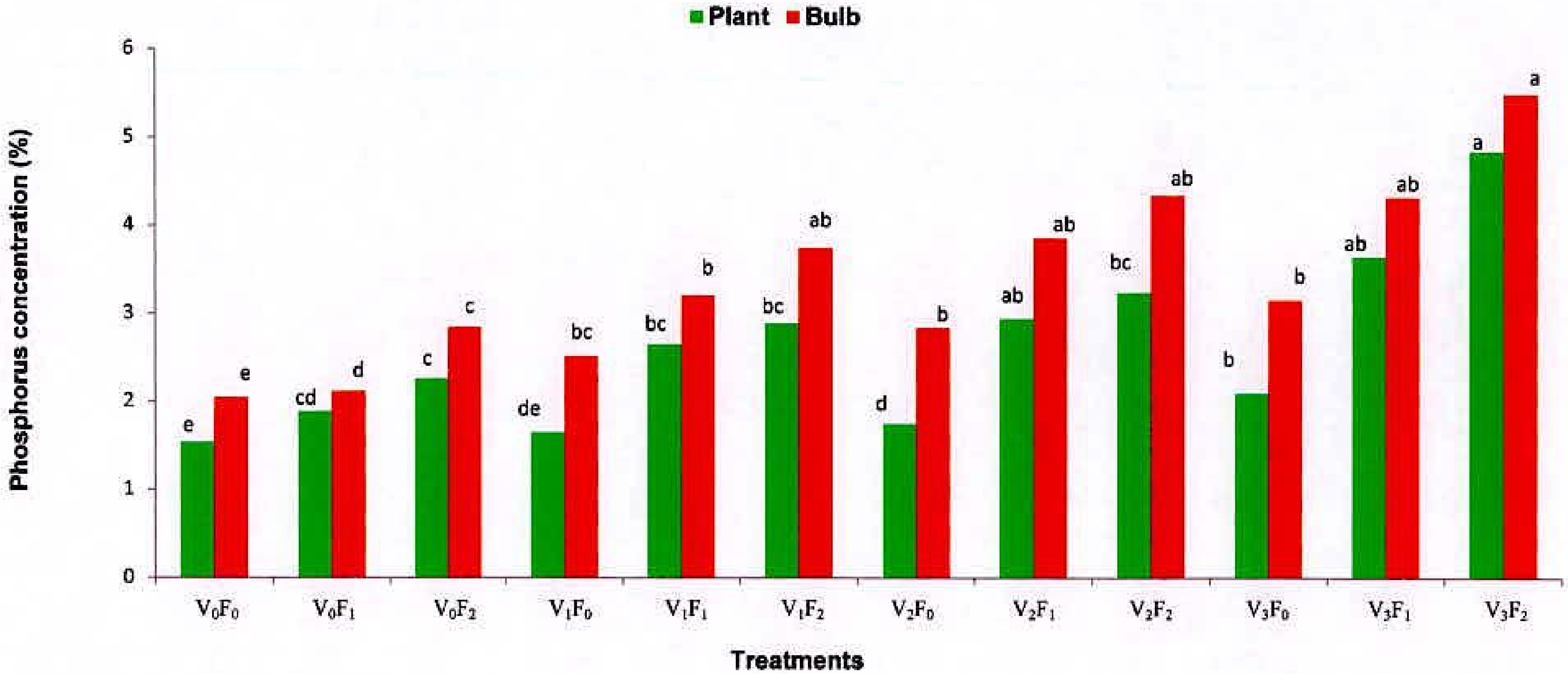


Fig. 23 Combined effect of different doses of vermicompost and chemical fertilizer on the phosphorus content in onion plant and bulb.

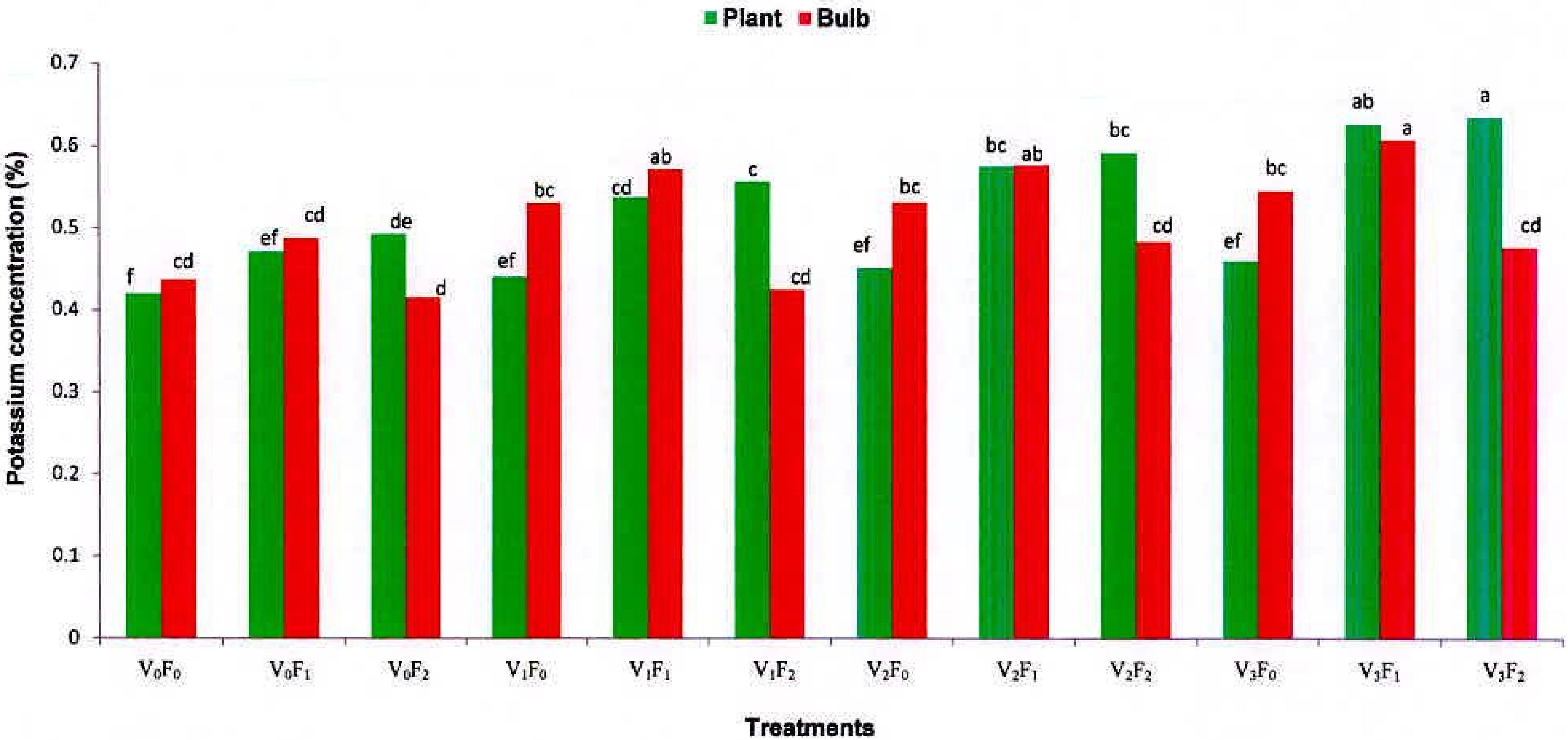


Fig. 24 Combined effect of different doses of vermicompost and chemical fertilizer on the potassium content in onion plant and bulb.

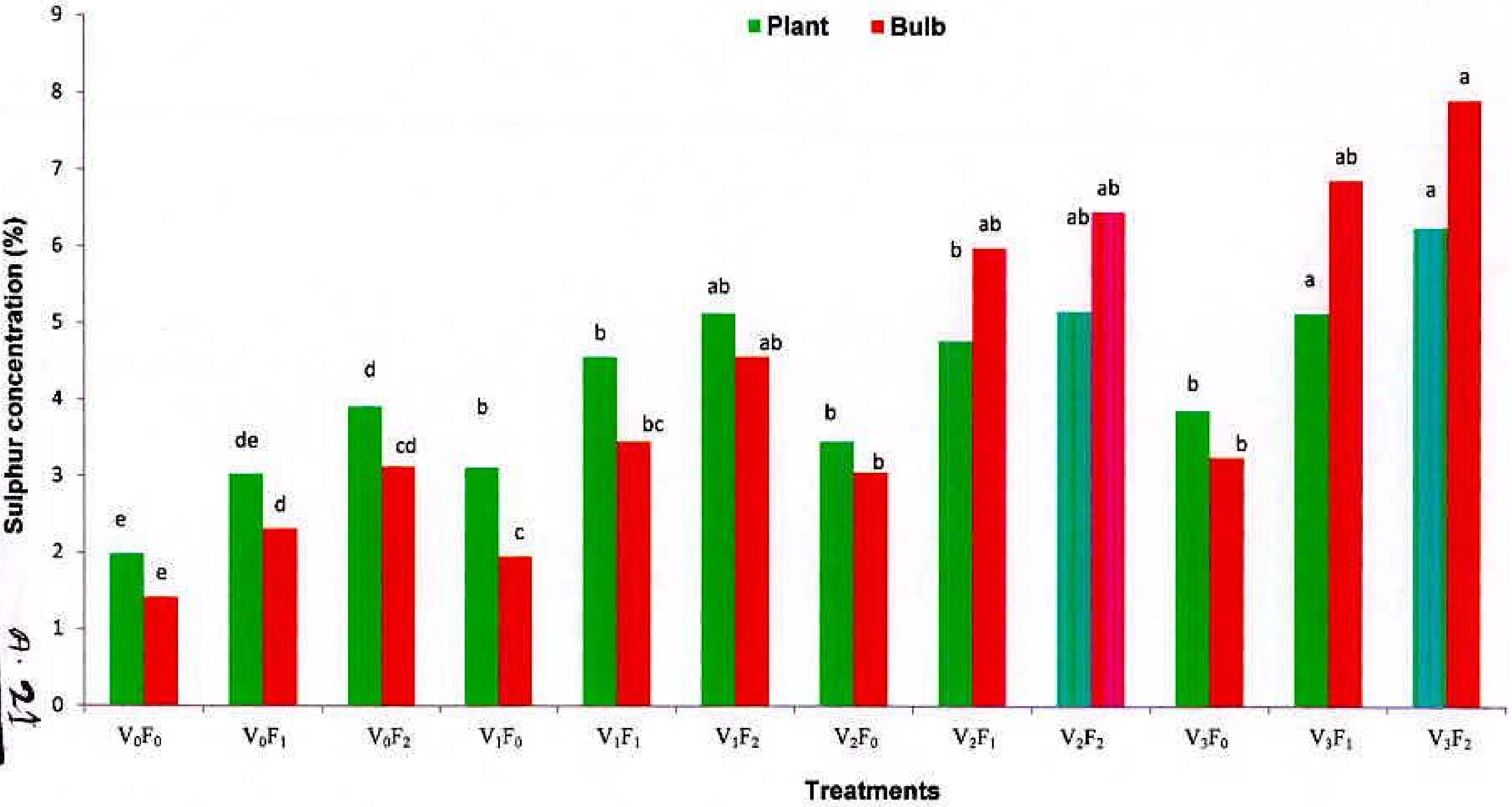


Fig. 25 Combined effect of different doses of vermicompost and chemical fertilizer on the potassium content in onion plant and bulb.