EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC MANURES AND SUPPLEMENTATION OF BIO-FERTILIZERS ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.)

G. SOMASHEKAR
B.Sc. (Hort.)

MASTER OF SCIENCE IN HORTICULTURE

(VEGETABLE SCIENCE)

DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE, RAJENDRANAGAR, HYDERABAD-500030
Dr.Y.S.R. HORTICULTURAL UNIVERSITY

AUGUST, 2014

EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC MANURES AND SUPPLEMENTATION OF BIO-FERTILIZERS ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.)

BY

G. SOMASHEKAR

B.Sc. (Hort.)

THESIS SUBMITTED TO Dr.Y.S.R. HORTICULTURAL UNIVERSITY

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE

AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN HORTICULTURE

(VEGETABLE SCIENCE)

DEPARTMENT OF VEGETABLE SCIENCE

COLLEGE OF HORTICULTURE, RAJENDRANAGAR, HYDERABAD-500030

Dr.Y.S.R. HORTICULTURAL UNIVERSITY

AUGUST, 2014

CERTIFICATE

Mr. G.SOMASHEKAR has satisfactorily prosecuted the course of research and that the thesis entitled **"EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC MANURES AND SUPPLEMENTA-TION OF BIO-FERTILIZERS ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.)"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part there of has been previously submitted by him for a degree of any university.

Place: Rajendranagar,
Hyderabad.

(Dr. Y P VENKATASUBBAIAH)
Chairman

Date:

CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC MANURES AND SUPPLEMENTA-TION OF BIO-FERTILIZERS ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.)"** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE (VEGETABLE SCIENCE)** of Dr.Y.S.R. Horticultural University, Venkataramannagudem, is a record of the bonafide research work carried out by **Mr. G.SOMASHEKAR** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

Thesis approved by the Student Advisory Committee

Chairman: Dr. Y. P. VENKATASUBBAIAH
Associate Professor (Hort.),
Dept. of Vegetable Science,
College of Horticulture,
Dr.Y.S.R. Horticultural University,
Rajendranagar, Hyderabad- 500 030. ______________________

MEMBER: Dr. K. RAVINDER REDDY
Professor (Hort.) & Head,
Dept. of Vegetable Science,
College of Horticulture,
Dr.Y.S.R. Horticultural University,
Rajendranagar, Hyderabad- 500 030. ______________________

MEMBER: Dr. M. GOVERDHAN
Principal Scientist (Agronomy),
AICRP on Integrated Farming Systems
ANGR Agricultural University,
Rajendranagar, Hyderabad- 500030. ______________________

MEMBER: Dr. S. SRIDEVI
Scientist (Soil Science)
AICRP on Integrated Farming Systems
ANGR Agricultural University,
Rajendranagar, Hyderabad- 500030 ______________________

Date of final viva-voce:

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

@	:	At the rate of
BF	:	bio-fertilizers
cm	:	Centimetre
CFU	:	Colony Forming Units
CBR	:	Cost-Benefit Ratio
CD	:	Critical Difference
cv.	:	Cultivar
DAS	:	Days after storage
DAT	:	Days After Transplanting
^{0}C	:	Degree Celcius
et al.	:	Et alia (and others)
etc.	:	Etcetera
FYM	:	Farmyard Manure
g	:	Gram
g m^{-2}	:	Gram per metre square
g $plant^{-1}$	:	Gram per plant
i.e.,	:	That is
Kg	:	Kilogram
mm	:	Millimetre
m ha	:	Million hectare

mg kg^{-1}	:	Milligram per kilogram
MOP	:	Muriate of Potash
NC	:	Neem cake
NS	:	Non-significant
NPK	:	Nitrogen, Phosphorus and Potassium
NPKS	:	Nitrogen, Phosphorus, Potassium and Sulphur
viz.	:	Namely
ppm	:	Parts per million
PM	:	Poultry Manure
$plant^{-1}$	:	Per plant
Rs.ha^{-1}	:	Rupees per hectare
%	:	Per cent
m^{-1}	:	Per metre
kg^{-1}	:	Per kilogram
kg $plot^{-1}$	:	Kilogram per plot
kg ha^{-1}	:	Kilogram per hectare
ha^{-1}	:	Per hectare
$plot^{-1}$	:	Per plot
PSB	:	Phosphorus solubilising bacteria
q	:	Quintal
q ha^{-1}	:	Quintals per hectare

RDF	:	Recommended Dose of Fertilizers
RDN	:	Recommended Dose of Nitrogen
SSP	:	Single super phosphate
TSS	:	Total soluble solids
$tree^{-1}$	:	Per tree
$t\ ha^{-1}$	:	tonnes per hectare
m	:	metre
m^2	:	Square metre
S Em±	:	Standard error of mean
VAM	:	Vesicular Arbuscular Mycorhizae
VC	:	Vermicompost
v/v	:	Volume per volume
w/w	:	Weight per weight

ACKNOWLEDGEMENTS

I am pleased to place my profound etiquette to ***Dr. Y. P. VENKATASUBBAIAH****, Associate Professor (Hort.), College of Horticulture, Rajendranagar, Hyderabad and esteemed Chairman of my Advisory Committee for his learned counsel, unstinted attention, arduous and meticulous guidance, kind treatment during the course of investigation and constructive criticism have installed in me the spirit of confidence and deep sense of respect and gratitude. The keen interest abundant because of which I have been able to successfully complete the work assigned to me.*

I sincerely extend my profound gratitude and appreciation to the members of my Advisory Committee, ***Dr. K. RAVINDER REDDY,*** *Professor, College of Horticulture, Rajendranagar,* ***Dr. M. GOVERDHAN,*** *Principal Scientist (Agronomy), ANGRAU, Hyderabad and* ***Dr. S. SRIDEVI****, Scientist (Soil science) ANGRAU , Hyderabad.*

It gives me immense pleasure in extending my sincere feelings of gratitude to ***Dr. P. VEERANNA GOUD,*** *Associate Dean, College of Horticulture, Rajendranagar, for his support and guidance which went a long way in shaping this humble piece of work.*

I sincerely extend my profound gratitude and appreciation to ***Sri. K. KALADHAR BABU, Dr. S. S. VIJAYA PADMA, Dr. M. JAYAPRADA, Smt. K. VENKATALAKSHMI, Dr. P. SAIDAIAH, Dr. K. RADHA RANI and Dr. CH. RAJA GOUD,*** *academic staff, College of Horticulture, Rajendranagar, Hyderabad.*

I allocate my highest respect and heartfelt regards from my inner core of heart to my ever loved parents, ***Smt.RAMADEVI and Sri. KRISHNAMURTHY,*** *who have given me life and taught the concepts of life and their dedicated efforts to educate me to this level, With boundless affection, I owe an encompassing debt to my beloved sister* ***SRAVANTHI*** *and for his constant encouragement throughout my career. They* *have been a fountain of inspiration throughout my life without whose help in every walk of life, this work would not have been possible.*

It is a pleasure to acknowledge the affection and inspiration rendered by my friends ***THIRUPATHI, SRAVAN, KIRAN, RAMBABU, PAVAN, SURESH BHANU MURTHY, JAGANMOHAN, PRADEEPTHI, VISHNU PRIYANKA, ANIL, VYJAYANTHI, NITHYA, MOUNIKA, KRISHNAVENI, SUHASINI, AIDOH AND JYOTHI PATIL*** *for their love, affection, special upliftment during my studies and worries; and my seniors* ***SANDEEP, MAHESH, SAIDULU, SRINU, VIJAY KRISHNA and NAGI REDDY*** *in whose cheerful company I have never felt my work as burden. No words are enough to express my heartiest sense of gratitude to my juniors* ***SRIDHAR, RAJASHEKAR, ARUN, NISSI PAUL, SUSMITHA REDDY, MEGHANA, SINDHU, SUSHMA, DIVYA, SUDHEER and CHANAKYA.*** *I also express my sincere gratitude to* ***APARNA and SRINIVAS*** *for their assistance in my PG academic career.*

I express my heartfelt gratitude and thanks to my cousins ***ARAVIND, HARISH AND AMARISH*** *for their valuable guidance, thought provoking ideas and encouragement throughout my career which elevated me to the world of competition.*

My special thanks to ***Dr. V. RAVINDER REDDY,*** *Scientist, AINP on Agricultural Ornithology, ANGRAU, Rajendranagar, Hyderabad for his assistance by giving chain link fence to the crop for protection from wild boars.*

I appreciate and thank ***RAJU and ASHOK,*** *drivers;* ***YETTAIAH, KIRAN, RAJU, RAMULU, SALEEMUDDIN AND SURESH,*** *farm labour and* ***NAVEEN, NARASIMHA and PRAMOD*** *lab assistants and* ***security guards*** *for their continuous assistance throughout my research work.*

I humbly thank the authorities of ***Dr Y S R Horticultural University*** *and Government of Andhra Pradesh for the financial help in the form of stipend during my study period.*

Besides, my whole hearted prostrations to the Almighty for sprinkling his blessings upon me.

(G.SOMASHEKAR)

DECLARATION

I, **Mr. G.SOMASHEKAR,** hereby declare that the thesis entitled **"EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC MANURES AND SUPPLEMENTATION OF BIO-FERTILIZERS ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.)"** submitted to Dr.Y.S.R. Horticultural University for the Degree of **MASTER OF SCIENCE IN HORTICULTURE (VEGETABLE SCIENCE)** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Rajendranagar, Hyderabad.

Date: 07-08-2014

Name: G.SOMASHEKAR

I.D.No: RHM/12-16

Name of the author : **G. SOMASHEKAR**

Title of the thesis : **“EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC MANURES AND SUPPLEMENTATION OF BIO-FERTILIZERS ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.)”**

Degree to which it is submitted : **MASTER OF SCIENCE IN HORTICULTURE**

Faculty : **HORTICULTURE**

Department : **VEGETABLE SCIENCE**

Major Advisor : **Dr. Y P VENKATASUBBAIAH**

University : **Dr.Y.S.R. HORTICULTURAL UNIVERSITY**

Year of submission : **2014**

ABSTRACT

A field experiment was conducted during *rabi*, 2013-14 to study the “Effect of different combinations of organic manures and supplementation of bio-fertilizers on growth, yield and quality of Onion (*Allium cepa*L.)” at college farm, College of Horticulture, Dr. Y.S.R. Horticultural University, Rajendranagar, Hyderabad, Andhra Pradesh. The experiment was laid out in randomized block design with three replicated 9 treatments *viz*., **T_1:** Farmyard manure (50%) + Vermicompost (50%), **T_2:** Farmyard manure (50%) + Vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each, **T_3:**Farmyard manure (50%) + Vermicompost (25%), + Neem cake (25%), **T_4:**Farmyard manure (50%) + Vermicompost (25%), + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each, **T_5:**Poultry manure (50%) + Vermicompost (50%), **T_6:**Poultry manure (50%) + Vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each, **T_7:** Poultry manure (50%) + Vermicompost (25%) + Neem cake (25%), **T_8:**Poultry manure (50%) Vermicompost (25%), + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each, and **T_9:** RDF. The data were recorded on plant height (cm), leaf length (cm), number of leaves plant^{-1}, neck thickness (mm), leaf width (cm), leaf dry weight(g), bulb dry weight (g), bulb diameter (cm), bulb length (cm), bulb shape index, number of scales bulb^{-1}, bulb yield (kg plot^{-1}), number of bulbs kg^{-1}, bulb yield (t ha^{-1}), double bulbs (%), marketable yield (%), physiological loss of weight (%), sprouting of bulbs (%), rotting of bulbs (%), TSS (Brix^{o}), moisture content (%), P & S content (%), NPK&S uptake (kg ha^{-1}) by the crop, available NPK&S (Kg ha^{-1}& ppm) and microbial count in the soil (CFU g soil^{-1}).

The highest plant height, leaf length, number of leaves, leaf dry weight, bulb dry weight, bulb diameter, bulb length, bulb shape index, number of scales, number of bulbs, bulb yield, TSS, P&S content, moisture content, and NPKS uptake were recorded with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each. Farmyard manure (50%) + vermicompost (25%) + neem cake (25%) recorded lower values for physiological loss of weight, sprouting of bulbs and rotting of bulbs. Poultry manure (50%) + vermicompost (50%) recorded maximum values for post-harvest available soil NPKS. Whereas poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each recorded maximum values for microbial activity in the soil. However, the higher net returns and BCR were obtained with recommended dose of fertilizers.

The results of the present investigation demonstrated that among different organic manures tried, farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each can be considered as the best treatment for obtaining higher growth and bulb yield. Better quality of onion was obtained with farmyard manure (50%) + vermicompost (25%) + neem cake (25%). Under organic cultivation of onion, for obtaining maximum net returns and benefit cost ratio farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each may be used as organic source of nutrients.

Chapter I

INTRODUCTION

Onion (*Allium cepa L.*) is one of the most important commercial vegetable crops cultivated extensively in India and belongs to the family Alliaceae. It is an indispensable item in every kitchen as vegetable and condiment. India is the second largest producer of onion in the world next to China, accounting for 11.4 per cent of the total vegetable area and 10.4 per cent of the total vegetable production. In India, onion is being grown in an area of 10.51 lakh ha. with production of 168.13 lakh tonnes and the productivity is 16.0 tonnes ha^{-1}. Maharashtra is the leading onion growing state in India and other important states are Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh and Tamil Nadu. In Andhra Pradesh, onion is cultivated in an area of 86.67 thousand hectares with production of 15.60 lakh tonnes and the average productivity is 18.0 tonnes ha^{-1} (NHB, 2013).

Onion is liked for its flavour and pungency which is due to the presence of a volatile oil ‘allyl propyl disulphide’- organic compound rich in sulphur. It is being used in several ways as fresh, frozen and dehydrated bulbs. Dehydrated onion is in great demand which reduces transport cost and storage losses. It has got good medicinal value too. Onions are diuretic, applied on wounds, boils and bruises. It relieves heat sensation, insect bites and soar throat, besides bulb juice is used as smelling agent on hysterial fits and faintness.

Green revolution in sixties gave tremendous boost to agricultural production in India. During the era of green revolution, spectacular increase in crop yields resulted primarily from the introduction of fertilizer responsive HYV, extension of irrigated area, high use of chemical fertilizers and pesticides. In this process, relative contribution of organic manures as a source of plant nutrients declined substantially. With increase in cost of inputs, inorganic fertilizers became increasingly more expensive. Another issue of great concern is that the sustainability of soil productivity as lands began to be intensively tilled to produce higher yields under multiple and intensive cropping system. The occurrence of multi-nutrient deficiencies and overall decline in the productivity of the soil under intensive fertilizer use have been widely reported (Chhonkar, 2003). Consequently, many farmers are seeking alternative practice of organic farming to make agriculture more sustainable.

Organic farming is not mere non-chemical agriculture but it is a system integrating relationships between soil, plant, water, soil micro flora and fauna. Organic farming aims in creating a healthy soil and helps in proper energy flows in soil, crop, water and environment, while the plant system keeps biological life cycle alive and helps in sustaining considerable levels in yield (Lampkin, 1990).

Several attempts have been made to increase yield potential of bulb and root crops, but they are concerned with use of inorganic fertilizers which results in loss of soil fertility and soil health. Farmyard manure being bulky organic material, releases the soil compactness and improves the aeration in addition to the supply of essential plant nutrients and organic matter and increase soil microbial establishment along with accumulation of excess humus content. It acts directly for increasing crop yield by accelerating the respiratory process through cell permeability or by hormones through growth action. It supplies nitrogen, phosphorus and sulphur in available form to the plants through biological decomposition. Indirectly it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Chandramohan, 2002).

Vermicompost provides vital macronutrients (N, P, K, Ca and Mg) and micronutrients (Fe, Mo, Zn and Cu). The chemical analysis of vermicompost revealed that N, P and K contents were 0.8, 1.1 and 0.5, per cent respectively. Vermicompost besides being a rich source of micronutrients, also acts as a chelating agent and regulates the availability of metallic micronutrients to the plants and increases the plant growth and yield by providing nutrients in the available form (Giraddi, 1993). Poultry manure generally refers to excretement, as voided by the animal. The total N and P contents of poultry manures and litters are among the highest of all animal manures (Somners and Sutton, 1980). Castellanos and Pratt (1981) estimated that 60 per cent of the organic N in poultry manure was available. Due to its rapid mineralization, poultry manure was recognized as a valuable source of plant nutrients for crops. The nitrogen (60%) is present as uric acid, 30 per cent as more stable organic nitrogen and the balance as mineral nitrogen (Srivastava, 1998). Neem cake is a main product of neem seed kernel and has adequate quantity of NPK in organic form for plant growth. Being a totally botanical product, it contains 100% natural NPK contents and other essential micro nutrients.

The bio-fertilizers are alternative sources to meet the nutrient requirement of crops and to bridge the future gaps. Further, knowing the deleterious effect of using only chemical fertilizers on soil health, use of organic manures supplemented with bio-fertilizers will be environmentally benign. Further, the bio-fertilizers are widely accepted as low cost supplements to chemical fertilizers without any deleterious effect either on soil health or environment (Bhagyaraj and Suvarna, 1999). It is suggested that organic farming should include green manure crops whenever possible, as part of a sustainable rotation system, and legumes are to be recommended when little N is available (Willumsen and Thorup-Kristensen, 2001).

Greenland (1975) suggested that for a sustainable crop production system, chemical nutrients removed by the crop must be replenished and physical conditions of the soil maintained. The continuous and imbalanced use of fertilizers is adversely affecting the sustainability of agricultural production besides causing environmental pollution. In view of increased awareness about organic farming, residue free food production, increased availability of organic inputs and sustainability in the farm, investigation on these aspects have thus become imperative to study and assess their effect on yield, quality and post harvest storage life of vegetables in general and onion in specific. Organic nutrient management provides excellent opportunities to overcome all the imbalances besides sustaining soil health and enhancing crop production. This optimizes the benefit from all possible sources of plant nutrients in an organic manner. Further, the information on organic cultivation and effect of different organics on postharvest quality of the produce is very meagre. Hence, this investigation is planned to identify the ideal organic nutrient management package.

Keeping in view of all the above points, the present investigation was proposed to be undertaken with the following objectives

1. To study the effect of organic manures and bio-fertilizers on growth and yield of onion.
2. To study the effect of organic manures and bio-fertilizers on quality and post-harvest life of onion.
3. To study the effect of organic manures and bio-fertilizers on the nutrient (N, P, K & S) uptake by the plants, nutrient status and microbial count in the soil.
4. To study the Benefit Cost ratio of different combinations of organic manures and bio-fertilizers.

Chapter II

REVIEW OF LITERATURE

In recent past, organic farming practice which encompasses use of organic manures, bio-fertilizers *etc.* is gaining paramount importance in vegetable cultivation. Onion being bulbous crop needs more of organic substances for proper growth and development of bulbs. Adoption of organic farming practices in crop like onion assumes special significance as it is most potential vegetable that earns maximum foreign exchange, among vegetable crops in India.

In this chapter, all the available and relevant literature pertaining to the "Effect of different combinations of organic manures and supplementation of bio-fertilizers on growth, yield and quality of Onion (*Allium cepa* L.)" has been reviewed. Since the literature on the effect of organic manures on growth, quality and yield attributes is not adequate in onion, the combined effect of organics in general and FYM, vermicompost, poultry manure, neem cake and bio-fertilizers in particular on various crops has been reviewed and presented in this chapter under following headings.

2.1 Effect of organic manures and bio-fertilizers on growth and yield parameters

2.2 Effect of organic manures and bio-fertilizers on quality and post-harvest life of onion

2.3 Effect of organic manures and bio-fertilizers on nutrient uptake by the plant, nutrient status and microbial count in the soil and benefit cost ratio.

2.1. Effect of organic manures and bio-fertilizers on growth and yield parameters.

Shete *et al*. (1993) reported that application of farmyard manure @ 20 t ha^{-1} produced maximum yield of onion bulbs (36.7 t ha^{-1}) as compared to control (28.7 t ha^{-1}) followed by application of vermicompost @ 5 t ha^{-1} which produced the bulb yield of 23.30 t ha^{-1}. Alkaff *et al.* (2002) obtained the highest rate of increase in total yield fed^{-1} with FYM, followed by the mineral fertilizer and bio-fertilizer in onion. Onion yield was increased by increasing the levels of fly ash and FYM, latter having more influence on yield of onion bulbs (Patil *et al.*, 2005).

Higher yield was recorded with application of FYM @ 50 t ha^{-1} in turmeric (Shaha, 1988) and @ 30 t ha^{-1} in potato (Grewal and Trehan, 1984). Balashanmugam *et al.* (1989) recorded higher yield of fresh rhizomes in turmeric with application of FYM @ 25 t $ha^{-1.}$

Maheswari *et al*. (1991) reported that application of FYM @ 15 t ha^{-1} observed 8% higher biomass and 10% higher oil yield in palmarosa compared to control.

Chavan *et al.* (1997) found that combined application of nitrogen through FYM and urea was more beneficial compared to fertilizer alone in order to increase the yield and quality of chilli.

Nirmala *et al.* (1999) found that incorporation of FYM @ 30 t ha^{-1} alone stimulated the yield of cucumber by 30%. They also noticed that the tender fruit yield and yield attributes increased significantly due to the application of bio-fertilizers, singly or in combination with FYM.

Harikrishna *et al.* (2002) reported that application of FYM @ 25 t ha^{-1} recorded significantly lower yield (30.13 q ha^{-1}) over RDF (40.21 q ha^{-1}) in tomato. Patil *et al.* (2004) reported that application of FYM (50 %) along with half RDF recorded maximum number of fruits $plant^{-1}$ and the highest fruit yield over 100% RDF in tomato.

Kumpawat (2004) recorded the maximum plant height with application of 100% recommended N through FYM in maize. Balyan *et al.* (2006) reported that application of FYM @ 10 t ha^{-1} significantly increased plant height and dry matter accumulation $plant^{-1}$ than no FYM over application of 100 % RDF in maize. Kler and Walia (2006) reported that the treatment supplemented with FYM along with crop residue incorporation and green manuring recorded higher dry matter accumulation over chemical farming in wheat and also proved beneficial in boosting up the crop yields by 12.40% compared to chemical fertilizers.

The greater plant height with application of FYM @ 20 t per ha was also obtained by Surlekov and Pankov (1989) in chilli. The increase in plant height due the application of vermicompost may be due to its rich content of macro and micro nutrients, vitamins, growth hormones and micro flora (Bhavalkar, 1991).

The increased leaf length in onion plant may be attributed to better availability of nutrients in vermicompost and bio-fertilizers (Giraddi, 1993).

Among control, RDF (120:60:60 kg ha^{-1}) + 10 t FYM ha^{-1}, 50% RDF + 50% N through FYM, 50% RDF + 50% N through vermicompost, 50% RDF + 50% N through neem cake, 50% RDF + 50% N through compost and 50% RDF + 50% N through poultry manure, Dalavi *et al*. (2009) reported that application of RDF + FYM @ 10 tha^{-1} resulted in maximum dry fodder and fresh cob yield in sweet corn.

In pot experiments, onions (*Allium cepa* var. *aggregatum*) were grown with 12 different combinations of soil, mine soil, vermicompost made from coir or water hyacinth and farmyard manure. Results revealed that organic amendments increased onion growth and yield in mine soil and coir vermicompost appears to be a very effective amendment for this purpose (Thanunathan *et al*., 1997).

In onion (cv. N-53), Reddy and Reddy (2005) recorded that the plant height, number of leaves $plant^{-1}$, leaf area, bulb length, diameter, weight and yield increased significantly with increasing levels of vermicompost (from 10 to 30 t ha^{-1}). Among three levels of vermicompost (2, 4 and 6 t ha^{-1}), Bybordi and Malakouti (2007) reported that the highest yield was obtained with vermicompost @ 6 t ha^{-1} in red onion.

The increase in number of leaves per plant in onion plant may be due to the vital macro and micro nutrient availability with vermicompost (Giraddi, 1993).

Kopczynski *et al.* (1999) reported that the highest root yield in sugar beet was recorded with the application of vermicompost @ 6 t ha^{-1}.

Tomar *et al*. (1998) reported that highest yields were recorded when brinjal plants were grown in pots containing soil with the addition of vermicompost followed by FYM, vermicompost + FYM compared to soil alone. They further reported that the highest yield was recorded when carrots were grown in pots containing soil amended with vermicompost and FYM compared to unamended soil.

Yadav and Vijayakumari (2003) reported the higher number of fruits plant^{-1}, fruit weight, fruit length and fruit diameter with vermicompost alone in chillies. Similar results are in agreement with the findings of Jayathilake *et al.* (2003) and Gunjan Aswini *et al.* (2005) in onion.

Among the different treatments of vermicompost (10 kg tree^{-1}), FYM (25 Kg tree^{-1}), pig, sheep, goat and poultry manures and guava leaf litter (20 Kg tree^{-1} each), NPK (250:350:200 g tree^{-1}) and control (without any treatment), Naik and Babu (2007) reported that highest yield was recorded in guava with the application of vermicompost @ 10 kg tree^{-1}.

Among vermicompost, rhizobium and DAP, Raghwendra *et al.* (2008) reported that the application of vermicompost resulted in higher dry matter, grain and straw yields in chickpea.

Peyvast *et al.* (2008a) reported that addition of vermicompost to soil increased plant height significantly in spinach. They further reported that leaves and roots were highest when fertilized with vermicompost and lowest when the vermicompost was not supplied. Peyvast *et al.* (2008b) reported that between vermicomposted cattle manure and soil (0:100, 10:100, 20:100 or 30:100 (v/v)) the highest total yield was recorded in vermicompost + soil @ 0:100 in parsley. They further reported that the incorporation of vermicompost into soil increased plant height.

Alam *et al.* (2011) reported that among twelve treatments of control, VC @ 2.5 t ha^{-1}, VC @ 5.0 t ha^{-1} , VC @ 10.0 t ha^{-1}, VC @ 2.5 t ha^{-1} + 50% NPKS, VC @ 5 t ha^{-1} + 50% NPKS, VC @ 10 t ha^{-1} + 50% NPKS, VC @ 2.5 t ha^{-1} + 100% NPKS, VC @ 5 t ha^{-1} + 100% NPKS, VC @ 10 t ha^{-1} + 100% NPKS, 50% NPKS and 100% NPKS, better growth and yield were recorded with the application of vermicompost @ 10 t ha^{-1} than 100% NPKS in red amaranth.

Darzi *et al.* (2012) reported that among vermicompost (0, 5 and 10 t ha^{-1}), PSB and *Bacillus circulans*, the highest plant height and biological yield were obtained with the application of vermicompost @ 10 t ha^{-1} in anise.

Ranuma *et al*. (2012) recorded the highest plant height and leaf yield in mulberry with vermicompost application.

Lopez *et al*. (2012) observed that when the rates of vermicompost were increased, the plant height, fruit and root dry weight were also found increased as compared to control when pepper was grown in greenhouse conditions.

Molina *et al*. (2012) reported that vermicompost promoted the faster plant growth and more dry weight in *Ardisiae scallonioides* than plants grown without vermicompost and the effect on plantlet weight was possibly for the highest content of phosphorus found in the vermicompost.

Mamta and Rao (2012) recorded higher plant height and fruit weight in the vermicompost treated field as compared to control in brinjal and recommended that while raising brinjal crop farmers should use vermicompost instead of synthetic fertilizers.

Abbey (2000) reported that application of poultry manure @ 3t ha^{-1} plus 100 kg NPK fertilizer gave the highest bulb yield of 12.4 t ha^{-1} in onion.

The increase in plant height due to availability of soluble phosphorus in soil solution was higher when poultry manure was applied in amaranthus (Warncke and Siregar, 1992).

Beaulah (2001) reported that highest pod yield $tree^{-1}$, plant height and dry matter production were observed with the application of poultry manure + neem cake @ 250 g $tree^{-1}$ + panchakavya @ 2% in moringa.

Sharma *et al*. (1986) found that only 105 kg N ha^{-1} was required when urea was blended with neem cake as against 205 kg N ha^{-1} through urea for producing 100 q ha^{-1} yield in radish.

Paturde *et al*. (2002) reported that in safed musli, the number of tubers, fresh and dry tuber yield increased with application of organic manures like neem cake over control.

Neem cake @ 2 % w/w was very effective in significantly increasing growth parameters (i.e., shoot dry weight, root fresh weight) of japanese mint (Singh and Vinod Kumar, 1995).

Ramachandra and Bhaskar (1996) reported that in moringa, application of neem cake @ 250 g m^{-2} along with modified form of panchakavya recorded maximum dry weight along with fruit yield of 16.7 t ha^{-1} compared to control (4.1 t ha^{-1}).

Amarendra Kumar *et al*. (1997) reported that application of neem cake resulted in significantly highest yield (225.5 q ha^{-1}) and increased plant height in tomato.

Studies conducted at Vridhachalam, Tamil Nadu showed that application of neem cake @ 1 t ha^{-1} recorded significantly higher yield of sesame as compared to FYM applied @ 5 t ha^{-1} and no manure (Anonymous, 1997). Application of neem cake @ 1 t ha^{-1} recorded significantly higher yield of sesame as compared to FYM applied @ 5 t ha^{-1} and no manure (Anonymous, 1998). Ojeniyi and Sanni (2000) reported that growth and yield of okra were significantly increased with the application of neem fruit powder up to 6 t ha^{-1}.

Murugan (2000) reported that combined application of vermicompost + neem cake, composted poultry manure + neem cake improved plant height in baby corn.

Renuka and Shankar (2001) reported that application of neem cake alone or in combination resulted in highest yields of 2 ½ times over control in tomato.

Arulmozhiyan *et al*. (2002) reported higher leaf yield of betel vine due to application of neem cake @ 2.5 kg $plot^{-1}$ compared to urea alone.

Hakeem *et al*. (2008) reported that application of neem cake at 0, 300 and 600 kg ha^{-1} with bio-fertilizers increased plant height and dry weight till 60 DAS and showed marked response on 1000 seed-weight in black gram.

Among different combinations of FYM (10, 15 and 20 t ha^{-1}), vermicompost and neem cake (0.5 and 1.0 t ha^{-1} each) Umesha *et al.* (2011) recorded that maximum plant height, total dry matter, fresh and dry herbage yield with the application of FYM @ 20 t ha^{-1} + vermicompost and neem cake @1.0 t ha^{-1} each in *Solanum nigrum*.

Nanthakumar and Veeraghavathatham (1999) noticed that combined nutrition of organic manure through FYM (2.5 t ha^{-1}), *Azospirillum* and PSB (2 kg ha^{-1} each) and 75% of recommended dose of inorganic nitrogen and phosphorus increased the yield and its components in brinjal.

Duraisamy *et al.* (1999) revealed that fruit yield of tomato recorded maximum with composted coir pith followed by FYM and *Azospirillum* over inorganic nitrogen.

2.2. Effect of organic manures and bio-fertilizers on quality and post-harvest life of onion.

The substitution of nitrogen through FYM showed minimum post harvest losses of onion bulb due to reduced rotting, sprouting and physiological weight loss (Anon., 1996). Further, the lowest decay, sprouting and total loss (11.24, 33.96 and 34.04 per cent, respectively) of onion bulb were recorded due to application of vermicompost at 3 tonnes per hectare at Karnal (Anonymous, 1996).

Sankar *et al*. (2005) reported that the organic treatment combination consisting of 3 per cent panchakavya + 50 per cent FYM + 50 per cent poultry manure registered the lowest post harvest loss (30.57%) in onion at 120 days after storage over onion grown with inorganic fertilizer of 100 per cent NPK (39.84%).

Mahendran and Kumar (1998) studied the effect of bio-fertilizers on quality parameters of potato. Application of two equal split doses of 100 per cent recommended dose of NPK with *Azosprillum* and *Phosphobacterium* increased the ascorbic acid content significantly over control.

Balasubramani (1988) reported that *Azospirillum* inoculation to seed and application to soil with 30 kg N per ha recorded the higher ascorbic acid content in bhendi.

Jadhav (1994) found significant increase in total carbohydrate content of mulberry leaves when it was supplemented with vermicompost or FYM manure over inorganic fertilizers.

Venkatesh (1995) observed higher amount of ascorbic acid and total sugars and decreased acidity in grapes due to application of organic manures when compared to inorganic fertilizer application.

In tomato, the application of organic manure such as FYM and bio-fertilizers like *Azospirillum* and *Phosphobacterium* along with recommended dose of fertilizer recorded maximum total soluble solids, ascorbic acid and lycopene content (Sendur *et al*., 1998). Patil *et al.* (2004) reported that application of FYM (50 %) along with half RDF recorded maximum TSS over 100 % RDF in tomato.

Yadav (2006) reported that the application of 50 per cent N through poultry manure along with foliar spray of Panchagavya (3%) on 30th and 50th day was the viable organic approach for eco-friendly rice production.

Sable *et al*. (2007) reported that more TSS with increased shelf life was recorded with application of 50% N through neemcake and 50% N through vermicompost in tomato.

Among addition of different vermicompost levels (0, 10, 20 and 30%) to sandy loam soil, Peyvast *et al.* (2008a) reported that the highest TSS was recorded when the soil was amended with 10% vermicompost in spinach.

Singh *et al*. (2010) reported that application of vermicompost alone increased shelf life by 250% and TSS beyond 4.5% in tomato. They also reported that application of vermicompost @ 7.5 t ha^{-1} + 50% dose of NPK fertilizer (60:30:30 kg ha^{-1}) was optimum for obtaining better quality in tomato.

2.3. Effect of organic manures and bio-fertilizers on nutrient uptake by the plant, nutrient status and microbial count in the soil and benefit cost ratio.

Chellamuthu (1978) reported that application of N as FYM @ 90 kg ha^{-1} registered the highest available N content as against inorganic source of N and control. The increase in available N status by continuous addition of FYM has been reported by Singh *et al*. (1980) and Gupta *et al*. (1983).

Muthuvel *et al*. (1990) also reported that the application of FYM @ 90 t ha^{-1} annually increased organic carbon, total nitrogen and microbial biomass. The higher available nitrogen content of soil with FYM addition could be due to favourable microbial activity and enhanced biomass addition to the soil probably as a result of improved soil physical properties. The beneficial effect of FYM on various physicochemical properties of soil was reported by Sudhakar (2000).

Barani and Anburani (2004) recorded the highest N, P and K uptake with the application of FYM @ 25 t ha^{-1} + 75% of RDF @ 40:50:30 NPK kg ha^{-1} and vermicompost @ 5 t ha^{-1} in bhendi. Parihar *et al.* (2005) recorded higher uptake of N, P and K with vermicompost application as compared to FYM.

Balyan *et al.* (2006) reported that application of FYM @ 10 t ha^{-1} significantly enhanced the uptake of N, P and K and was 36.32%, 39.32% and 26.01 % increase over application of 100% RDF in maize.

Kumari and UshaKumari (2002) reported that enriched vermicompost resulted in higher uptake of N, P and K in cowpea.

In sunflower, Kademani *et al*. (2003) recorded the highest uptake and available N, P and K in soil with the application of vermicompost @ 2 t ha^{-1} treatment followed by FYM. Similarly in maize, Jayaprakash *et al*. (2004) recorded the highest available N, P and K of the soil with the application of vermicompost @ 2 t ha^{-1} followed by FYM @ 10 t ha^{-1}.

Namita *et al.* (2005) reported that the available soil P and N were improved with the addition of vermicompost. They also reported that multi fold increase was noticed in the total colony counts of fungal populations with application of vermicompost to the soil.

Omraj *et al.* (2007) reported that higher nutrient content and uptake by maize was recorded with application of vermicompost @ 1.5 t ha^{-1} than 1.0, 0.5 t ha^{-1} and control.

Venkatakrishnan and Ravichandran (2007) reported that the highest NPK uptake of tops and trashes (98.29 and 89.12 kg ha^{-1} for N, 57.15 and 46.01 kg ha^{-1} for P and 233.17 and 169.54 kg ha^{-1} for K respectively) were recorded with pressmud @ 25 t ha^{-1} + vermicompost @ 5 t ha^{-1}. They also reported that the highest postharvest available soil N (254 kg ha^{-1}) and P (22.7 kg ha^{-1}) were recorded with the same treatment in sugarcane.

Hu Cheng *et al.* (2007) reported that total N, available P, K and soil microbial biomass were positively influenced by the application of vermicompost.

Sunita *et al.* (2007) reported that the highest microbial biomass, available P and N content of wheat grown soil were recorded with the application of vermicompost.

Among different levels of vermicompost (0, 5, 10 and 15 t ha^{-1}), Azarmi *et al.* (2008) reported that significant increase was observed in soil N, P and K availability with the addition of vermicompost @ 15 t ha^{-1} compared to control in tomato grown soil.

In Kasuri cultivar of fenugreek, Deora and Jitendra Singh (2008) reported that application of vermicompost significantly increased N content in seed and P content in both seed and straw. There was also significant increase in N, P, and K uptake by the crop and P and K content in soil after the harvest over control.

Parthasarathi *et al.* (2008) reported that vermicompost application increased available NPK and microbial population in black gram cultivated soil. Raghawendra *et al.* (2008) reported that the application of vermicompost increased significantly total N and P uptake by chickpea.

Peyvast *et al.* (2008a) recorded significantly highest N, P and K in petioles and leaves of spinach with the addition of 10% vermicompost.

Ramesh *et al.* (2008) reported that the highest soil available N (173.3 kg ha^{-1}) was recorded with application of vermicompost in maize.

Narolia *et al.* (2009) reported that significant increase was observed in N, P and K nutrient uptake by grain and stover, net returns and BC ratio when vermicompost was applied @ 2 t ha^{-1} compared to control in pearl millet.

Tejada and Gonzalez (2009) reported that application of vermicompost had shown positive effect on soil biological properties. Murthy *et al.* (2009) reported that the application of RDF with vermicompost and gypsum recorded higher NPK uptake in groundnut.

Nihad and Jessykutty (2010) reported that the nitrogen content from the recommended FYM was substituted through vermicompost and green manure (50%

each) + RDF (125:100:50 kg ha^{-1}) recorded the highest available phosphorus (48.32 kg ha^{-1}), microbial density of the soil (40.50 CFU g^{-1} bacterial, 31.00 CFU g^{-1} fungi and 27.00 CFU g^{-1}actinomycetes) and nutrient uptake (60.86 kg ha^{-1} N, 7.55 kg ha^{-1} P, 66.89 kg ha^{-1} K) of brinjal plants. This treatment was at par with the substitution of nitrogen content from the recommended FYM through FYM and green manure (50% each) + RDF (125:100:50 kg ha^{-1}) which recorded the available phosphorus (44.83 kg ha^{-1}), microbial density (40.00 CFU g^{-1} bacterial, 30.90 CFU g^{-1} fungi and 26.93 CFU g^{-1}actinomycetes) and nutrient uptake (54.15 kg ha^{-1} N, 6.57 kg ha^{-1} P, 56.47 kg ha^{-1} K). Further, the treatment 150% N content from the recommended FYM was substituted through vermicompost recorded highest available potassium (506.95 kg ha^{-1}).

Marathe *et al.* (2010) reported that significant improvement in available N was observed with the incorporation of vermicompost in soil while available P and K were very high with FYM by pomegranate seedlings. The total nutrient uptake by the seedlings was also highest with vermicompost incorporated in soil. Incorporation of FYM showed complete supremacy in improving nutrient content of leaves, stems and roots of the plants except N.

Pramanik *et al.* (2010) reported that vermicompost application significantly increased the concentration of mineralizable N, available P and exchangeable K in soil. They further emphasized that application of vermicompost increased the proportion of fungal biomass in total soil microorganisms.

Tharmaraj *et al.* (2011) reported that N, P and K in rice cultivated soil were found distinctly enhanced in vermicompost treated soil.

Trivedi *et al.* (2012) reported that maximum N and P uptake were recorded with the incorporation of vermicompost and FYM respectively in guava.

Jayakumar *et al.* (2012) reported that vermicompost could enhance soil biodiversity by promoting the beneficial microbes which inturn enhance plant growth directly by production of plant growth-regulating hormones and enzymes and indirectly by controlling plant pathogens, nematodes and other pests thereby enhancing plant health and minimizing the yield loss.

Dhanushkodi and Kannathasan (2012) recorded the highest available N, P and K with the application of biocompost and vermicompost @ 5 t ha^{-1} each in rice grown soil.

Pant *et al.* (2012) reported that microbial activities in soil increased with increasing concentrations of vermicompost tea in Pak choi. They further reported that vermicompost tea could be used to improve plant nutrient status and enhance soil biological properties in vegetable production.

Khan *et al.* (1974) reported that application of oilcakes of neem, groundnut and castor increased total fungal population in rhizosphere and supported the number of parasitic fungi.

Umareddy (1999) reported that the application of 100% RDN through neem cake significantly increased the available P (38.6 kg P_2O_5 ha^{-1}) over control of 13.44

kg P_2O_5 ha^{-1} and available K in the soil (321.52 kg K_2O ha^{-1}) over control of 226.19 kg K_2O ha^{-1} in soil.

Ojeniyi and Sanni (2000) reported that application of neem fruit powder up to 6 t ha^{-1}increased soil K and leaf P contents of okra significantly.

In tomato, Sable *et al.* (2007) reported that the nutritional value of the soil was increased with application of 25% N through neem cake and 75% N through vermicompost.

Hakeem *et al*. (2007) reported that available nitrogen status was increased with progressive increase in levels of neem cake in in black gram. They also reported that available phosphorus increased with neem cake @ 600 Kg ha^{-1}. However, neem cake @ 300 kg ha^{-1} showed a decrease in available P and K relative to initial status.

Hakeem *et al*. (2008) reported that the uptake of NPK was increased significantly by the application of neem cake and bio-fertilizers in black gram.

Nihad and Jessykutty (2010) reported that application of 50% RDN through FYM and neem cake along with the microbial inoculants mixture recorded highest nutrient uptake, and benefit cost ratio in *Plumbago rosea*.

Patra *et al*. (2011) reported that there was significant improvement in N, P and K uptake by groundnut with the combined application of vermicompost, phospho compost, poultry manure and neem cake each @ 2.5 t ha^{-1}.

Sushanta *et al*. (2012) reported that available N and P content of wheat increased with the increasing levels of nitrogen and neem cake. The uptake of NPK by wheat increased significantly with increasing levels of N up to 60 mg kg^{-1} and neem cake upto 0.125%. But the available K content of soil decreased with the application of N and increased with the application of NC.

Among different combinations of FYM (10, 15 and 20 t ha^{-1}), vermicompost (0.5 and 1.0 t ha^{-1}) and neem cake (0.5 and 1.0 t ha^{-1}), Umesha *et al*. (2011) reported that the highest net returns of Rs. 34,000 ha^{-1} and BC ratio (1.80) were recorded with the application of FYM @ 20 t ha^{-1} + vermicompost @ 1.0 t ha^{-1} + neem cake @ 1.0 t ha^{-1} in *Solanum nigrum*.

Sandeep Kumar (2013) reported that the net returns (Rs.2,99,080 ha^{-1}) and BCR (5.05) were higher with vermicompost (100%) in carrot.

The application of dairy cattle waste and poultry waste composts released approximately 31.5 and 51.3 per cent nitrogen, respectively and had decreased nitrate leaching to deeper soil layer in Kyushu area (Yanwang *et al.*, 2002).

Incorporation of organic substances could increase the micronutrient status in soil depending upon the supply of reducing and chelating substances. In this regard, the studies of Bijay Sijngh *et al.* (1988) observed that the higher concentrations of micronutrients were observed in the soil tested with poultry manure and *Sesbania aculatae*.

Manisha Kachari Korla (2012) reported that inoculation of PSB 1 + 100 per cent phosphorus + recommended dose of nitrogen and potassium recorded highest yield (33.94 t/ha) with cost benefit ratio of 1:2.58 over uninoculated control (FYM) in cauliflower.

Singh *et al.* (2013) reported that the plant grown at fertility level of $N_{200}P_{100}$ K_{100} along with application of Azospirillum as seed and seedlings treatment as well as soil application gave the highest dry matter yield per plant as well as NPK-uptake by plant from the soil in cabbage.

Mathews *et al*. (2006) reported that application of 150% RDF, bio-fertilizers (Azospirillum and PSB) and $ZnSO_4$ at 25 kg ha^{-1} resulted in the highest total uptake of N, P and K and Zn at all the stages of crop growth in rice. Residual N, P and K were also found to be highest for this treatment.

Narayanamma *et al.* (2005) reported that there was a significant increase in the total N, P and K contents of cauliflower curds with the bio-fertilizers (*Azotobacter*, *Azospirillum*, PSB and VAM) compared with the RDF. The use of bio-fertilizers also enhanced the nutrient status of available N, P and K in the soil.

Chapter III

MATERIAL AND METHODS

A field experiment was conducted during *rabi,* 2013-14 to study the **"Effect of different combinations of organic manures and supplementation of bio-fertilizers on growth, yield and quality of Onion (*Allium cepa* L.)"**. The details of material and methods used and the experimental techniques adopted during the course of investigation are described below.

3.1 EXPERIMENTAL SITE

The experiment was laid out at the "college farm", College of Horticulture, Dr. Y.S.R. Horticultural University, Rajendranagar, Hyderabad, Andhra Pradesh. This region falls under VI Agro climatic zone of Andhra Pradesh state. Previously no crops were grown at the experimental site since it was virgin soils.

3.2 CLIMATE AND WEATHER CONDITION

The experimental site is located at college farm, College of Horticulture, Rajendranagar, Hyderabad comes under sub-tropical zone and is situated at a latitude of $17^0 19^1$ N and longitude of $79^0 23^1$ E. The altitude of the place is 542.3 m above mean sea level. The mean annual precipitation on the basis of last ten years was 852 mm which will be received almost from South-West Monsoon during June to October. The average minimum and maximum temperatures recorded during crop growth period were 15.7°C and 29.7°C respectively. The average humidity ranged from 44.38 % to 83.76 %. Hyderabad thus has hot dry summer and moderate cold winter.

The meteorological data were collected from the Agrometerology centre, Agricultural Research Institute (ARI), Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad for the period of November to March, 2014 and furnished in Appendix-I.

3.3 Soil characteristics of the experimental site

The soil of experimental plot was uniform in texture and was levelled before transplanting the seedlings. In order to understand the physical and chemical properties of the soil, a representative soil sample was collected from 15-20 different locations from the surface to a plough depth (15-22 cm). The physical and chemical analysis of the collected soil was done before commencement of the experiment and the details are furnished below.

3.3.1 Physical properties of the experimental site

Ingredient	Quantity (%)	Method adopted
Sand	72.0	International pipette method (Piper,1966)
Silt	8.2	
Clay	19.8	

3.3.2 Chemical properties of the experimental site

Chemical Ingredient	Analysed quantity or %	Method Adopted
Available ‘N’	238.0 kg ha^{-1}	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available ‘P’	36.1 kg ha^{-1}	Olsen’s method (Jackson, 1973)
Available ‘K’	271.0 kg ha^{-1}	Neutral normal ammonium acetate method (Jackson, 1973)
Available ‘S’	12.4 ppm	Barium sulphate turbidimetry method (Chesnin and Yein, 1951)
Organic carbon	0.53 %	Walkley and Black wet oxidation method (Jackson,1973)
pH	6.12	pH meter (Piper, 1966)

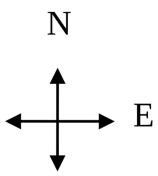
3.4. Technical programme of work

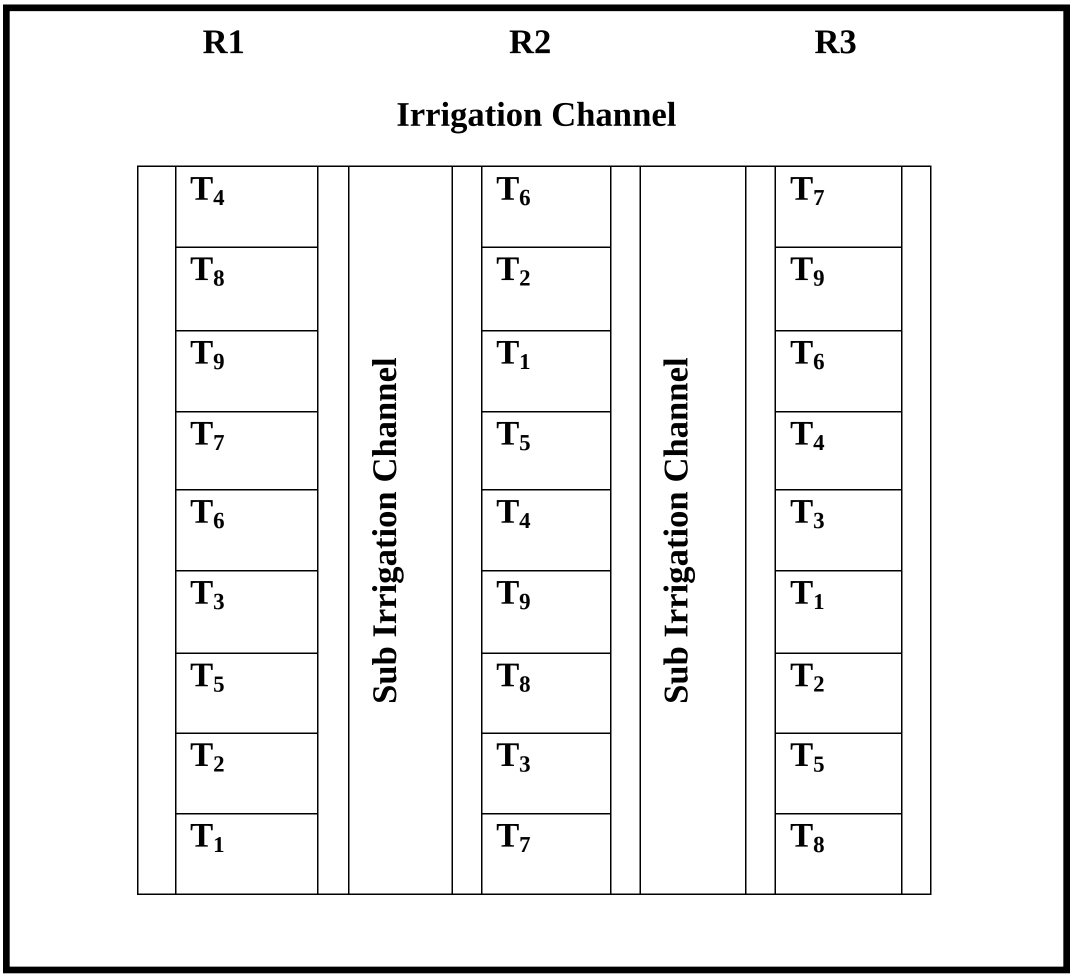
Experimental details

1. Location	: College farm, COH, Rajendranagar
2. Crop	: Onion
3. Variety	: Agrifound Light Red
4. Season	: *rabi*, 2013-14
5. Design	: Randomised Block Design
6. Number of Replications	: 03
7. Number of treatments	: 9
8. Total Number of plots	: 27
9. Row to Row distance	: 15 cm
10. Plant to Plant distance	: 10 cm
11. Gross plot area	: 3.5 m x 2.25 m = 7.875 m^2
12. Net Plot size	: 3.0 m X 2.0 m = 6.0 m^2
13. Date of sowing	: 25th November, 2013
14. Date of Harvesting	: 25th March, 2014
15. Observation intervals	: 30 days

3.5 EXPERIMENTAL MATERIALS

3.5.1 EXPERIMENTAL DESIGN AND LAYOUT:





3.5.2 Treatment details

T_1 : FYM (50%) + VC (50%)

T_2 : FYM (50%) + VC (50%) + BF

T_3 : FYM (50%) + VC (25%) + NC (25%)

T_4 : FYM (50%) + VC (25%) + NC (25%) + BF

T_5 : PM (50%) + VC (50%)

T_6 : PM (50%) +VC (50%) + BF

T_7 : PM (50%) + VC (25%) + NC (25%)

T_8 : PM (50%) + VC (25%) + NC (25%) + BF

T_9 : RDF @ 150:60:60 kg NPK ha^{-1}

FYM = Farmyard manure,

VC = Vermicompost,

NC = Neemcake

PM = Poultry manure,

BF = Bio-fertilizers (*Azospirillum* and PSB @ 5 kg ha^{-1} each)

RDF = Recommended dose of fertilizers.

Manures (FYM, VC, PM and NC) were applied equivalent to RDF on Nitrogen content basis.

3.6 CULTURAL OPERATIONS:

3.6.1 Field preparation

The field was ploughed three times followed by planking to bring the soil to a fine tilth. Clods were broken and the plot was levelled. Before transplanting the seedlings, pre-planting irrigation was given to provide optimum moisture for better establishment of seedlings.

3.6.2 Nursery

The nursery area was ploughed, harrowed and soil was brought to a fine tilth. Raised bed of about 6 metre long, 1 metre width and 15 cm above the ground level was prepared and the top soil was mixed thoroughly with FYM and sand. Later seeds were sown in the bed and watered regularly on alternate days.

3.6.3 Transplanting of seedlings

Transplanting was done at 45 days after sowing (DAS). For bio-fertilizer treatments, *Azospirillum* and *phosphorus solubilizing bacteria* @ 5 kg ha^{-1} each were mixed with FYM, incubated for 3-4 days and applied to the soil 15 days prior to transplanting.

3.6.4 Application of manures and fertilizers

The nutrient contents of the organic manures used in the experiment were analysed and the data are furnished below.

Organic manure	**N (%)**	**P_2O_5 (%)**	**K_2O (%)**
Farmyard manure	**1.20**	0.35	0.55
Vermicompost	**0.95**	0.50	0.55
Poultry manure	**1.03**	1.35	0.67
Neem cake	**0.84**	0.25	1.34

To meet the recommended dose of nitrogen (150 kg ha^{-1}), the quantity of manures applied was calculated and is mentioned here under.

Organic manure	**Quantity applied (t ha^{-1})**
Poultry manure	14.56
Neem cake	17.85
Vermicompost	15.78
Farmyard manure	12.50

As per the treatments, all the manures were applied to the soil 15 days prior to transplanting.

3.6.5 Variety used – AGRIFOUND LIGHT RED

This variety has been developed by National Horticultural Research and Development Foundation (NHRDF), Nashik (Maharashtra), India. Bulbs are globular in shape with tight skin and light red colour. Mature in 110-120 days after transplanting with good keeping quality. Recommended for growing in rabi season all over country.

3.6.6 Weeding and hoeing

In order to keep the soil porus and also free from weeds, hand weeding was done at 30 and 60 days after transplanting. Shallow hoeing was done twice.

3.6.7 Plant protection measures

As any severe attack of pests and diseases were not observed during crop growth period, no plant protection measure was practised.

3.6.8 Irrigation

For establishment of the crop, a light irrigation was given immediately after transplanting. Subsequent irrigations were given as per the crop requirement.

3.6.9 Harvesting

The crop was harvested at maturity at 125 days after sowing when the plants turned yellowish with necrotic leaf tips coupled with neck fall in more than 50% plants. The plants were uprooted from the net plot of each treatment separately and the soil adhered to the bulbs was removed. Then the tops and roots were removed and bulbs were cured under the shade for 8-10 days.

3.7 COLLECTION OF EXPERIMENTAL DATA

3.7.1 GROWTH PARAMETERS

Five plants were selected randomly from each treatment and various morphological, yield and quality parameters were recorded at different stages of crop growth i.e. at 30, 60, 90 DAT and at harvest.

3.7.1.1 Plant height (cm)

The plant height was measured from ground level to the tip of the longest leaf when held vertically. The mean of five plants in all the blocks was worked out for further computation and expressed in centimetres (cm).

3.7.1.2 Leaf length (cm)

The average length of leaves in all five randomly selected and labelled plants was recorded and mean was computed and expressed in centimetres.

3.7.1.3 Number of leaves

The number of fully grown, green and photosynthetically active leaves was recorded and average number of leaves per plant was worked out from the five randomly selected plants.

3.7.1.4 Leaf width (cm)

The width of leaf for five plants was recorded in centimetre at the centre of leaf, when held horizontally and the average width of leaf was worked out.

3.7.1.5 Neck thickness (mm)

The neck thickness below the joint of leaf lamina was measured with the help of vernier calipers and expressed in millimetre. The observations recorded for all the five plants in all the blocks were averaged to get the mean values.

3.7.1.6 Dry weight of leaf (g plant^{-1})

The leaves were dried in oven at 60° C for 72 hours till constant weight was achieved and their average dry weight was recorded and expressed in g plant^{-1}.

3.7.2 Yield parameters

3.7.2.1 Bulb dry weight (g)

The bulbs were dried in oven at 60° C for 72 hours till constant weight was achieved and their average dry weight was recorded and expressed in g $plant^{-1}$.

3.7.2.2 Bulb length (cm)

The length between two polar ends of the bulb was recorded with the help of vernier calipers and mean length was worked out from five bulbs in each block and expressed in centimetres (cm).

3.7.2.3 Bulb diameter (cm)

The diameter at the maximum width of the bulb across the polar length was measured with the help of vernier calipers and expressed in centimetres (cm).

3.7.2.4 Bulb shape index (B.S.I.)

The bulb shape index was worked out by dividing the bulb length with diameter of the bulb.

$$\text{B.S.I.} = \frac{\text{Bulb length}}{\text{Bulb diameter}}$$

The bulbs with index value 1 were considered as 'globular', those with less than 1 as 'flat' and the bulbs with a value of more than 1 are considered as 'torpedo'.

3.7.2.5 Number of scales per bulb

The bulbs were cut across the bulb length with help of a sharp knife. The number of complete fleshy rings encircling the growing center was recorded from five bulbs. Then the mean number of rings per bulb was computed.

3.7.2.6 Bulb yield (kg plot^{-1})

The bulbs were harvested from the net plot (3m x 2m) from each treatment and total bulb weight was recorded. The bulb weight was expressed as bulb yield per plot in kilogramme.

3.7.2.7 Number of bulbs (kg^{-1})

The number of bulbs per kg was recorded in each treatment of the experiment.

3.7.2.8 Bulb yield (t ha^{-1}) and Dry matter Production (kg ha^{-1})

The total bulb yield was obtained after harvest of the crop. The bulbs were weighed after separating from the top. Then, yield in tonnes per ha was computed from the yield obtained from net plot. Dry matter production was calculated using the formula

$$\text{Bulb dry matter production (kg ha}^{-1}\text{)} = \frac{\text{Yield (kg ha}^{-1}\text{) x (100-Moisture(\%))}}{100}$$

3.7.2.9 Double bulbs (%)

The bulbs having splits or doubles were recorded after the harvest. Then the percentage of doubles/splits was worked out for each block.

3.7.3 QUALITY PARAMETERS

The following quality parameters were recorded from five plants randomly selected from each treatment at harvest.

3.7.3.1 Phosphorus and sulphur content (%)

Phosphorus and sulphur contents were estimated in bulbs by using Colorimetric phospho-vanado molybdate method (Jackson, 1973) and 'Barium sulphate turbidimetry method' (Chesnin and Yein, 1951) respectively and expressed in per cent.

3.7.3.2 Moisture content (%)

Moisture content was determined by oven dry method at 60°C for 72 hours till constant weight was achieved and after taking differences in the initial weight of the sample and the final weight. It is finally expressed as percentage.

3.7.3.3 Total soluble solids (TSS) $^{\circ}$Brix

The total soluble solids were recorded using hand refractometer and the mean obtained was expressed in $^{\circ}$Brix.

3.7.3.4 Physiological loss in weight (%)

The weight of onion bulbs was recorded at every 7 days. The physiological loss in weight was calculated with the help of following formula.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}}$$

3.7.3.5 Sprouting of bulbs (%)

The total number of bulbs sprouted during the storage was recorded and expressed in percentage.

$$\text{Sprouting (\%)} = \frac{\text{Number of sprouted bulbs}}{\text{Total number of bulbs}} \times 100$$

3.7.3.6 Rotting of bulbs (%)

The total number of onion bulbs spoiled due to rotting were counted and computed into percent.

$$\text{Rotting (\%)} = \frac{\text{Number of decayed bulbs}}{\text{Total number of bulbs}} \times 100$$

3.7.3.7 Marketable yield (%)

At the end of storage period (30 DAS), the rotted and sprouted bulbs were separated and the weight of healthy bulbs was recorded. The recovery of marketable bulbs was calculated by using the following formula.

$$\text{Marketable yield (\%)} = \frac{\text{Weight of the healthy bulbs obtained}}{\text{Initial weight of bulbs stored}} \times 100$$

3.7.4. OTHER PARAMETERS

3.7.4.1 Nutrient uptake by the plant (kg ha^{-1})

The bulbs of onion were estimated for their nitrogen, phosphorus, potassium and sulphur contents using Microkjeldhal method (AOAC, 1969), Vanado molybdophosphoric yellow colour method, Elico-Flame Photometer method (Piper, 1966) and 'Barium sulphate turbidimetry method' (Chesnin and Yein, 1951) respectively.

The nutrient uptake was computed using the formula

$$\text{Bulb nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Bulb dry matter production (kg ha}^{-1})}{}$$

3.7.4.2 Nutrient status of post harvest soil (kg ha^{-1})

The available soil nitrogen, phosphorus, potassium and sulphur were determined by alkaline permanganate method (Subbaiah and Asija,1956), Olsen's method, Flame Photometer of Elico-22A (Muhr *et al*., 1965) method and 'Barium sulphate turbidimetry method' (Chesnin and Yein, 1951)respectively.

3.7.4.3 Microbial count (Bacteria, fungi and actinomycetes) (CFU g^{-1} of soil)

Population of bacteria, fungi and actinomycetes in the soils of different organically treated plots were enumerated by serial dilution plate method (Johnson and Curl, 1972).

The serial dilution plate technique was employed to enumerate the rhizosphere soil bacteria, fungi and actinomycetes. Nutrient agar, potato dextrose agar and actinomycetes isolation agar media were used for isolation of soil bacteria, fungi and actinomycetes respectively. The inoculated petri plates were incubated at 30±1°C for 24 hrs, 25±1°C for 5 days and 30±1°C for one week for bacteria, fungi and actinomycetes respectively. After the incubation period, the colony forming units were counted and expressed as CFU g^{-1} of soil on a moisture free basis.

3.7.5 ECONOMICS OF TREATMENTS

The economics of different treatments were worked out in terms of net returns ha^{-1} and cost of the treatment. The benefit cost (BC) ratio was also calculated treatment wise to ascertain economic viability of the treatment. Cost of production and net profit were calculated on the basis of prevailing prices of product and inputs.

3.7.6 STATISTICAL ANALYSIS

The data obtained on various observations for each treatment were subjected to "Analysis of Variance" as recommended by Panse and Sukhatme (1985).

Chapter IV

RESULTS AND DISCUSSION

The effect of different organic manures viz, FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at various stages of crop growth in onion with respect to plant growth, yield, quality, nutrient uptake, post-harvest soil nutrient status, microbial count and benefit cost ratio were studied. The results of the present investigations on the above aspects are presented hereunder.

4.1. GROWTH PARAMETERS

Data on growth parameters of onion crop as influenced by different organic manures and their combinations are presented in Tables 1 to 6.

4.1.1 Plant height (cm)

The plant height was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 1 & Figure 1.

The highest plant height was recorded in T_4 (29.32, 47.31, 54.31 and 55.18 cm at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (28.68, 47.23, 54.23 and 55.12 cm at 30, 60, 90 and 120 DAT respectively) with recommended dose of fertilizers which were significantly superior to all other treatments. The lowest plant height was recorded in T_3 (27.07, 46.02, 52.62 and 53.40 cm at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%).

4.1.2. Leaf length (cm)

The leaf length was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 2.

Similar to the plant height, the highest leaf length was also recorded in T_4 (25.34, 43.35, 46.83 and 45.30 cm at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (25.22, 43.14, 46.24 and 45.18 cm at 30, 60, 90 and 120 DAT respectively) with recommended dose of fertilizers which were significantly superior to all other treatments. However, the lowest leaf length was recorded in T_7 (23.72, 41.70, 45.03 and 42.93 cm at 30, 60, 90 and 120 DAT respectively) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%).

4.1.3. Number of leaves per plant

The number of leaves per plant was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 3.

Similar to the plant height and the leaf length, the highest number of leaves per plant were also recorded in T_4 (5.29, 8.50, 14.39 and 18.27 at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (5.19, 7.70, 14.26 and 18.15 at 30, 60, 90 and 120 DAT respectively) with recommended dose of fertilizers which were significantly superior to all other treatments. The lowest number of leaves was recorded in T_1 (4.10, 5.60, 13.27 and 17.11 cm at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (50%).

4.1.4. Neck thickness (mm)

There was no significant difference found among various treatments of organic manures with respect to neck thickness at different stages of plant growth. The results are presented in Table 4. However, numerically higher neck thickness was observed with T_9 treatment receiving RDF and lowest neck thickness was obtained in T_2 with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each .

4.1.5. Leaf width (cm)

Similar to neck thickness, there was no significant difference found among various treatments of organic manures with respect to leaf width at different stages of plant growth. The results are presented in Table 5. However, numerically higher leaf width was observed with T_9 treatment receiving RDF and lowest at T_5 with poultry manure (50%) + vermicompost (50%).

4.1.6. Leaf dry weight (g)

The leaf dry weight was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 6.

Similar to the plant height, leaf length and number of leaves per plant, the highest leaf dry weight was also recorded in T_4 (0.50, 1.43, 2.92 and 9.46 g at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (0.45, 1.40, 2.33 and 9.28 g at 30, 60, 90 and 120 DAT respectively) with recommended dose of fertilizers which were significantly superior to all other treatments. The lowest leaf dry weight was recorded in T_3 (0.12, 0.88, 1.75 and 7.48 g at 30, 60, 90 and 120 DAT respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%).

The morphological features like plant height, leaf length, number of leaves and leaf dry weight were greatly influenced by organic sources.

The increased plant height with the application of farmyard manure, vermicompost and neem cake may be attributed to their higher N content of 1.20, 0.95 and 0.84 % respectively. The increase in plant height due the application of vermicompost may be due to its rich content of macro and micro nutrients, vitamins, growth hormones and micro flora (Bhavalkar, 1991).

Similar results of increased plant height with FYM were reported in chilli (Surlekov and Pankov, 1989) and maize (Kumpawat, 2004 ; Balyan *et al.*, 2006), with vermicompost in onion (Reddy and Reddy, 2005), spinach (Peyvast *et al.* 2008a), mulberry (Ranuma *et al*. 2012), pepper (Lopez *et al*. 2012), brinjal (Mamta and Rao, 2012) and anise (Darzi *et al.*, 2012), with neem cake in tomato (Amerendra kumar *et al.*, 1997), with poultry manure in amaranthus (Warncke and Siregar, 1992), with FYM, vermicompost and neem cake in *Solanum nigrum* (Umesha *et al.*, 2011), with vermicompost and neem cake in baby corn (Murugan, 2000), with neem cake and bio-fertilizers in blackgram (Hakeem *et al.*, 2008) and with poultry manure, neem cake and panchakavya in moringa (Beaulah, 2001). Similar to plant height, Reddy and Reddy (2005) further recorded significant increase in number of leaves plant^{-1} with increasing levels of vermicompost (from 10 to 30 t ha^{-1}) in onion (cv. N-53). Thanunathan *et al.* (1997) also reported that application of vermicompost appears to be very effective amendment in onion.

The leaf dry weight increased with the age of the crop registering the highest at harvest with the application of different combinations of organic manures. The increase in leaf dry weight may be due to progressive increase in plant height, number of leaves plant^{-1} and leaf length. Similar findings were made by Chauhan and Sekhawat (1971) and Neeraja (1998). The FYM can substitute inorganic fertilizers to maintain productivity and environmental quality (Choudhary *et al.* 2002 in chilli ; Bhuma, 2001). Neem cake was found very effective in significantly increasing the root fresh weight of japanese mint (Singh and Vinod Kumar, 1995).

4.2. YIELD PARAMETERS

Data on yield parameters of onion crop as influenced by different organic manures and their combinations are presented in Tables 7 to 8.

4.2.1. Bulb dry weight (g)

The bulb dry weight was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 7.

The highest bulb dry weight was recorded in T_4 (89.00 g) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (87.50 g) with recommended dose of fertilizers which were at par but significantly superior to all other treatments. The lowest bulb dry weight was recorded in T_5 (80.66 g) with poultry manure (50%) + vermicompost (50%).

4.2.2. Bulb length (cm)

The bulb length was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 7.

Similar to the bulb dry weight, the highest bulb length was also recorded in T_4 (7.60 cm) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (7.50 cm) with recommended dose of fertilizers which were at par but significantly superior to all other treatments. The lowest bulb length was also recorded in T_5 (6.08 cm) with poultry manure (50%) + vermicompost (50%).

4.2.3. Bulb diameter (cm)

The bulb diameter was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 7.

Similar to the bulb dry weight, bulb length the highest bulb diameter was also recorded in T_4 (8.20 cm) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (8.12 cm) with recommended dose of fertilizers which were at par but significantly superior to all other treatments. The lowest bulb diameter was also recorded in T_5 (6.35 cm) with poultry manure (50%) + vermicompost (50%).

4.2.4. Bulb shape index

There was no significant difference among various treatments of organic manures with respect to bulb shape index at different stages of plant growth. The results are presented in Table 7. However, numerically higher bulb shape index was observed with treatment receiving with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each and lowest bulb shape index was also obtained at poultry manure (50%) + vermicompost (50%).

4.2.5. Number of scales per bulb

The number of scales per bulb was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 8.

Similar to the bulb dry weight, bulb length and bulb diameter the highest number of scales per bulb was also recorded in T_4 (8.40) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (7.60) with recommended dose of fertilizers which were significantly superior to all other treatments. The lowest number of scales per bulb was also recorded in T_5 (6.20) with poultry manure (50%) + vermicompost (50%).

4.2.6. Bulb yield per plot (kg)

The bulb yield per plot was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 8.

Similar to the bulb dry weight, bulb length, bulb diameter and number of scales per bulb the highest bulb yield per plot was also recorded in T_4 (11.20 kg) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (11.04 kg) with recommended dose of fertilizers which were significantly superior to all other treatments. The lowest bulb yield per plot was also recorded in T_5 (8.04 kg) with poultry manure (50%) + vermicompost (50%).

4.2.7. Number of bulbs per kg

The number of bulbs per kg was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 8.

The highest number of bulbs per kg was recorded in T_5 (13.56) with poultry manure (50%) + vermicompost (50%) followed by T_1 (13.11) with farmyard manure (50%) + vermicompost (50%) which were significantly superior to all other treatments. The lowest number of bulbs per kg was recorded in T_4 (11.33) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

4.2.8. Bulb yield per hectare (t ha^{-1})

The bulb yield per hectare was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 8 & Figure 2.

Similar to the bulb dry weight, bulb length, bulb diameter, number of scales per bulb, bulb yield per plot and number of bulbs per kg the highest bulb yield per hectare was also recorded in T_4 (18.66 t ha^{-1}) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (18.40 t ha^{-1}) with recommended dose of fertilizers which were significantly superior to all other treatments. The lowest bulb yield per hectare was recorded in T_5 (13.40 t ha^{-1}) with poultry manure (50%) + vermicompost (50%).

4.2.9. Double bulbs (%)

The double bulbs was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 8.

The highest double bulbs was recorded in T_5 (7.70 %) with poultry manure (50%) + vermicompost (50%) followed by T_7 (6.73 %) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) which were at par but significantly superior to all other treatments. The lowest double bulbs was recorded in T_3 (4.53 %) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%).

Bulb yield of onion differed significantly due to different organic manure combinations and inoculation of bio-fertilizers. In the present study, among the various manurial treatment combinations tried, maximum yield (18.66 t/ha) was recorded with FYM + vermicompost + neem cake + bio-fertilizers. This increased yield might be due to increased yield attributing characters like photosynthetic potential, total dry matter, number of scales, polar and equatorial diameter. The present results are in colloboration with the findings of Subbaiah *et al*. (1983) in brinjal and Ushakumari *et al*. (1996) in bhendi.

It is relevant to note that, farmyard manure seems to be directly responsible in increasing crop yields either by accelerating the respiratory process by increasing cell permeability by hormone growth action or by combination of all these processes. It supplies nitrogen, phosphorus and potassium of which phosphorus is involved in cell division, photosynthesis and metabolism of carbohydrates where as potash regulates proper translocation of photosynthates and stimulates enzyme activity which in turn might have increased the rate of growth and positive development in yield characters leading to high bulb yield of onion.

Further, it is noticed that FYM increased the soil organic matter and improved the soil structure. This would have reduced the loss of nitrogen by increased cation and anion exchange capacities in soil, thereby enhancing the bulb development and yield. Further, by improving the structure of the soil by more aggregation, water holding capacity and air permeability are increased. These comprehensive changes in soil might have improved the bulb development. This is in line with the findings of Mizuno (1996).

The increased yields with FYM were reported in onion (Shete *et al*., 1993; Thanunathan *et al.*, 1997; Alkaff *et al.,* 2002; Patil *et al.*, 2005), turmeric (Shaha,1988; Balashanmugam *et al.,* 1989), potato (Grewal and Trehan, 1984), palmarosa (Maheswari *et al*., 1991), cucumber (Nirmala *et al*., 1999), wheat (Kler and Walia, 2006), tomato (Patil *et al.*, 2004) and sweet corn (Dalavi *et al*., 2009).

Vermicompost acts as a chelating agent and regulates the availability of micronutrients for plants thereby increase the growth and yield by providing nutrients in available form. Similar results were also obtained by Yadav and Vijayakumari, (2003) in chilli and Jayathilake *et al.* (2003) and Gunjan Aswini *et al.* (2005) in onion.

In onion (cv. N-53), Reddy and Reddy (2005) recorded that the bulb length, diameter, weight and yield increased significantly with increasing levels of vermicompost (from 10 to 30 t ha^{-1}). Similar results of increased yields with vermicompost were reported in onion (Shete *et al*., 1993; Bybordi and Malakouti, 2007), sugar beet (Kopczynski *et al.*, 1999), brinjal (Tomar *et al.*, 1998), guava (Naik and Babu, 2007), chickpea (Raghwendra *et al.,* 2008), parsley (Peyvast *et al.,* 2008b), red amaranth (Alam *et al.,* 2011), anise (Darzi *et al.,* 2012) and mulberry (Ranuma *et al*., 2012). The increased dry weight with the application of vermicompost was also reported in chillies (Yadav and Vijayakumari, 2003) and pepper (Lopez *et al*., 2012).

The increased yields were also reported with neem cake in safed musli (Paturde *et al*., 2002), moringa (Ramachandra and Bhaskar, 1996), tomato (Amarendra Kumar *et al*., 1997), sesame (Anon., 1997 and 1998), radish (Sharma *et al*., 1986), okra (Ojeniyi and Sanni, 2000), tomato (Renuka and Shankar, 2001) and betel vine (Arulmozhiyan *et al*., 2002). The increased dry weight was also reported with the application of neem cake and panchakavya in moringa (Ramachandra and Bhaskar, 1996) and with neem cake and bio-fertilizers in black gram (Hakeem *et al*., 2008).

Higher yields with FYM, *Azospirillum* and PSB were reported in brinjal (Nanthakumar and Veeraghavathatham, 1999) and tomato (Duraisamy *et al.*, 1999).

The increase in bulb diameter and length in the present study may be attributed to solubilization of plant nutrients by addition of FYM, vermicompost, neem cake and bio-fertilizers leading to increase in uptake of N, P, K (Subbaiah *et al.*, 1982). The results are in agreement with the findings of Renuka and Ravishankar (1998) and Giraddi (1993) in onion.

The difference in the yield and yield components could be related to improved vegetative growth and vigour of the plant as influenced by beneficial effects of organics on vegetative growth of crops as reported by several workers (Patil, 1995 in onion; Kale *et al*., 1991 in cereals, vegetables and ornamental plants; Suresh 1997 in garlic; Krishna, 2002 in tomato, Mamata, 2006 in onion).

4.3. QUALITY PARAMETERS

Data on various quality parameters of onion crop as influenced by the different organic manures and their combinations are presented in Tables 9 to 14.

4.3.1. Phosphorus and Sulphur content (%)

The phosphorus and sulphur content was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 9.

The highest phosphorus and sulphur content (0.54 % and 0.49 %) was recorded in T_4 with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_8 (0.47 % and 0.48 %) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were significantly superior to all other treatments.

The lowest phosphorus and sulphur content was recorded in T_5 (0.40 % and 0.36 %) with poultry manure (50%) + vermicompost (50%).

4.3.2. Moisture content (%)

There was no significant difference found among various treatments of organic manures with respect to moisture content. The results are presented in Table 9. However, numerically higher moisture content was observed with treatment receiving farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each and lowest moisture content was obtained with RDF.

4.3.3. Total soluble solids (°Brix)

The total soluble solids was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 10.

The highest total soluble solids was recorded in T_4 (13.57, 13.64, 13.71, 13.79 and 13.80 °Brix at 0, 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_5 (12.88, 12.92, 12.96, 13.02 and 13.14 °Brix at 0, 7, 14, 21 and 30 DAS respectively) with poultry manure (50%) + vermicompost (50%) which were significantly superior to all other treatments. The lowest total soluble solids was recorded in T_9 (10.68, 10.74, 10.83, 10.94 and 11.02 °Brix at 0, 7, 14, 21 and 30 DAS respectively) with recommended dose of fertilizers.

4.3.4. Physiological loss of weight (%)

The physiological loss of weight was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 11.

The lowest physiological loss of weight was recorded in T_3 (1.03, 1.70, 2.48 and 3.82 % at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) followed by T_2 (1.07, 1.80, 2.51 and 4.18 % at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The highest physiological loss of weight was recorded in T_9 (1.44, 2.70, 3.67 and 4.83 % at 7, 14, 21 and 30 DAS respectively) with recommended dose of fertilizers.

4.3.5. Sprouting of bulbs (%)

The sprouting of bulbs was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 12 & Figure 3.

Similar to the physiological loss of weight, the lowest sprouting of bulbs was recorded in T_3 (1.07, 2.10, 3.01 and 3.49 % at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) followed by T_2 (1.12, 2.22, 3.02 and 3.56 % at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The highest sprouting of bulbs was also recorded in T_9 (2.06, 3.39, 4.13 and 5.23 % at 7, 14, 21 and 30 DAS respectively) with recommended dose of fertilizers.

4.3.6. Rotting of bulbs (%)

The rotting of bulbs was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 13.

Similar to the physiological loss of weight and sprouting of bulbs, the lowest rotting of bulbs was also recorded in T_3 (0.45, 0.80, 1.80 and 2.27 % at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) followed by T_2 (0.47, 0.90, 1.90 and 2.28 % at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and

PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The highest rotting of bulbs was also recorded in T_9 (0.59, 1.80, 2.52 and 3.50 % at 7, 14, 21 and 30 DAS respectively) with recommended dose of fertilizers.

4.3.7. Marketable yield

The marketable yield was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers at different stages of plant growth. The results are presented in Table 14.

The highest marketable yield was recorded in T_8 (98.92, 97.92, 94.87 and 92.82 % at 7, 14, 21 and 30 DAS respectively) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_4 (98.14, 97.18, 94.24 and 92.24 at 7, 14, 21 and 30 DAS respectively) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The lowest marketable yield was recorded in T_7 (95.34, 94.09, 90.87 and 89.84 at 7, 14, 21 and 30 DAS respectively) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%).

Among the organic sources, the highest storage loss was incurred due to the treatment Recommended Dose of NPK. This may be attributed to application of urea, SSP and MOP which normally tend to develop soft tissues with high moisture content which in turn renders bulbs to higher storage loss in onion (Gopalkrishna and Srinivas, 1990).

The treatment ‘Recommended Dose of NPK’ exhibited higher sprouting loss. Whereas, the organic sources, FYM, vermcompost and neem cake exhibited significantly low sprouting losses, reflecting the requirement of proper source of nutrients for the better availability of nitrogen. Similar results have been reported by Patil (1995) and Anonymous (1996). The rate of sprouting increased with the storage period which is in conformity with the results obtained by Kuknoor (2005).

The loss due to rotting was also significantly higher with the application of Recommended Dose of NPK. This increase in rotting due to NPK indicates the role of nitrogen in the form of urea. Whereas onion grown with “FYM, vermicompost and neem cake” exhibited least loss due to rotting. The organic sources like FYM, vermicompost, neem cake, and bio-fertilizers resulted in significantly low rotting losses in onion during storage. Beneficial effects of organics in reducing the post harvest rotting of horticultural crops have been reported in onion (Patil,1995), tomato (Krishna, 2002) and garlic (Suresh,1997).

The TSS level increased in storage for one month in all the treatments. These results are in conformity with Dabhi *et al*. (2008). Increase in TSS as a quality parameter may be due to increased availability of major as well as minor nutrients, as major nutrients especially nitrogen and potassium play vital role in enhancing quality of produce. The treatments having the combination of FYM, vermcompost, neem cake and bio-fertilizers could be able to produce onion of better quality as rendered by high TSS. The beneficial effect of bio-fertilizers may be attributed to increased activity of microbes which might have resulted in release of more amount of gibberellins, auxins and cytokinins. These growth hormones in turn accelerate the physiological process like synthesis of carbohydrates and might have other proximate substances. Similar results of increased TSS with FYM + RDF in tomato (Patil *et al.,* 2004), with vermicompost in spinach (Peyvast *et al.,* 2008) and tomato (Singh *et al*., 2010) and with neem cake and vermicompost in tomato (Sable *et al*., 2007) have been reported earlier.

4.4. OTHER PARAMETERS

Data on other parameters of onion crop such as nutrient uptake, post-harvest soil nutrient status, microbial count and benefit cost ratio as influenced by the different organic manures and their combinations are presented in Tables 15 to 18 & Figure 4.

4.4.1. Nutrient uptake

The N, P, K and S uptake by the onion bulb was significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 15.

4.4.1.1. Nitrogen uptake (kg ha^{-1})

The highest nitrogen uptake (44.41 kg ha^{-1}) was recorded in T_4 with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (43.80 kg ha^{-1}) with RDF which were significantly superior to all other treatments. The lowest was recorded in T_5 (20.91 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%).

The increased N uptake could be due to increased and prolonged availability of N to the plants in these treatments and also due to increased dry matter yield. Nutrient uptake is a positive function of dry matter yield (Ramakal *et al*., 1988). This is in consonance with the findings of Chalapathi *et al*. (1997) in stevia and Mallangouda *et al*. (1995) in onion and garlic.

4.4.1.2. Phosphorus uptake (kg ha^{-1})

Similar to the nitrogen uptake the highest phosphorus uptake (9.44 kg ha^{-1}) was also recorded in T_4 with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (8.51 kg ha^{-1}) with RDF which were significantly superior to all other treatments. The lowest was also recorded in T_5 (5.63 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%).

Normally phosphorus is said to be in fixed form and its absorption is a slow process or sometimes not available. Interestingly, in the present study plant supplied with the organic manures have recorded larger uptake of phosphorus. This could be attributed to their chelating action in making ions available and maintaining soil physical condition. It could also be due to the increased availability of P due to the solubility effect of organic acids which were produced from the decomposing organic manures. Further FYM and vermicompost might also have reduced the fixation of P and increased the availability of P in soil solution for its better absorption resulting in increased uptake of P in onion.

Neem cake contains 0.25% of P in addition to nitrogen. The additional phosphorus might be one of the reasons for improving the uptake of P by the plants. More over neem cake might have enriched the soil with additional phosphorus and improved the water retention capacity of the soil and thereby maintained a condusive environment in the soil for making phosphorus more available to the plants in higher quantities (Bringi, 1987).

4.4.1.3. Potassium uptake (kg ha^{-1})

The highest potassium uptake (56.78 kg ha^{-1}) was also recorded in T_4 with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (54.91 kg ha^{-1}) with RDF which were significantly superior to all other treatments. The lowest was also recorded in T_5 (33.01 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%).

Nitrogen possibly might have influenced the potassium uptake by virtue of its complementary action with potassium. The increase in K uptake was due to the increased availability of nutrients from the native, as well as from the mineralized organic manures which might have increased the concentration of K in soil solution making it readily available for absorption. Similar trend was recorded in onion by Geeta (1994). Potash likely to be maintained in exchangeable form in soil treated with organic manures, which in turn might have restricted the K^+ ions getting fixed by inorganic clay particles in soil.

The increased uptake of NPK due to addition of organic manure is due to the action of organic acids which form organic matter complex. Some of which in addition to influencing pH, form stable complexes or chelated compounds with cations responsible for phosphate fixation (Prabhu *et al*., 2002). The application of FYM, vermicompost and neem cake, in combination with bio-fertilizers significantly increased yield, improved the chemical properties of the soil, increased the nutrient availability and thereby lead to increased nutrient uptake by onion.

4.4.1.4. Sulphur uptake (kg ha^{-1})

The highest sulphur uptake (8.69 kg ha^{-1}) was recorded in T_4 with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_9 (8.61 kg ha^{-1}) with RDF which were significantly superior to all other treatments. The lowest was also recorded in T_5 (5.07 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%).

4.4.1.5. Dry matter (kg ha^{-1})

The highest dry matter (1,955 kg ha^{-1}) was recorded in T_9 with RDF followed by T_7 (1,817 kg ha^{-1}) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) which were significantly superior to all other treatments. The lowest was recorded in T_5 (1,407 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%).

The uptake of NPK was increased significantly with the application of vermicompost in pearl millet (Narolia *et al.*, 2009), brinjal (Nihad and Jessykutty, 2010), pomegranate (Marathe *et al.*, 2010) and fenugreek (Deora and Jitendra Singh, 2008), with neem cake in okra (Ojeniyi and Sanni, 2000) and wheat (Sushanta *et al*., 2012) and with bio-fertilizers in cauliflower (Narayanamma *et al.*, 2005).

4.4.2. Nutrient status of the soil after harvest of the crop

The available N, P_2O_5, K_2O and S were significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 16.

4.4.2.1. Available nitrogen (kg ha^{-1})

The highest post-harvest available soil nitrogen (282.12 kg ha^{-1}) was recorded in T_5 with poultry manure (50%) + vermicompost (50%) followed by T_6 (265.34 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. RDF recorded an available nitrogen of 205.33 kg ha^{-1} and the lowest was recorded in T_4 (191.54 kg ha^{-1}) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

4.4.2.2. Available phosphorus (kg ha^{-1})

Similar to the post-harvest available soil nitrogen, the highest post-harvest available soil phosphorus (36.51 kg ha^{-1}) was also recorded in T_5 with poultry manure (50%) + vermicompost (50%) followed by T_6 (33.55 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were significantly superior to all other treatments. RDF recorded an available phosphorus of 25.15 kg ha^{-1} and the lowest was also recorded in T_4 (23.70 kg ha^{-1}) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each. The build up of available P in the soil could be due to the organic acids which were released during the microbial decomposition of vermicompost increasing the available P in soil (Khan *et al*., 1974).

4.4.2.3. Available potassium (kg ha^{-1})

Similar to the post-harvest available soil nitrogen, post-harvest available soil phosphorus the highest post-harvest available soil potassium (332.99 kg ha^{-1}) was also recorded in T_5 with poultry manure (50%) + vermicompost (50%) followed by T_6 (320.23 kg ha^{-1}) with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. RDF recorded an available potassium of 256.68 kg ha^{-1} and the lowest was also recorded in T_4 (241.30 kg ha^{-1}) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each. The higher build up of available K in soil due to the reduction of K fixation, release of K due to the interaction of organic matter with clay, and direct addition of K to the available pool of soil.

4.4.2.4. Available sulphur (ppm)

Similar to the post-harvest available soil nitrogen, post-harvest available soil phosphorus and post-harvest available soil potassium the highest post-harvest available soil sulphur (25.81 ppm) was also recorded in T_5 with poultry manure (50%) + vermicompost (50%) followed by T_6 (25.18 ppm) with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were significantly superior to all other treatments. RDF recorded an available phosphorus of 17.83 ppm and the lowest was also recorded in T_4 (15.68 ppm) with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

The organic manures positively influenced the available NPK contents of soil after the crop harvest. The increase in available NPK may be due to added supply of nutrients and proliferous root system developed under balanced nutrient application resulting in better absorption of water and nutrient along with improved physical environment (Devender *et al*., 1998). The availability of nutrients can be attributed to the solubilizing effect of minerals by decomposing FYM (Subbiah, 1982). This might also be due to the direct addition and slow release of NPK through neem cake added to the soil.

The increase in available NPK indicated that the NPK present in the manure was available to the crop and the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers would have increased the available NPK content in soil. Similar results were obtained in chilli by Rajesh (1997) and Doikova (1979) in brinjal.

The available NPK was increased significantly with the application of FYM in ragi (Chellamuthu, 1978) with vermicompost in wheat (Sunita *et al.,* 2007) and fenugreek (Deora and Jitendra Singh, 2008), with neem cake in okra (Ojeniyi and Sanni, 2000) and wheat (Sushanta *et al*., 2012) and with bio-fertilizers in cauliflower (Narayanamma *et al.,* 2005).

4.4.3. Microbial count in the soil

Bacteria, fungi and actinomycetes in the soil were significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 17 & Figure 4.

4.4.3.1. Bacteria (CFU X 10^6 g soil^{-1})

The highest bacterial count (42.52 CFU X 10^6 g soil^{-1}) was recorded in T_6 with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_8 (41.50 CFU X 10^6 g soil^{-1}) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The lowest bacterial count (30.93 CFU X 10^6 g soil^{-1}) was recorded in RDF.

4.4.3.2. Fungi (CFU X 10^3 g soil^{-1})

Similar to the bacteria, the highest fungi count (26.22 CFU X 10^3 g soil^{-1}) was also recorded in T_6 with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_8 (25.91 CFU X 10^3 g soil^{-1}) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The lowest fungi count (20.46 CFU X 10^3 g soil^{-1}) was also recorded in RDF.

4.4.3.3. Actinomycetes (CFU X 10^4 g soil^{-1})

Similar to the bacteria, fungi the highest actinomycetes count (21.30 CFU X 10^4 g soil^{-1}) was also recorded in T_6 with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each followed by T_8 (20.93 CFU X 10^4 g soil^{-1}) with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments. The lowest actinomycetes count (14.50 CFU X 10^4 g soil^{-1}) was also recorded in RDF.

Khan *et al.* (1974) reported that application of neem cake increased total fungal population in rhizosphere and supported the number of parasitic fungi. Nihad and Jessykutty (2010) reported that the nitrogen content from the recommended FYM was substituted through vermicompost and green manure (50% each) + RDF (125:100:50 kg ha^{-1}) recorded the highest microbial density of the soil (40.50 CFU g^{-1} bacterial, 31.00 CFU g^{-1} fungi and 27.00 CFU g^{-1}actinomycetes) of brinjal plants.

Poultry manure in combination with vermicompost recorded better results for all the microbes analyzed, which may be attributed to the congenial environment for the multiplication of the microbes. The lowest population of microbes in the soil applied with chemical fertilizers may be due to low natural population and also due to the lower availability of organic substrates in the soil not applied with organic manures (Bhawalkar, 1991).

4.4.4. Benefit-cost ratio of the treatments

Net returns and benefit cost ratio of the treatments were significantly affected by the application of FYM, vermicompost, poultry manure, neem cake and bio-fertilizers. The results are presented in Table 18.

4.4.4.1. Net returns (Rs. ha^{-1})

The maximum net returns (Rs. 2,15,154 ha^{-1}) were recorded in T_9 with RDF followed by T_2 (Rs. 1,92,440 ha^{-1}) with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

4.4.4.2. Benefit-cost ratio

Similar to the net returns the highest benefit cost ratio (3.53) was also recorded in T_9 with RDF followed by T_2 (3.37) with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

In general, the benefit cost ratio was found to be greater than unity in all the treatments, indicating fairly higher returns on every rupee invested. The treatments T_9 with RDF and T_2 with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each recorded higher values for benefit cost ratio due to their lower cost of cultivation compared to other treatments.

The net returns and benefit cost ratio increased significantly with the application of vermicompost in pearl millet (Narolia *et al.*, 2009) and carrot (Sandeep Kumar, 2013), with FYM, vermicompost and neem cake in *Solanum nigrum* (Umesha *et al.*, 2011) and with FYM, neem cake and bio-fertilizers in *Plumbago rosea* (Nihad and Jessykutty, 2010).

Table 1. Plant height (cm) of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

Treatments	30 DAT	60 DAT	90 DAT	120 DAT
T_1 : FYM (50%) + Vermicompost (50%)	27.14	46.17	53.01	54.28
T_2 : FYM (50%) + Vermicompost (50%) + BF	27.26	46.47	53.21	54.66
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	27.07	46.02	52.62	53.40
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	29.32	47.31	54.31	55.18
T_5 : Poultry manure(50%) + Vermicompost (50%)	27.11	46.12	52.76	53.83
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	27.62	46.28	53.27	54.43
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	27.53	46.30	53.34	54.31
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	28.35	47.06	54.10	55.07
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	28.68	47.23	54.23	55.12
S Em±	0.009	0.008	0.009	0.01
CD	0.02	0.02	0.02	0.04

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAT= Days After Transplanting.

Table 2. Leaf length (cm) of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

Treatments	30 DAT	60 DAT	90 DAT	120 DAT
T_1 : FYM (50%) + Vermicompost (50%)	24.50	42.68	45.32	44.46
T_2 : FYM (50%) + Vermicompost (50%) + BF	24.32	42.36	45.34	43.56
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	24.19	42.59	45.39	43.73
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	25.34	43.35	46.83	45.30
T_5 : Poultry manure(50%) + Vermicompost (50%)	24.09	42.29	45.31	43.33
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	23.89	42.14	45.17	43.24
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	23.72	41.70	45.03	42.93
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	25.14	43.09	46.12	45.08
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	25.22	43.14	46.24	45.18
S Em±	0.003	0.01	0.04	1.54
CD	0.009	0.05	0.13	4.64

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAT= Days After Transplanting.

Table 3. Number of leaves per plant of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

Treatments	30 DAT	60 DAT	90 DAT	120 DAT
T_1 : FYM (50%) + Vermicompost (50%)	4.10	5.60	13.27	17.11
T_2 : FYM (50%) + Vermicompost (50%) + BF	4.33	6.86	13.54	17.44
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	4.53	7.14	13.71	17.53
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	5.29	8.50	14.39	18.27
T_5 : Poultry manure(50%) + Vermicompost (50%)	4.73	7.60	13.66	17.68
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	4.53	7.40	13.83	17.82
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	4.26	6.60	13.42	17.35
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	5.03	7.65	14.12	18.04
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	5.19	7.70	14.26	18.15
S Em±	0.05	0.26	0.007	0.008
CD	0.15	0.78	0.02	0.02

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAT= Days After Transplanting.

Table 4. Neck thickness (mm) of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

Treatments	30 DAT	60 DAT	90 DAT	120 DAT
T_1 : FYM (50%) + Vermicompost (50%)	5.00	12.61	16.85	15.93
T_2 : FYM (50%) + Vermicompost (50%) + BF	4.79	12.07	16.43	15.31
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	5.26	13.02	18.91	17.41
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	6.20	13.63	19.67	18.64
T_5 : Poultry manure(50%) + Vermicompost (50%)	4.84	12.52	16.47	15.83
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	5.63	13.46	18.97	17.04
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	5.66	12.88	18.96	16.33
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	5.78	13.49	19.00	18.50
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	6.36	14.93	20.00	18.79
S Em±	0.62	0.78	1.50	1.49
CD	N.S.	N.S.	N.S.	N.S.

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAT= Days After Transplanting.

Table 5. Leaf width (cm) of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

Treatments	30 DAT	60 DAT	90 DAT	120 DAT
T_1 : FYM (50%) + Vermicompost (50%)	0.41	0.85	0.89	0.97
T_2 : FYM (50%) + Vermicompost (50%) + BF	0.48	0.87	0.91	1.02
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	0.42	0.83	0.92	1.02
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	0.52	0.92	1.04	1.18
T_5 : Poultry manure(50%) + Vermicompost (50%)	0.40	0.87	0.88	0.91
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	0.45	0.84	1.00	1.09
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	0.46	0.89	0.96	1.03
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	0.51	0.91	1.01	1.07
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	0.56	0.93	1.05	1.19
S Em±	0.04	0.02	0.06	0.07
CD	N.S.	N.S.	N.S.	N.S.

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAT= Days After Transplanting.

Table 6. Leaf dry weight (g) of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

Treatments	30 DAT	60 DAT	90 DAT	120 DAT
T_1 : FYM (50%) + Vermicompost (50%)	0.13	0.89	1.83	7.51
T_2 : FYM (50%) + Vermicompost (50%) + BF	0.24	0.91	1.98	8.25
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	0.12	0.88	1.75	7.48
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	0.50	1.43	2.92	9.46
T_5 : Poultry manure(50%) + Vermicompost (50%)	0.36	1.18	2.25	8.61
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	0.29	1.12	2.20	8.38
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	0.35	0.96	2.23	8.30
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	0.40	1.39	2.30	9.12
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	0.45	1.40	2.33	9.28
S Em±	0.01	0.004	0.19	0.01
CD	0.03	0.01	0.58	0.05

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAT= Days After Transplanting.

Table 7. Bulb dry weight and bulb dimensions as affected by different organic manures and bio-fertilizers

Treatments	Bulb dry weight (g)	Bulb length (cm)	Bulb diameter (cm)	Bulb shape index
T_1 : FYM (50%) + Vermicompost (50%)	81.20	6.21	6.60	0.94
T_2 : FYM (50%) + Vermicompost (50%) + BF	84.40	6.78	7.37	0.91
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	83.47	6.69	7.20	0.94
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	89.00	7.60	8.20	0.99
T_5 : Poultry manure(50%) + Vermicompost (50%)	80.66	6.08	6.35	0.86
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	85.08	6.77	7.32	0.92
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	83.50	6.64	6.94	0.93
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	85.15	6.79	8.00	0.95
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	87.50	7.50	8.12	0.95
S Em±	0.75	0.23	0.16	0.02
CD	2.26	0.70	0.50	N.S.

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Table 8. Number of scales per bulb and bulb yield parameters as affected by different organic manures and bio-fertilizers

Treatments	Number of scales per bulb	Bulb yield (kg plot^{-1})	Number of bulbs (kg^{-1})	Bulb yield (t ha^{-1})	Double bulbs (%)
T_1 : FYM (50%) + Vermicompost (50%)	6.66	9.12	13.11	15.20	4.73
T_2 : FYM (50%) + Vermicompost (50%) + BF	7.13	9.98	12.08	16.63	5.56
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	7.26	10.11	12.10	16.85	4.53
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	8.40	11.20	11.33	18.66	5.70
T_5 : Poultry manure(50%) + Vermicompost (50%)	6.20	8.04	13.56	13.40	7.70
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	7.00	8.91	11.64	14.85	6.60
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake	6.66	10.46	12.18	17.43	6.73
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake+ BF	7.40	10.93	12.43	18.21	5.90
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	7.60	11.04	12.25	18.40	6.63
S Em±	0.23	0.001	0.005	0.07	0.42
CD	0.72	0.002	0.014	0.19	1.27

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Table 9. Phosphorus, Sulphur and Moisture content (%) in onion bulbs as affected by different organic manures and bio-fertilizers

Treatments	P(%)	S(%)	Moisture content(%)
T_1 : FYM (50%) + Vermicompost (50%)	0.41	0.41	89.88
T_2 : FYM (50%) + Vermicompost (50%) + BF	0.43	0.44	89.43
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	0.42	0.40	90.36
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	0.54	0.49	90.63
T_5 : Poultry manure(50%) + Vermicompost (50%)	0.40	0.36	89.50
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	0.45	0.39	89.38
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	0.44	0.43	89.57
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	0.47	0.48	90.06
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	0.42	0.44	89.37
S Em±	0.005	0.001	0.43
CD	0.014	0.003	N.S.

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Table 10. TSS (Brix^0) in onion during storage as affected by different organic manures and bio-fertilizers

Treatments	INITIAL	7 DAS	14 DAS	21 DAS	30 DAS
T_1 : FYM (50%) + Vermicompost (50%)	11.04	11.14	11.20	11.26	11.35
T_2 : FYM (50%) + Vermicompost (50%) + BF	11.63	11.72	11.75	11.80	11.85
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	11.36	11.43	11.53	11.55	11.60
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	13.57	13.64	13.71	13.79	13.80
T_5 : Poultry manure(50%) + Vermicompost (50%)	12.88	12.92	12.96	13.02	13.14
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	11.75	11.83	11.87	11.90	11.95
T_7: Poultry manure(50%) + Vermicompost (25%)+ Neem cake	11.72	11.74	11.79	11.84	11.93
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake + BF	12.03	12.09	12.18	12.24	12.36
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	10.68	10.74	10.83	10.94	11.02
S Em±	0.004	0.004	0.002	0.003	0.002
CD	0.013	0.012	0.006	0.009	0.005

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAS= Days After Storage.

Table 11. Physiological loss of weight (%) in onion during storage as affected by different organic manures and bio-fertilizers

Treatments	7 DAS	14 DAS	21 DAS	30 DAS
T_1 : FYM (50%) + Vermicompost (50%)	1.07	2.20	2.79	4.47
T_2 : FYM (50%) + Vermicompost (50%) + BF	1.07	1.80	2.51	4.18
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	1.03	1.70	2.48	3.82
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	1.14	2.10	2.79	4.34
T_5 : Poultry manure(50%) + Vermicompost (50%)	1.25	2.50	3.56	4.76
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	1.08	1.90	2.68	4.20
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	1.15	2.00	2.68	4.22
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	1.22	2.40	3.46	4.67
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	1.44	2.70	3.67	4.83
S Em±	0.07	0.08	0.18	0.19
CD	0.24	0.26	0.55	0.59

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAS= Days After Storage.

Table 12. Sprouting of bulbs (%) in onion during storage as affected by different organic manures and bio-fertilizers

Treatments	7 DAS	14 DAS	21 DAS	30 DAS
T_1 : FYM (50%) + Vermicompost (50%)	1.16	2.23	3.13	3.70
T_2 : FYM (50%) + Vermicompost (50%) + BF	1.12	2.22	3.02	3.56
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	1.07	2.10	3.01	3.49
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	1.30	2.30	3.17	4.25
T_5 : Poultry manure(50%) + Vermicompost (50%)	1.80	2.50	3.50	4.46
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	1.22	2.37	3.30	4.13
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	1.22	2.44	3.20	4.26
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	1.60	2.47	3.47	4.30
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	2.06	3.39	4.13	5.23
S Em±	0.06	0.12	0.10	0.09
CD	0.19	0.37	0.32	0.29

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAS= Days After Storage.

Table 13. Rotting of bulbs (%) in onion during storage as affected by different organic manures and bio-fertilizers

Treatments	7 DAS	14 DAS	21 DAS	30 DAS
T_1 : FYM (50%) + Vermicompost (50%)	0.49	1.20	2.20	3.26
T_2 : FYM (50%) + Vermicompost (50%) + BF	0.47	0.90	1.90	2.28
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	0.45	0.80	1.80	2.27
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	0.50	1.40	2.00	2.37
T_5 : Poultry manure(50%) + Vermicompost (50%)	0.57	1.60	2.50	3.43
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	0.52	1.30	2.18	2.52
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	0.48	1.10	2.00	2.27
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	0.56	1.50	2.30	3.27
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	0.59	1.80	2.52	3.50
S Em±	0.009	0.07	0.115	0.114
CD	0.02	0.23	0.347	0.343

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAS= Days After Storage.

Table 14. Marketable yield (%) in onion during storage as affected by different organic manures and bio-fertilizers

Treatments	7 DAS	14 DAS	21 DAS	30 DAS
T_1 : FYM (50%) + Vermicompost (50%)	96.87	96.26	92.49	90.55
T_2 : FYM (50%) + Vermicompost (50%) + BF	96.28	95.34	92.30	90.44
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	96.53	95.52	93.56	91.51
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	98.14	97.18	94.24	92.24
T_5 : Poultry manure(50%) + Vermicompost (50%)	96.94	96.00	93.88	91.90
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	96.15	95.31	92.25	90.38
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	95.34	94.09	90.87	89.84
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	98.92	97.92	94.87	92.82
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	97.76	96.48	94.18	92.17
S Em±	0.54	0.48	0.47	0.49
CD	1.64	1.45	1.43	1.48

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each, DAS= Days After Storage.

Table 15. N, P, K and S uptake (kg ha^{-1}) by onion bulb as affected by different organic manures and bio-fertilizers

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})	Dry matter (kg ha^{-1})
T_1 : FYM (50%) + Vermicompost (50%)	32.15	7.10	39.20	6.31	1,538
T_2 : FYM (50%) + Vermicompost (50%) + BF	31.99	7.56	46.07	7.73	1,757
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	34.54	6.82	40.60	6.50	1,624
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	44.41	9.44	56.78	8.69	1,748
T_5 : Poultry manure(50%) + Vermicompost (50%)	20.91	5.63	33.01	5.07	1,407
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	22.74	6.31	38.46	6.15	1,577
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake	31.09	8.00	47.84	7.82	1,817
T_8: Poultry manure(50%) + Vermicompost (25%)+ Neem cake+ BF	38.34	8.21	54.69	8.57	1,810
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	43.80	8.51	54.91	8.61	1,955
S Em±	0.01	0.001	0.01	0.002	0.36
CD	0.04	0.002	0.04	0.006	1.10

BF = *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Table 16. Available NPK and S (kg ha^{-1} and ppm) in the soil after harvest of onion as affected by different organic manures and bio-fertilizers

Treatments	N (kg ha^{-1})	P_2O_5 (kgha^{-1})	K_2O (kgha^{-1})	S (ppm)
T_1 : FYM (50%) + Vermicompost (50%)	217.35	28.40	269.70	24.42
T_2 : FYM (50%) + Vermicompost (50%) + BF	213.00	29.43	314.54	21.34
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	252.49	32.38	286.87	23.42
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	191.54	23.70	241.30	15.68
T_5 : Poultry manure(50%) + Vermicompost (50%)	282.12	36.51	332.99	25.81
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	265.34	33.55	320.23	25.18
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	242.73	29.87	315.18	19.11
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	230.61	28.22	319.55	18.87
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	205.33	25.15	256.68	17.83
S Em±	9.03	0.38	15.54	0.009
CD	27.30	1.16	47.00	0.02

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Table 17. Microbial count (CFU g soil^{-1}) in the soil as affected by different organic manures and bio-fertilizers

Treatments	Bacteria (CFU X 10^6 g soil^{-1})	Fungi (CFU X 10^3 g soil^{-1})	Actinomycetes (CFU X 10^4 g soil^{-1})
T_1 : FYM (50%) + Vermicompost (50%)	33.49	21.57	18.13
T_2 : FYM (50%) + Vermicompost (50%) + BF	36.55	23.16	17.58
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	34.53	25.51	16.59
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	37.72	23.23	15.45
T_5 : Poultry manure(50%) + Vermicompost (50%)	34.53	23.95	16.20
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	42.52	26.22	21.30
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	36.54	23.86	16.18
T_8 : Poultry manure(50%)+Vermicompost (25%)+ Neem cake (25%) + BF	41.50	25.91	20.93
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	30.93	20.46	14.50
S Em±	1.53	0.55	0.69
CD	4.63	1.66	2.09

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Table 18. Benefit cost ratio of onion as affected by different organic manures and bio-fertilizers

Treatments	Yield ($t\ ha^{-1}$)	Gross returns ($Rs.\ ha^{-1}$)	Cost of cultivation ($Rs.\ ha^{-1}$)	Net returns ($Rs.\ ha^{-1}$)	Benefit Cost Ratio
T_1 : FYM (50%) + Vermicompost (50%)	15.20	2,28,000	56,610	1,71,390	3.02
T_2 : FYM (50%) + Vermicompost (50%) + BF	16.63	2,49,450	57,010	1,92,440	3.37
T_3 : FYM (50%) + Vermicompost (25%) + Neem cake (25%)	16.85	2,52,750	1,03,350	1,49,400	1.44
T_4 : FYM (50%) + Vermicompost (25%) + Neem cake (25%) + BF	18.66	2,79,900	1,03,750	1,76,150	1.69
T_5 : Poultry manure(50%) + Vermicompost (50%)	13.40	2,01,000	71,350	1,29,650	1.81
T_6 : Poultry manure(50%) +Vermicompost (50%) + BF	14.85	2,22,750	71,750	1,51,000	2.10
T_7 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%)	17.43	2,61,450	1,17,990	1,43,460	1.21
T_8 : Poultry manure(50%) + Vermicompost (25%)+ Neem cake (25%) + BF	18.21	2,73,150	1,18,390	1,54,760	1.30
T_9 : RDF @ 150:60:60 NPK kg ha^{-1}	18.40	2,76,000	60,846	2,15,154	3.53

BF= *Azospirillum* and PSB @ 5 kg ha^{-1} each.

Plate 1. Field view of the experimental plot

T_1 : FYM (50%) + VC (50%)

T_2 : FYM (50%) + VC (50%) +BF

T_3 : FYM (50%) + VC (25%) + NC (25%)

T_4 : FYM (50%) + VC (25%) + NC (25%) + BF

Plate 2a: Effect of different organic manures and bio-fertilizers on onion growth at 60 DAT

T_5 : PM (50%) + VC (50%)

T_6 : PM (50%) + VC (50%) + BF

T_7 : PM (50%) + VC (25%) + NC (25%)

T_8 : PM (50%) + VC (25%) + NC (25%) + BF

T_9 : RDF @ 150:60:60 NPK kg ha^{-1}

Plate 2b: Effect of different organic manures and bio-fertilizers on onion growth at 60 DAT

T_1 : FYM (50%) + VC (50%)

T_2 : FYM (50%) + VC (50%) +BF

T_3 : FYM (50%) + VC (25%) + NC (25%)

T_4 : FYM (50%) + VC (25%) + NC (25%) + BF

Plate 3a: Bulb size in onion as influenced by different organic manures and bio-fertilizers at harvest

T_5 : PM (50%) + VC (50%)

T_6 : PM (50%) + VC (50%) + BF

T_7 : PM (50%) + VC (25%) + NC (25%)

T_8 : PM (50%) + VC (25%) + NC (25%) + BF

T_9 : RDF @ 150:60:60 NPK kg ha^{-1}

Plate 3b: Bulb size in onion as influenced by different organic manures and bio-fertilizers at harvest

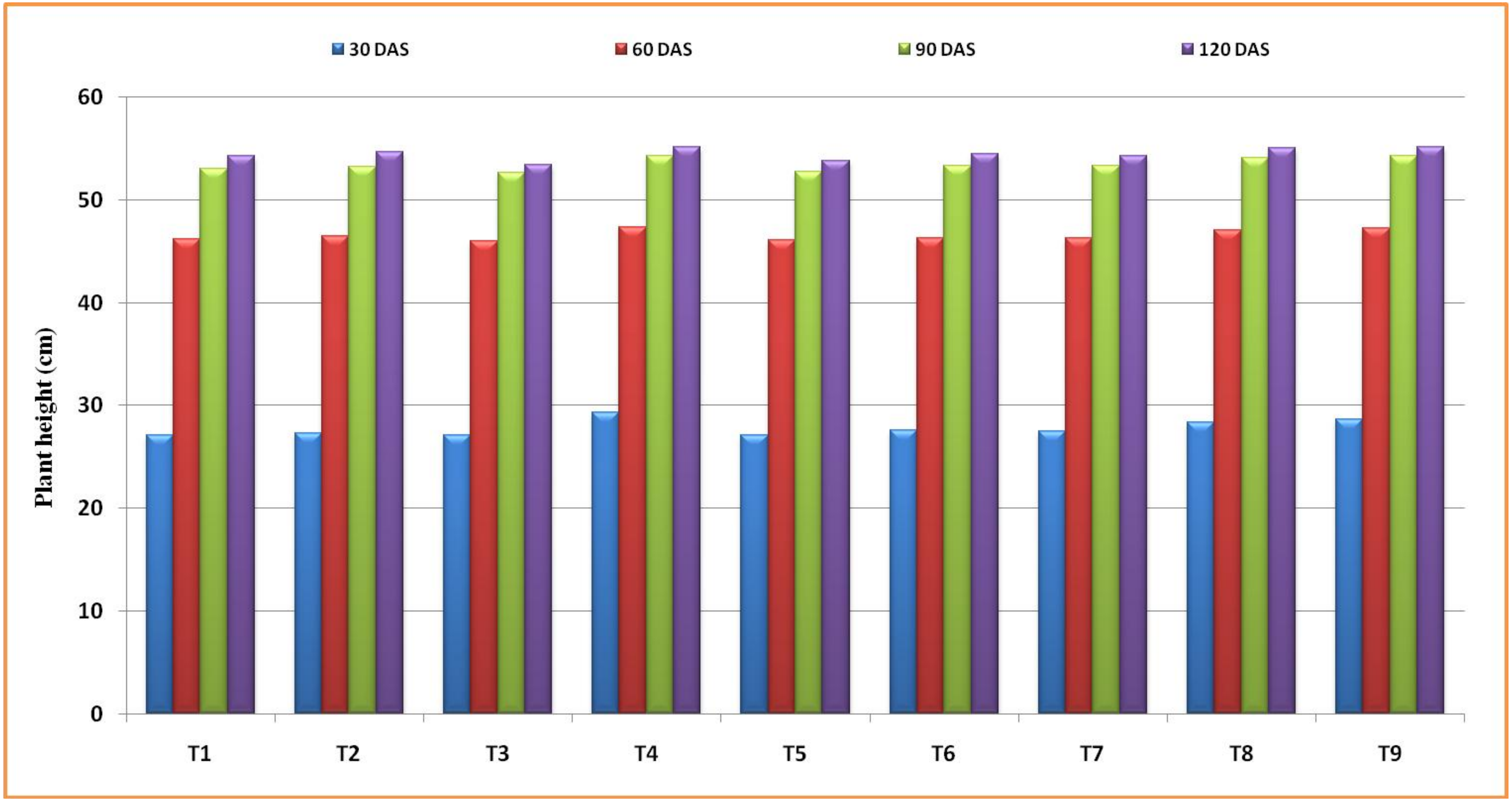


Figure 1.Plant height (cm) of onion at different stages of crop growth as affected by different organic manures and bio-fertilizers

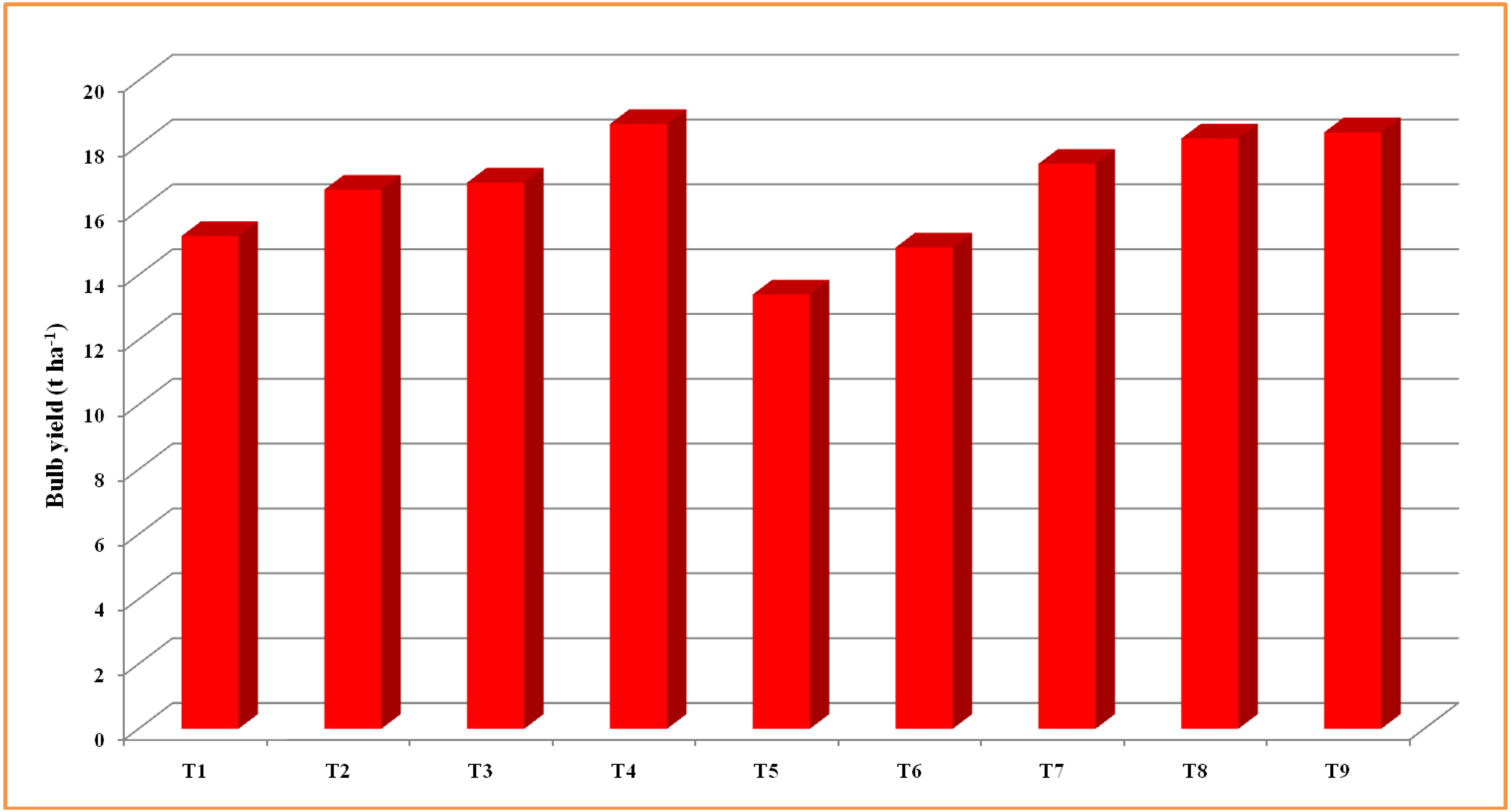


Figure 2.Bulb yield (t ha^{-1}) of onion at harvest as affected by different organic manures and bio-fertilizers

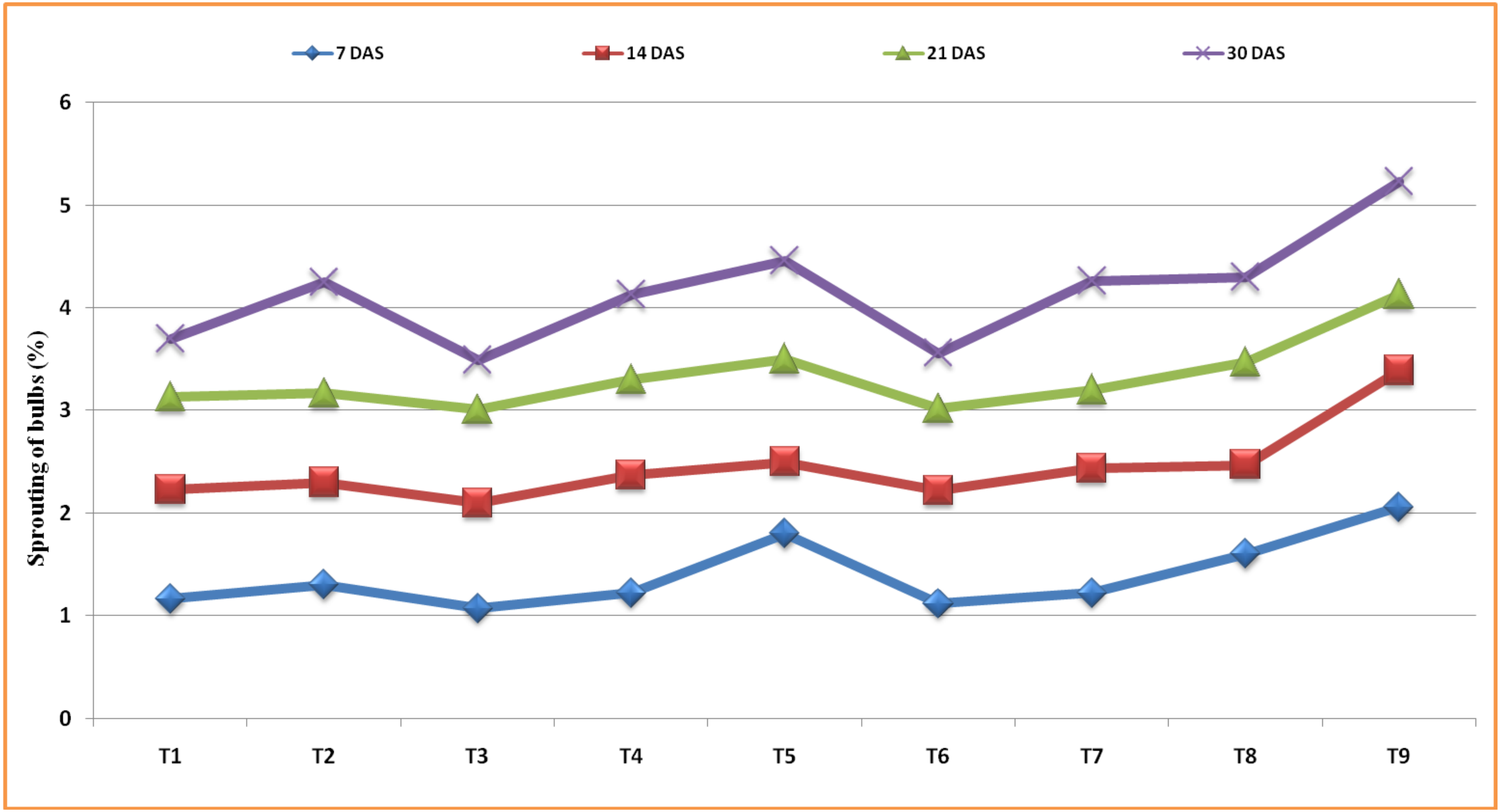


Figure 3. Sprouting of bulbs (%) in onion during storage as affected by different organic manures and bio-fertilizers

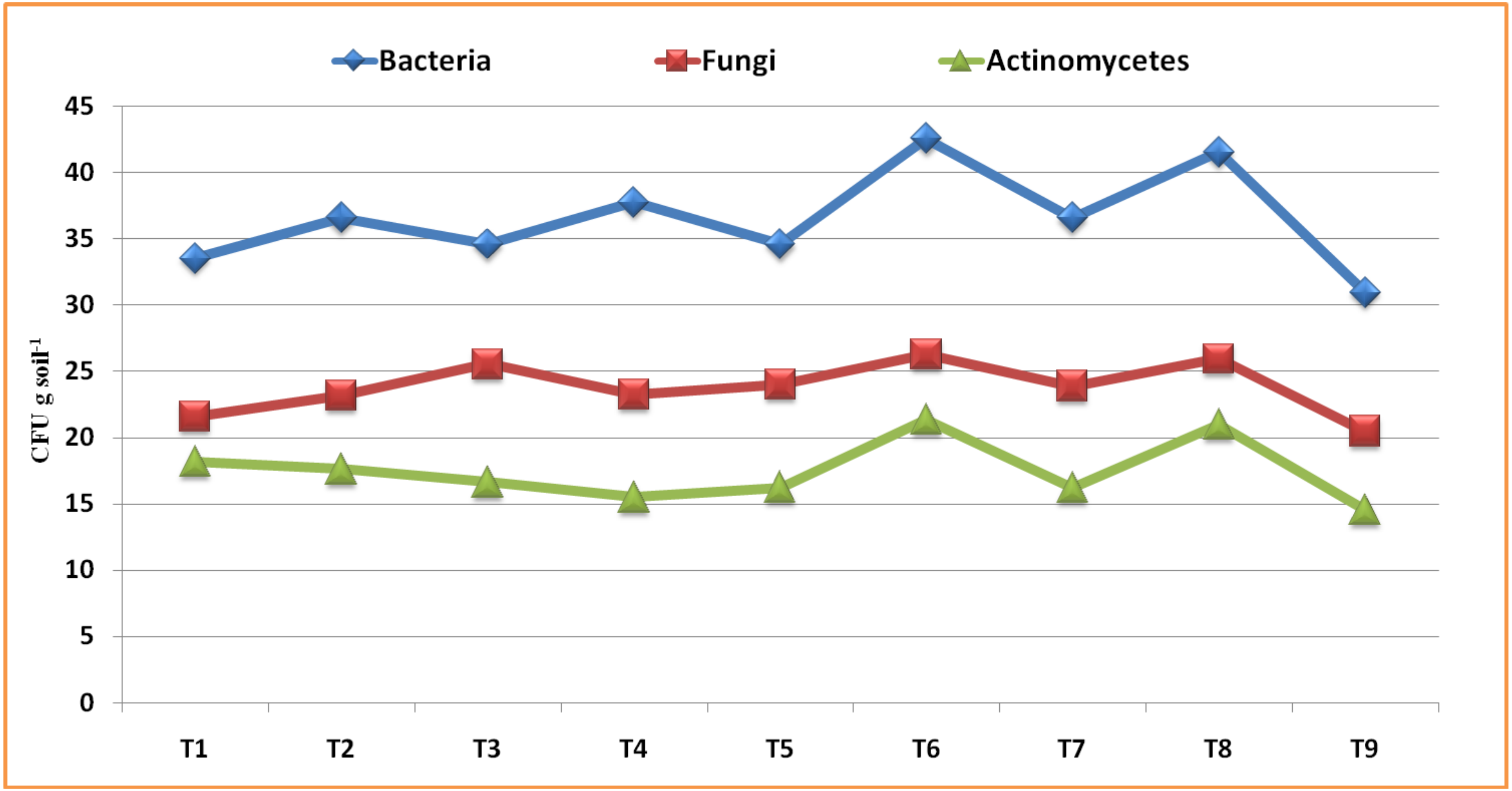


Figure 4. Number of bacteria (CFU X 10^6 g $soil^{-1}$), fungi (CFU X 10^3 g $soil^{-1}$) and actinomycetes (CFU X 10^4 g $soil^{-1}$) in onion grown soil after harvest as affected by different organic manures and bio-fertilizers

Chapter V

SUMMARY AND CONCLUSIONS

A field experiment was conducted during *rabi,* 2013-14 to study the **"Effect of different combinations of organic manures and supplementation of bio-fertilizers on growth, yield and quality of Onion (*Allium cepa* L.)"** at college farm, College of Horticulture, Dr. Y.S.R. Horticultural University, Rajendranagar, Hyderabad, Andhra Pradesh. This region falls under VI Agro climatic zone of Andhra Pradesh state. The experiment was laid out in Randomized Block Design with 9 treatments consisting different combinations of organic manures such as FYM, vermicompost, poultry manure, neem cake and bio-fertilizers along with RDF. The results of the experiment are summarized hereunder.

5.1. GROWTH AND YIELD PARAMETERS

- All the growth and yield parameters of onion were significantly influenced by the organic manures such as FYM, vermicompost, poultry manure, neem cake and bio-fertilizers.

- Among different organic manures, farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each recorded the highest plant height of 28.68, 47.23, 54.23 and 55.12 cm at 30, 60, 90 and 120 DAT respectively.

- At 30, 60, 90 and 120 DAT the highest leaf length (25.22, 43.14, 46.24 and 45.18 cm respectively) was recorded with the application of farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

- Maximum number of leaves (5.19, 7.70, 14.26 and 18.15) was recorded with the application of farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each at 30, 60, 90 and 120 DAT respectively.

- The highest leaf dry weight (0.45, 1.40, 2.33 and 9.28 g) was recorded with the application of farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each at 30, 60, 90 and 120 DAT respectively.

- The highest bulb dry weight (89.00 g), number of scales per bulb (8.40), bulb length (7.60 cm), bulb diameter (8.20 cm), bulb yield per plot (11.20 kg) and bulb yield per hectare (18.66 t ha^{-1}) was recorded with the application of farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

- Higher double bulbs (7.70) was recorded with the application of poultry manure (50%) + vermicompost (50%) which was at par with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) (6.73) and lowest (4.53) was recorded with the application of farmyard manure (50%) + vermicompost (25%) + neem cake (25%).

5.2. QUALITY PARAMETERS

- All the quality parameters were improved significantly with the organic manures over inorganic fertilizers.

- The highest phosphorus (0.54 %) and sulphur (0.47 %) contents were recorded with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

- The highest total soluble solids (13.57, 13.64, 13.71, 13.79 and 13.80 °Brix) were recorded with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each at 0, 7, 14, 21 and 30 DAS respectively.

- The lowest physiological loss of weight (1.03, 1.70, 2.48 and 3.82 %), sprouting of bulbs (1.07, 2.10, 3.01 and 3.49 %) and rotting of bulbs (0.45, 0.80, 1.80 and 2.27 %) was recorded with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) at 7, 14, 21 and 30 DAS respectively followed by 1.07, 1.80, 2.51 and 4.18 % physiological loss of weight, 1.12, 2.22, 3.02 and 3.56 % sprouting of bulbs and 0.47, 0.90, 1.90 and 2.28 % rotting of bulbs with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each which were at par but significantly superior to all other treatments at 7, 14, 21 and 30 DAS respectively.

- The highest marketable yield (98.92, 97.92, 94.87 and 92.82 %) was recorded with poultry manure (50%) + vermicompost (25%) + Neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each at 7, 14, 21 and 30 DAS respectively which was at par with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each (98.14, 97.18, 94.24 and 92.24) at 7, 14, 21 and 30 DAS respectively.

5.3. OTHER PARAMETERS

- The nutrient uptake (N, P, K and S), post-harvest available soil nutrients (N, P_2O_5, K_2O and S), microbial count (bacteria, fungi and actinomycetes), net returns and BCR were significantly affected with various organic manures.

- The uptake of N (44.41 kg ha^{-1}), P (9.44 kg ha^{-1}), K (56.78 kg ha^{-1}) and S (8.69 kg ha^{-1}) were maximum with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each; the post-harvest available soil N (282.12 kg ha^{-1}), P_2O_5 (36.51 kg ha^{-1}), K_2O (332.99kg ha^{-1}) and S (25.81 ppm) were maximum with with poultry manure (50%) +

vermicompost (50%). The highest dry matter 1,955 was recorded with recommended dose of fertilizers.

- Bacterial (42.52 CFU X 10^6 g $soil^{-1}$), fungal (26.22 CFU X 10^3 g $soil^{-1}$) and actinomycetes (21.30 CFU X 10^4 g $soil^{-1}$) count were maximum with poultry manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

- The highest gross returns (Rs. 2,79,900 ha^{-1}) was recorded with farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each

- However, the net returns (Rs. 2,15,154 ha^{-1}) and BCR (3.53) were higher with recommended dose of fertilizers followed by Rs. 1,92,440 ha^{-1} net returns and 3.37 BCR with farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each.

- From the present investigation it is concluded that growing of onion with the combined use of farmyard manure (50%) + vermicompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each was found effective in promoting growth, yield and NPKS uptake. Better quality of onion was obtained with farmyard manure (50%) + vermicompost (25%) + neem cake (25%). If premium price is available, farmers can go for organic farming of onion considering its beneficial effects on soil health and environment besides sustainability. Under organic cultivation of onion, for obtaining maximum net returns and benefit cost ratio farmyard manure (50%) + vermicompost (50%) + *Azospirillum* and PSB @ 5 kg ha^{-1} each may be used as organic source of nutrient.

FUTURE LINE OF WORK:

- ✓ Sustainable organic farming is gaining importance and hence studies on the possibilities of using green manure crops and other locally available organics (litter, compost, urban waste) may be tested.
- ✓ There is an urgent need to screen large number of organics on different locally cultivated onion varieties which have profound influence on yield and quality.
- ✓ Organic manures may be tried with and without bio-fertilizers to know the exact role of the latter in enhancing bulb yield of onion.
- ✓ Research may be taken up to study the onion varieties for the suitability for organic production.
- ✓ Research may be taken up to reduce the cost of producing organics there by reducing the cost of cultivation.

LITERATURE CITED

Abbey, L. 2000. Effect of poultry manure and post production application of fungicides on the shelf life of onion cv. Bawku Red. *Crop Research.* 20(1): 87-92.

*Alam, M.N, Jahan, M.S, Ali, M.K, Islam, M.S and Khandaker, S.M. 2011. Effect of vermicompost and NPKS fertilizers on growth, yield and yield components of red amaranth. *Australian Journal of Basic and Applied Sciences.* 1: 4, 706-716.

Alkaff, H.A, Saeed, O.S and Salim, A.Z. 2002. Effect of biofertilizer, inorganic, organic and foliar application of Power 4 on the productivity of onion. *University of Aden Journal of Natural and Applied Sciences.* 6(1): 1-14.

Amarendra Kumar, Prasad, K.K, Jain, B.P and Kumar, A. 1997. Effect of organic amendments and chemicals on growth and yield of tomato (*Lycopersicon esculentum* Mill.) *Journal of Research. Bisra Agricultural University* 9(1): 49-52.

*Association of Official Agricultural Chemists (AOAC). 1969. Official and tentative methods of analysis. Association of Official Agricultural Chemists. Washington D C.

*Anonymous. 1996. To study the effect of different organic manures and inorganic fertilizers on yield and quality of rabi onion. In: *Annual Report of National Horticulture Research and Development Foundation,* Nasik, p.5.

*Anonymous. 1997. *Annual Progress Report of All India Coordinated Research Project on Oilseeds Sesame*. *Niger.* pp.73-86.

*Anonymous. 1998. *Annual Progress Report of All India Coordinated Research Project on Oilseeds Sesame. Niger.* pp.79-97.

Arulmozhiyan, R, Wilfredmanuel, W and Velmurugan, S. 2002. Effect of organics vs inorganics on betelvine cv. Vellaikodi in open system cultivation. *South Indian Horticulture.* 50(1-3): 169-172.

Azarmi, R, Giglou, M.T and Taleshmikail, R.D. 2008. Influence of vermicompost on soil chemical and physical properties in tomato (*Lycopersicum esculentum*) field. *African Journal of Biotechnology. 7: 14, 2397-2401.*

Balashanmugam, P.V, Vanangamudi, K.S and Chamy, A. 1989. Studies on the influence of farmyard manure on the rhizome yield of turmeric. *Indian Cocoa Arecanut Spices Journal.* 12: 126.

Balasubramani, P. 1988. Effect of *Azospirillum* and nitrogen on growth and yield of bhendi, cv. Pusa Savani. *M.Sc. (Agri.) Thesis*, Tamil Nadu Agricultural University, Madurai, India.

Balyan, J.K, Singh, P, Kumpawat, B.S and Jain, L.K. 2006. Effect of integrated nutrient management on maize (*Zea mays* L.) growth and its nutrients uptake. *Current Agriculture.* 30(1-2): 79-82.

Barani, V.S and Anburani. 2004. Integrated nutrient management in bhendi. *Journal of Indian Society of Soil Science.* 42: 166-171.

Beaulah, A. 2001. Growth and development of moringa (*Moringa oleifera* Lam.) under organic and inorganic systems of culture. *Ph D. Thesis* submitted to Tamil Nadu Agricultural University, Coimbatore.

Bhagyaraj, D.J and Suvarna, C.V. 1999. Bio-fertilizers and their application. *AGRIEAS.* 1 : 16-21.

*Bhawalkar, U.S. 1991. *Vermiculture biotechnology for LESIA* – Seminar on low external input sustainable agriculture, Amsterdam, Netherlands, pp. 1-6.

Bhuma, M. 2001. Studies on the impact of humic acid on sustenance of soil fertility and productivity of greengram (VBNGG-2). *M. Sc. (Agri.) Thesis*, Tamil Nadu Agricultural University, Coimbatore, India.

Bijaysingh, U, Yadvindersingh, Sadana, S and Meelu, O. P. 1988. Effect of green manure, wheat straw and organic manure on DTPA extractable Fe, Mn, Zn and Cu in a calcareous sandy loam soil at field capacity and under water logged conditions. *Journal of Indian Society of Soil Science.* 40(1) : 114-118.

*Bringi, N.V. 1987. *Non traditional oilseeds in India*. Oxford and IBH Publishing Company private Limited, New Delhi, pp 254.

*Bybordi, A and Malakouti, M.J. 2007. Effect of different organic fertilizers (animal manure, compost, and vermicompost) on the yield and quality of red onion in Khosrowshahr and Bonab. [Persian] *Iranian Journal of Soil and Water Sciences.* 21: 1, 33-43.

Castellanos, S.J.Z and Pratt, P.F. 1981. Mineralization of manure, nitrogen correlation with laboratory indices. *Soil Science society of America Journal.* 45: 254-357.

Chalapathi, M.V, Shivaraj, B and Parama, V.R.R. 1997. Nutrient uptake and yield of stevia (*Stevia rebaudiana* Bertoni.) as influenced by methods of planting and fertilizer levels. *Crop Research, Hisar.* 14(2): 205-208.

Chandramohan, S. 2002. Organic farming in cotton + black gram intercropping system. *M.Sc. (Agri.) Thesis*, Tamil Nadu Agricultural University, Coimbatore.

Chauhan K.S and Sekhawat J.S. 1971. Response of onion to nitrogen, phosphorus and potassium applications. Fertilizer News 16(2): 45-47.

Chavan, P.J, Jimail, S, Rudrakha, G.B, Malewar, G.V and Baig, M.I. 1997. Effect of various nitrogen levels through FYM and urea on yield and uptake of nutrients and ascorbic acid content of chilli. *Journal of Indian Society of Soil Science.* 45: 833-835.

Chellamuthu, S. 1978. Studies on the yield and quality of ragi as influenced by organic and inorganic formation of nitrogen, *M. Sc. (Ag.) Thesis,* Tamil Nadu Agricultural University, Coimbatore, India.

Chesnin, L and Yein, C.H. 1951. Turbidimetric method of sulphate sulphur in plant materials. *Proceedings of Soil Science society of America* 15: 149-151.

Chhonkar, P.K. 2003. Organic farming: Science and belief. *Journal of the Indian Society of Soil Science.* 51(4): 365-367. Department of Agricultural Microbiology, University of Agricultural Sciences, Dharwad. pp. 50-54.

Choudhary, B.R, Fageria, M.S and Dhaka, R.S. 2002. Role of growth hormones in chillies – A review. *Agricultural Review.* 23(2) : 145-148.

Dalavi, P.N, Bhondave, T.S, Jawale, S.M, Shaikh, A.A and Dalavi, N.D. 2009. Effect of sources of organic manures in integrated nutrient management on yield and quality of sweet corn. *Journal of Maharashtra Agricultural Universities.* 34: 2, 222-223.

Darzi, M.T, Seyed Hadi, M.H and Rejali, F. 2012. Effects of the application of vermicompost and phosphate solubilizing bacterium on the morphological traits and seed yield of anise *(Pimpinella anisum* L.*). Journal of Medicinal Plants Research.* 6: 2, 215-219.

Deora, N.S and Jitendra Singh. 2008. Effect of integrated nutrient management and seed rate on quality of fenugreek (*Trigonella corniculata* L.) cv. Kasuri and post harvest soil fertility status in loamy sand soil of Rajasthan. *Environment and Ecology.* 26: 4A, 1749-1752.

Devender, K, Parmar, Pritam, K, Sharma and Sharma, T.R. 1998. Integrated nutrient supply system for DPP 68 vegetable pea (*Pisum sativum* var. *arvense*) in dry temperate zone of Himachal Pradesh. Indian Journal of Agricultural Sciences. 68(2). 84-86.

*Dhanushkodi, V and Kannathasan, M. 2012. Importance of industrial waste in maximizing the yield of rice and its effect of soil fertility in coastal region. *International Journal of Research in Chemistry and Environment (IJRCE).* 2: 3, 21-25.

Dabhi, M.N, Patel, N.C and Dhamsaniya, N. K. 2008. Effect of Storage conditions on the Quality characteristics of Onion. *Journal of Food Science and Technology.* 45(4): 376-377.

*Doikova, M. 1979. Nutrient uptake by eggplants. *Fiziologiya na Rastemiyata.* 5(3): 72-77.

Duraisamy, R, Mani, A.K and Balasubramaniam, P. 1999. Effect of fertilizer nitrogen, Azospirillum and organics on yield and nutrition of rainfed tomato. *South Indian Horticulture.* 47 : 234-236.

Geetha K. 1994. Effect of integrated use of farm yard manure and potassium fertilizer on potassium nutrition and yield of onion (*Allium cepa* L.) in Alfisol. M Sc (Ag) Thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.

Giraddi, R.A. 1993. Vermiculture and role in agriculture. In : *Proc. Course on the Officers of the State Department of Agriculture, Karnataka*, 18-20 October 1993 by the Department of Agricultural Microbiology, University of Agricultural Sciences, Dharwad. pp. 50-54.

Gopalkrishna Rao, K.P and Srinivas, K. 1990. Studies on storage behavior of onion as influenced by the Nitrogen fertilization. *Indian Food Packer.* (44): 5-11.

Greenland, D.J. 1975. The magnitude and importance of the problem, pp. 3-7. In: D. J. Greenland and R. Lal (eds). Soil Conservation and Management in the Humid Tropics, John Wiley & Sons, NY, USA.

Grewal, J.S and Trehan, S.P. 1984. Comparative efficiency of phosphorus, potassium and farmyard manure and their combinations for potato in acidic hill soil. *Journal of Indian Society of Soil Science.* 32 : 438-486.

Gunjan Aswani, 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. *Agricultural Sciences Digest.* 25(2): 124-126.

Gupta, J.P, Aggarwal, R.K, Gupta, G.N and Kaul, P. 1983. Effect of continuous application of FYM and urea on soil properties and the production of pearlmillet in Western Rajasthan. *Indian Journal of Agricultural Sciences.* 30: 342-345.

Hakeem, S.A. Thomas, T and Shagufta Wani. 2007. Effect of different levels of neem cake and biofertilizer on properties of soil, nutrient status and grain yield of black gram (*Vigna mungo* L.) type - 9. *Plant Archives.* 7: 2, 847-849.

Hakeem, S.A, Thomas, T and Shagufta Wani. 2008. Effect of different levels of neem cake and biofertilizers on growth, yield attributes and nutrient uptake in black gram (*Vigna mungo* L.) type-9. *Environment and Ecology.* 26: 1A, 369-371.

Harikrishna, B.L. Channal, H.T. Hebsur, N.S. Dharmatti, P.R and Sarangamath, P.A. 2002. Integrated nutrient management (INM) on availability of nutrients, uptake and yield of tomato. *Karnataka Journal of Agricultural. Sciences.* 15(2): 275-278.

*Hu Cheng Cao, ZhiPing Luo, YanRui Ma and Yong Liang. 2007. Effect of long-term application of microorganismic compost or vermicompost on soil fertility and microbial biomass carbon. [Chinese] *Zhongguo Shengtai Nongye Xuebao / Chinese Journal of Eco-Agriculture.* 15: 3, 48-51.

Jackson, M. L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd, New Delhi, pp. 183- 192.

Jadhav. S. N., 1994, Role of vermiculture mulberry and its impact on silkworm (*Bombyx mori* L.). *M.Sc. (Agri.) Thesis,* University of Agricultural Sciences, Dharwad.

Jayakumar, Pathma, Natarajan and Sakthivel. 2012. Microbial diversity of vermicompost bacteria that exhibit useful agricultural traits and waste management potential. *Springer Plus.* 1: 26, (4 October 2012*).*

Jayaprakash, T.C, Nagalikar, V.P, Pujari, B.T and Setty, R.A. 2004. Effect of organics and inorganics on soil properties and available nutrient status of soil after harvest of maize crop under irrigation. *Karnataka Journal of Agricultural Sciences.* 17: 2, 311-314.

Jayathilake, P.K.S, Reddy, I.P, Srihari, D, Reddy, K.R and Neeraja, G. 2003. Integrated nutrient management in onion (*Allium cepa* L.). *Tropical Agricultural Res*earch. 15 : 19.

Johnson, L.F and Curl, A.E. 1972. *Method for the research on ecology of soil borne plant pathogens.* Burgess publishing company. pp. 247. Minneapolis.

Kademani, M.B, Radder, B.M and Hebsur, N.S. 2003. Effect of organic and inorganic fertilizers on availability and uptake of nutrientsby sunflower in vertisol of Malaprabha Command. *Karnataka Journal of Agricultural Sciences.* 16: 1, 48-53.

Khan, M.W, Khan, A.M and Saxena, S.K. 1974. Rhizosphere fungi nematodes of eggplant as influenced by oil cake amendments. *Indian Phyto Pathology.* 27(4): 480-484.

Kler, D.S and Walia, S.S. 2006. Organic, inorganic and chemical farming in wheat (*Triticum aestivum*) under maize (*Zea mays*) – wheat cropping system. *Indian Journal of Agronomy.* 51(1): 6-9.

Kale, R.D, Banu, K and Satyavathi, G.P. 1991. Influence of vermicompost application on growth and yield of cereals, vegetables and ornamental plants. *Final Report of Karnataka State Council for Science and Technology Project*No. 67-041 Vermi 134 B (3478) Bangalore.

*Kopczynski, J. Bury, M. Denkiewicz, J. 1999. The influence of surface application of vermicompost and calcium on the yield and quality of sugarbeet roots. [Polish] *Folia Universitatis Agriculturae Stetinensis, Agricultura;* 78, 49-54.

Krishna, B. E. 2002. Production potentials of Tomato in Leucaena based alley cropping system with different sources of nutrients. *M. Sc. (Agri.) Thesis.* University of Agricultural Sciences, Dharwad.

Kukanoor, L. 2005. Post harvest studies in onion cv. N-53. *Ph. D. Thesis,* University of Agricultural Sciences, Dharwad, Karnataka, India.

Kumari, M.S and Ushakumari, K. 2002. Effect of vermicompost enriched with rock phosphate on the yield and uptake ofnutrients in cowpea (*Vigna unguiculata* L. Walp). *Journal of Tropical Agriculture.* 40: 1/2, 27-30.

Kumpawat, B.S. 2004. Integrated nutrient management for maize – Indian mustard cropping system. *Indian Journal of Agronomy.* 49(1): 18-21.

*Lampkin, N.1990. In: Organic farming, Ipswich, W.K., Farming Press Book, pp. 801-910.

*Lopez, Gomez, B.F, Lara-Herrera, A, Bravo-Lozano, A.G, Lozano-Gutierrez, J, Avelar-Mejia, J.J, Luna-Flores, M and Llamas-Llamas, J. 2012. Improvement of plant growth and yield in pepper by vermicompost application, in greenhouse conditions. *Journal of Acta Horticulture.* 947, 313-317.

Maheswari, S.K, Joshi, R.C, Gangrade, S.K, Chuban, G.S and Trivedi, K.C. 1991. Effect of farm yard manure and zinc on rainfed palmarosa oil grass. *Indian Perfumer.* 35(4): 226-229.

Mahendran, P.P and Kumar, N. 1998. Effect of biofertilizers on tuber yield and certain quality parameters of potato cv. Kufri Jyoti. *South Indian Horticulture.* 46 (1&2): 97-98.

Mallangouda, B, Sulikeri, G.S, Hulamani, N.C, Murthy, B.G and Madalgeri, B.B. 1995. Effect of NPK and FYM on growth parameters of onion, garlic and coriander. *Current Research,* University of Agricultural Sciences, Bangalore. 24(11): 212-213.

Mamta Wani, K.A and Rao, R. 2012. *Effect of vermicompost on growth of brinjal plant (Solanum melongena*) under field conditions. *Journal on New Biological Reports.* 1: 1, 25-28.

Mamatha, H.N. 2006. Effect of organic and Inorganic sources of nitrogen on Yield and Quality of Onion (*Allium cepa* L.) and Soil properties in Alfisols. *M. Sc. (Agri.) Thesis,* University of Agricultural Sciences, Dharwad, Karnataka, India.

Manisha Kachari Korla, B.N. 2012. Studies on influence of bio-fertilizers on quality and economics of cauliflower cv.PSB K-1 production. *Indian Journal of Horticulture 69(2):215-220.*

Marathe, R.A, Ram and Chandra Jadhav, V.T. 2010. Influence of different potting media on soil properties, plant nutrient content and nutrient uptake by pomegranate (*Punica granatum*) seedlings. *Indian Journal of Agricultural Sciences.* 80: 6, 544-547.

Mathews, D.V, Patil, P.L and Dasog, G.S. 2006. Effect of nutrients and biofertilizers on nutrient uptake by rice and residual soil fertility status in coastal alluvial soil of Karnataka. *Karnataka Journal of Agricultural Sciences.* 19(4):793-798.

Mizuno, S. 1996. Integrated soil building: Concept and practices. Problems farming under different agroclimatic conditions. Organic farming and sustainable agriculture. *Proceedings of the National Seminar* held at UAS, Bangalore, India. pp. 76-89.

*Molina, Maldonado, J.R, Salvador-Figueroa, M, Montes-Molina, J.A, Alvarez-Solis, J.D and Gutierrez Miceli, F.A. 2012. Vermicompost effect on growth and production of secondary metabolites in *Ardisia escallonioides*. [Spanish] *Gayana Botanica. 69: Special issue, 82-88.*

Murugan, 2000. Integrated nutrient management in baby corn. *Indian Journal of Horticulture*. 63(1): 98-100.

Muhr, G. R, Datta, N.P, Shankara Mbramoney, R, Lelley, V.R and Donahahue, R.L. 1965. *Soil Testing in India*. UASID, New Delhi, pp. 47-77.

Murthy, R.K, Vasudev, H.S, Devagiri, G.M, Umashankar, N and Raveendra, H.R. 2009. Effect of integrated nutrient management of growth and yield parameters andnutrient uptake of groundnut (*Arachis hypogaea*). *Mysore Journal of Agricultural Sciences.* 43: 4, 696-699.

Muthuvel, P.R, Sivasamy, V, Subramaniam and Sreeramulu, U,S. 1990. Soil fertility under continuous rotational cropping in a dry land vertisol. *Madras Agricultural Journal.* 77(1): 48-50.

Naik, M.H and Babu, R.S.H. 2007. Feasibility of organic farming in guava (*Psidium guajava* L.). *Acta Horticulture.* 735, 365-372.

Namita, Joshi, Deep Gupta and Rachna Nagar. 2005. A comparative analysis of physicochemical and mycofloral properties of vermicompost and soil. *Uttar Pradesh Journal of Zoology*. 25: 3, 243-246.

Nanthakumar, S and Veerargavathatham, D. 1999. Effect of integrated nutrient management on yield and yield attributes of brinjal (*Solanum melongena*) cv. PLR1. *South Indian Horticulture.* 47(1-6): 42-48.

Narayanamma, M, Chiranjeevi, C.H, Reddy, I.P and Ahmed, S. R. 2005 Integrated nutrient management in cauliflower (*Brassica oleracea* var. *botrytis* L.). *Vegetable Science*. 32(1):62-64.

Narolia, R.S, Poonia, B.L and Yadav, R.S. 2009. Effect of vermicompost and inorganic fertilizers on productivity of pearl millet (*Pennisetum glaucum*). *Indian Journal of Agricultural Sciences.* 79: 7, 506-509.

Neeraja, G. 1998. Effect of irrigation and nitrogen levels on growth, plant water relations, nutrient uptake, yield and quality of onion, Ph D (Hort.) Thesis Acharya N G Ranga Agricultural University, Hyderabad.

NHB, database-2013, National Horticulture Board, Ministry of Agriculture, Govt. of India, Gurgaon, pp. 164-165.

Nihad, K and Jessykutty, P.C. 2010. Long term effect of organic manures and microbial inoculants on nutrient uptakeand yield of *Plumbago rosea* when grown as an intercrop in coconut garden. *Journal of Medicinal and Aromatic Plant Sciences.* 32: 3, 257-261.

Nirmala, R, Vadivel, E and Azakiamanavalan, R.S. 1999. Influence of organic manures on fruit characters and yield of cucumber (*Cucumber sativus* Linn.) cv. Local. *South Indian Horticulture.* 47(1-6): 65-68.

*Ojeniyi, S.O and Sanni, T.S. *2000.* Response of soil and okra nutrient contents, growth and yield to application of neem fruit powder. *Journal of Sustainable Agriculture and the Environment.* 2: 2, 269-274.

Omraj Meena, Khafi, H.R, Shekh, M.A, Mehta, A.C and Davda, B.K. 2007. Effect of vermicompost and nitrogen on content, uptake and yield of rabi maize. *Crop Research (Hisar).* 33: 1/3, 53-54.

Pant, A.P, Radovich, T.J.K, Hue, N.V and Miyasaka, S.C. 2012. Pak choi (*Brassica rapa*, Chinensis group) yield, phytonutrient content, and soil biological properties as affected by vermicompost-to-water ratio used for extraction. *Horticultural Sciences.* 47: 3, 395-402.

Parihar, N.S, Saini, R.S and Pathan, A.R.K. 2005. Effect of sulphur, zinc and organic manures on yield and nutrient uptake of wheat in Typic ustipsamment soil. *Annals of Agricultural Research.* 26: 1, 64-68.

Parthasarathi, K, Balamurugan, M and Ranganathan, L.S. 2008. Influence of vermicompost on the physico-chemical and biological properties in different types of soil along with yield and quality of the pulse crop-blackgram. *Iranian Journal of Environmental Health Science & Engineering.* 5: 1, 51-58.

Patil, M.S, Mehta, A.C and Saini, R.S. 2004. Integrated nutrient management in commercial vegetables. *Indian Journal of Horticulture*. 63(2): 90-92.

Patra, R.K, Upadhyay, D.D, Tewari, S.K and Baksh, H. 2011. *Crop Research* (Hisar). 44: 3, 344-348.

Paturde, J.T, Wanmkhade, S.G, Khade, P.P, Chatal, P.U, Deo, D.D and Bhuyar, S.A. 2002. Effect of organic manures and plant population on yield of safed musli (*Chlorophytum borivallianum). Agricultural Science Digest.* 22(1): 51-52.

Panse, V.G and Sukhatme, P.V. 1985, *Statistical methods for agricultural workers*. Indian Council for Agricultural research (ICAR), New Delhi, India.

Patil, P.V, Chalwade, P.B, Solanke, A.S and Kulkarni, V.K. 2005. Effect of fly ash and FYM on nutrient uptake and yield osf onion. *Journal of Soils and Crops.* 15(1): 187-197.

Patil. M. P. 1995. Integrated nutrient management in commercial vegetables. *M.Sc. (Agri). Thesis*. University of Agricultural Sciences, Dharwad, Karnataka, India.

*Peyvast, G, Olfati, J.A, Madeni, S and Forghani, A. 2008a. Effect of vermicompost on the growth and yield of spinach (*Spinacia oleracea* L.). *Journal of Food, Agriculture & Environment.* 6: 1, 110-113.

*Peyvast, G, Olfati, J.A, Madeni, S, Forghani, A and Samizadeh, H. 2008b. Vermicompost as a soil supplement to improve growth and yield of parsley. *International Journal of Vegetable Science.* 14: 1, 82-92.

Piper, C. S. 1966. *Soil and Plant Analysis*. Hands Publishers, Bombay.137-153.

Prabhu, T, Narwadkar, P.R, Sajindranath, A.K and Mohd. Rafi. 2002. Integrated nutrient management studies in Okra. *South Indian Horticulture*. 50(5-6): 550-553.

Pramanik, P, Ghosh, G.K and Chung, Y.R. 2010. Changes in nutrient content, enzymatic activities and microbial properties of lateritic soil due to application of different vermicomposts: a comparative study of ergosterol and chitin to determine fungal biomass in soil. *Soil Use and Management.* 26: 4, 508-515.

Raghwendra, Singh, Kedar and Prasad. 2008. Effect of vermicompost, Rhizobium and DAP on growth, yield and nutrient uptake by chickpea. *Journal of Food Legumes.* 21: 2, 112-114.

Rajesh, S. 1997. Comparative performance of chillies (*Capsicum annuum* L.) cv. PLR-1 with inorganic fertilizers and vermicompost in association with biofertilizers. *M.Sc. Thesis* submitted to Annamalai University, Annamalainagar.

Ramachandra, L.P and Bhaskar, S.S. 1996. Effect of integrated nutrient management in moringa. *Indian Journal of Horticulture.* 48 : 129-135.

Ramakal, K.S, Khera, A.P, Bhatia, R.N, Gupta, S.P and Duhan, B.S. 1988. Effect of combined application of FYM and inorganic fertilizers on grain yield and soil fertility status in Bajra wheat crop sequence. *Haryana Journal of Agronomy.* 4(1): 42-47.

Ramesh, P, Panwar, N.R, Singh, A.B and Ramana, S. 2008. Effect of organic manures on productivity, nutrient uptake and soil fertility of maize (Zea mays)-linseed (*Linum usitatissimum*) cropping system. *Indian Journal of Agricultural Sciences.* 78: 4, 351-354.

Ranuma, Das Neog, K, Pamehgam, M, Borua, U.C and Bindro, B.B. 2012. Effect of Vermicompost application on leaf yield of mulberry and cocoon characters of silkworm Bombyx mori in the north eastern region of India. *Bulletin of Indian Academy of Sericulture.* 15: 2, 33-36.

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. Journal of Research,* ANGRAU. 33 (1) : 11-17.

Renuka, B and Sankar, C.R. 2001. Effect of organic manures on growth and yield of tomato. *South Indian Horticulture.* 49: 216-219.

Renuka, B and Ravishankar, C. 1998. Effect of organic manures on growth and yield of tomato. In : *Proc. Nation. Sem. Changing Scenario in the Production System of Horticultural Crops*, held at Tamil Nadu Agricultural University, Coimbatore, August 28-30, pp. 215-218.

Sable, C.R, Ghuge, T.D, Jadhav, S.B and Gore, A.K. 2007. Impact of organic sources on uptake, quality and availability of nutrients after harvest of tomato. *Journal of Soils and Crops.* 17(2): 284-287.

Sendur, K.S, Natarajan, S and Thamburaj, S. 1998. Effect of organics and inorganic fertilizers on growth, yield and quality of tomato. *South Indian Horticulture.* 46 (3-4) : 203-205.

Shaha, A.K. 1988. Note on response of turmeric to manures and sources of nitrogen and phosphorous under terrace conditions of mid altitude rizoram. *Indian Journal of Horticulture.* 45 : 139-140.

Sharma, H.L, Singh, C.M and Kapur, B.C. 1986. Effect of neem cake blended urea on germination and yield of radish. *Indian Journal of Agricultural Sciences.* 56(11): 802-804.

Singh, B.K, Pathak, K.A, Boopathi, T and Deka, B.C. 2010. Vermicompost and NPK fertilizer effects on morpho-physiological traits of plants, yield and quality of tomato fruits: (*Solanum lycopersicum* L.). *Vegetable Crops Research Bulletin.* 73: 77-86.

Sandeep kumar, G. 2013. Effect of organic manures on growth, root yield and quality of Carrot (*Daucus carota* L.), M Sc (Hort.) Thesis submitted to Dr. Y.S.R. Horticultural University, Venkataramannagudem, West-Godavari.

Sankar, V, Veeraraghavathatham, D and Kannan, M. 2005. Post harvest storage of onion influenced by organic farming practices. In: NRCG Report, *National symposium on current trends in onion, garlic, chillies and spices production, marketing and utilization,* 25-27 November, 2005, Rajgurunagar, Pune, pp. 104-105.

Shete, M.B, Chaudhary, S.M and Warade, S.D. 1993. A note on use of FYM and vermicompost on yield of white onion Cv. Phule Safed. *Allium Improvement Newsletter*, pp. 36-38.

Singh, R.P, Prasad, R.N, Singh, H and Singh, K.D.N. 1980. Effect of organic amendments in zinc availability to maize and soybean in calcareous soil. *Journal of Indian Society of Soil Science.* 27 (3) : 321-324.

Singh, R.V and Vinod Kumar. 1995. Effect of carbofuran and neem cake on *Meloidogyne incognita* infecting Japanese mint. *Indian Journal of Nematology*. 5 : 12-13.

Singh, V.K, Singh, K.P and Ashish Ranjan. 2013. Influence of chemical fertilizers and biofertilizers on dry matter yield and NPK uptake by cabbage (*Brassica oleracea* var. *capitata* Linn.). *Asian Journal of Horticulture*. 8(2):568-571.

Somners, L.E and Sutton, A.L. 1980. Use of waste materials as sources of phosphorus. In: *The Role of Phosphorus in Agriculture*. pp. 515-544.

Srivastava, O.P. 1998. Integrated Nutrient Management for sustained fertility of soil. *Indian Journal of Agricultural Chemistry.* 31(1): 1-12.

Subbaiah, B.V and Asija, G.L. 1956. Alkaline permanganate method. Current Science. 25: 258-260.

Subbaiah, K, Sundararajan, S and Muthuswami, S. 1983. Effect of varying levels of organic and inorganic fertilizers on yield and nutrient uptake in brinjal. *South Indian Horticulture.* 31 : 287-290.

Subbaiah, k, Helkaih, J, Ravikumar, V and Rajagopal, 1982. Effect of combined application of organic and inorganic fertilizers on the yield and nitrogen uptake of MDV chilli. *South Indian Horticulture.* 30 : 45-47.

Sudhakar, G. 2000. Studies on to identify crop wastes/lowland weed as alternate source to organics to sustain the productivity of rice based system. *Ph. D. Thesis,* Tamil Nadu Agricultural University, Coimbatore, India.

Sunita, Gaind, Lata and Nain. 2007. Chemical and biological properties of wheat soil in response to paddy straw incorporation and its biodegradation by fungal inoculants. *Biodegradation.* 18: 4, 495-503.

Suresh, M.J. 1997. Growth, yield and quality of garlic (*Allium sativum* L.) as influenced by spacing and manures. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad, Karnataka, India.

Surlekov, P and Pankov, V. 1989. The effect of fertilization on capsicum productivity and soil agro – chemical and biological properties in monoculture. *Pochvozanie-i- Agrokhimiya*. 24: 17– 23.

Sushanta, Saha Antil, R.S, Saha, B.N and Dahiya, D.S. 2012. Effect of neem cake and N on the yield and uptake of nutrients by wheat. *Crop Research (Hisar)*. 44: 3, 251-254.

*Tejada, M and Gonzalez, J.L. 2009. Application of two vermicomposts on a rice crop: effects on soil biological properties and rice quality and yield. *Agronomy Journal.* 101: 2, 336-344.

Thanunathan, K, Natarajan, S, Senthilkumar, R and Arulmurugan, K. 1997. Effect of different sources of organic amendments on growth and yield of onion in mine spoil. *Madras Agricultural Journal*. 84(7): 382-384.

Tharmaraj, K, Ganesh, P, Kolanjinathan, K, Suresh, K.R and Anandan, A. 2011. Influence of vermicompost and vermiwash on physico chemical properties of rice cultivated soil. *Current Botany*. 2: 3, 18-21.

*Tomar, V.K, Bhatnagar, R.K and Palta, R.K. 1998. Effect of vermicompost on production of brinjal and carrot. [Hindi] *Bhartiya Krishi Anusandhan Patrika.* 13: 3/4, 153-156.

Trivedi, Y.V, Patel, N.L, Ahlawat, T.R, Gaikwad, S.S and Bhalerao, P.P. 2012. Impact of organic manures and inorganic fertilizers on growth, yield, nutrient uptake and soil nutrient status in guava. *Indian Journal of Horticulture.* 69: 4, 501-506.

Uma Reddy, K. 1999. Integrated nutrient management in tomato-onion cropping system. *Ph. D. Thesis* submitted to Acharya N G Ranga Agricultural University, Hyderabad.

Umesha, K, Soumya, S.P, Smitha, G.R and Sreeramu, B.S. 2011. Influence of organic manures on growth, yield and quality of *makoi* (*Solanum nigrum* L.). *Indian Journal of Horticulture.* 68: 2, 235-239.

Ushakumari, K, Prabhakumari and Padmaja, P. 1996. seasonal response of bhendi(*Abelmoschus esculentum*) to VC / vermiculture. In : *Nat. Sem. On Organic Farming and Sustainable Agril.* Assoc. for Promotion for organic farming. p.1.

Venkatakrishnan, D and Ravichandran, M. 2007. Influence of nutrient management on growth and yield of sugarcane (var. Co 86032). *Plant Archives.* 7: 1, 99-102.

Venkatesh, 1995. Effect of vermiculture on soil composition, growth, yield and quality of Thompson seedless grapes (*Vitis vinifera* L.). *M. Sc. (Agri.) Thesis*. University of Agricultural Sciences, Dharwad, Karnataka, India.

Warncke, D.D and Siregar, D. 1992. Phosphorus availability and uptake by plant from poultry manure and leaf composition. *Journal of Environmental Horticulture.* 5(7) : 8550-9288.

Willumsen, J, Thorup-Kristensen, K. 2001. Effect of green manure crops on soil mineral nitrogen available for organic production of onion and white cabbage in two contrasting years. *Biological Agriculture and Horticulture.* 18(4): 365-384.

Yadav, B.K and Christopher, L.A. 2006. Effect of organic manures and panchagavya spray on yield attributes, yield and economics of rice (*Oryza sativa* L.). *Crop Research*. 31(1): 1-5.

Yadav, H and Vijayakumari, B. 2003. Influence of vermicompost with organic and inorganic manures on biometric and yield parameters of chilli (*Capsicum annuum* L.). *Crop Research.* 25(2): 236-243.

*Yanwang, K, Yamamoto and Yakushido, K. 2002. Changes in nitrate N content in different soil layers after the application of livestock waste compost pellets in a sweet corn field. *Soil Science Plant Nutrition.* 48(2) : 165-170.

*Originals not seen

Note: The pattern of ‘Literature cited’ presented above is in accordance with the “Guidelines for thesis presentation-2012” for Dr.Y.S.R. Horticultural University

APPENDIX – I

WEEKLY METEOROLOGICAL DATA DURING THE CROP GROWTH PERIOD

(29-09-2013 to 25-03-2014)

Standard week	Period	Temperature(^{0}C)		Relative Humidity(%)		Sun Shine hours day^{-1}	Mean evaporation (mm day^{-1})	Rainfall (mm)	Wind speed Km hour^{-1}	Mean Temp. (^{0}C)	Rainy days
		Max.	Min.	I	II						
39	24-30 Sep	31.5	19.9	84	60	8.9	5.0	0.0	4.8	25.7	0
40	01-07 Oct	30.5	22.0	84	63	4.7	4.5	0.2	4.0	26.2	0
41	08-14	31.1	20.8	87	61	6.4	4.4	2.5	3.7	26.0	0.2
42	15-21	31.7	17.7	87	53	8.1	5.0	1.6	2.4	24.8	0.1
43	22-28	26.3	19.3	96	81	1.3	1.4	31.7	2.3	22.8	0.8
44	29-04 Nov	30.1	17.5	87	56	7.4	3.3	0.0	1.0	23.8	0
45	05-11	28.5	14.3	84	49	7.2	3.0	0.0	2.1	21.4	0
46	12-18	27.7	11.3	84	37	8.0	2.9	0.0	1.6	19.6	0
47	19-25	28.3	15.1	89	58	5.8	2.5	4.1	1.0	21.7	0.2
48	26-02 Dec	28.4	14.8	90	54	6.2	1.9	0.0	1.9	21.6	0
49	03-09	27.6	11.1	77	37	8.1	2.8	0.0	2.3	19.4	0
50	10-16	29.0	7.5	86	27	9.6	2.7	0.0	1.4	18.3	0
51	17-23	28.0	8.8	81	35	9.2	2.8	0.0	1.4	18.4	0

APPENDIX – I

WEEKLY METEOROLOGICAL DATA DURING THE CROP GROWTH PERIOD

(29-09-2013 to 25-03-2014)

Standard week	**Period**	**Temperature(^{0}C)**		**Relative Humidity(%)**		**Sun Shine hours day^{-1}**	**Mean evaporation (mm day^{-1})**	**Rainfall (mm)**	**Wind speed Km hour^{-1}**	**Mean Temp. (^{0}C)**	**Rainy days**
		Max.	**Min.**	**I**	**II**						
52	24-31	27.0	11.0	86	40	8.5	2.5	0.0	1.9	19.0	0
1	01-07 Jan	28.7	11.2	87	41	8.4	2.7	0.0	1.3	20.0	0
2	08-14	29.3	12.8	81	35	8.6	3.2	0.0	2.4	21.1	0
3	15-21	29.0	13.7	87	41	8.3	3.3	0.0	3.5	21.4	0
4	22-28	27.9	14.3	83	46	7.5	3.0	0.0	3.1	21.1	0
5	29-04 Feb	28.6	14.5	86	33	8.1	3.3	0.0	1.5	21.6	0
6	05-11	33.1	14.7	82	26	9.6	4.1	0.0	1.6	23.9	0
7	12-18	30.9	17.2	72	32	8.5	4.7	0.0	3.2	24.1	0
8	19-25	30.6	18.8	76	40	8.3	5.1	0.0	3.4	24.7	0
9	26-04 Mar	30.3	18.7	84	49	7.6	4.5	4.6	4.4	24.5	0.2
10	05-11	27.5	20.0	90	49	4.7	2.7	3.4	4.0	23.8	0.4
11	12-18	33.3	19.9	77	24	8.2	4.5	0.0	2.3	26.7	0
12	19-25 Mar	36.7	21.0	71	27	8.7	5.8	0.0	1.9	28.9	0
Mean		**29.67**	**15.68**	**83.76**	**44.38**	**7.53**	**3.52**	**1.85**	**2.47**	**22.71**	**0.07**

APPENDIX –IIb

DETAILS OF COST OF CULTIVATION IN DIFFERENT TREATMENTS (Rs. ha^{-1})

S. No.	Operations	T1	T2	T3	T4	T5	T6	T7	T8	T9
1.	Ploughing with Tractor Harrowing	3,000 800	3,000 800	3,000 800	3,000 800	3,000 800	3,000 800	3,000 800	3,000 800	3,000 800
2.	Cost of Seeds Transplanting	5,500 1600	5,500 1600	5,500 1600	5,500 1600	5,500 1600	5,500 1600	5,500 1600	5,500 1600	5,500 1600
3.	Cost of Fertilizers/manures Application charges	39,060 650	39,460 650	85,700 750	86,100 750	53,400 1,050	53,800 1,050	1,00,040 1,050	1,00,440 1,050	43,196 750
4.	Hand Weeding	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
5.	Harvesting, Cutting and Cleaning	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	TOTAL	**56,610**	**57,010**	**1,03,350**	**1,03,750**	**71,350**	**71,750**	**1,17,990**	**1,18,390**	**60,846**

APPENDIX –IIa

PRICES OF INPUTS

S. No.	Particulars	Price(Rs.)
1.	**Chemical fertilizers**	
a.	Urea	320/- per 50kg
b.	SSP	420/- per 50kg
c.	MOP	980/- per 50kg
2.	**Organic manures**	
a.	Farmyard manure	1,200/- per tonne
b.	Vermicompost	4,000/- per tonne
c.	Neem cake	14,000/- per tonne
d.	Poultry manure	3,000/- per tonne
3.	**Biofertilizers**	
a.	Azospirillum	40/- per kg
b.	PSB	40/- per kg
4.	**Wages**	
a.	Men	250/- per day
b.	Women	150/- per day
c.	Bullock pair	800/- per day
5.	**Onion seeds**	550/- per kg