"EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN

(*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*)"

Thesis submitted to Kuvempu University for the award of Degree of

DOCTOR OF PHILOSOPHY

in

APPLIED BOTANY

By

Mr. Manjesh , M. M.Sc. (Hort.)

Research Guide
Dr. H.N. Ramesh Babu
Professor
Dept. of Botany and Seed Technology
Sahyadri Science College, Shivamogga
Kuvempu University, Shankaraghatta
Karnataka, India

Research Co-Guide
Dr. Nagarajappa Adivappar
Associate Professor (Horticulture)
Zonal Agricultural and Horticultural Research Station, KSN University of Agricultural and Horticultural Sciences,
Shivamogga, Karnataka, India

DEPARTMENT OF POST GRADUATE STUDIES AND RESEARCH IN APPLIED BOTANY
KUVEMPU UNIVERSITY
JNANA SAHYADRI, SHANKARAGHATTA - 577451
SHIVAMOGGA DISTRICT, KARNATAKA, INDIA.

2023

“EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN

(*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*)”

Thesis submitted to Kuvempu University for the award of Degree of

DOCTOR OF PHILOSOPHY

in

APPLIED BOTANY

By

Mr. Manjesh , M. **M.Sc. (Hort.)**

Research Guide
Dr. H.N. Ramesh Babu
Professor
Dept. of Botany and Seed Technology
Sahyadri Science College, Shivamogga
Kuvempu University, Shankaraghatta
Karnataka, India

Research Co-Guide
Dr. Nagarajappa Adivappar
Associate Professor (Horticulture)
Zonal Agricultural and Horticultural Research Station, KSN University of Agricultural and Horticultural Sciences,
Shivamogga, Karnataka, India

DEPARTMENT OF POST GRADUATE STUDIES AND RESEARCH IN APPLIED BOTANY
KUVEMPU UNIVERSITY
JNANA SAHYADRI, SHANKARAGHATTA - 577451
SHIVAMOGGA DISTRICT, KARNATAKA, INDIA.

2023

Affectionately Dedicated to my beloved parents

Sri. K.M. Manjappa,

Smt. T. Lakshmi

Mr. Manjesh, M.
Research Fellow

Dept. of P.G. Studies and Research in Applied Botany
Kuvempu University
Jnana Sahyadri, Shankaraghatta-577451
Shivamogga District, Karnataka, India.

DECLARATION

I, **Manjesh, M.** hereby declare that thesis entitled **"EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN (*Vigna unguiculata ssp. sesquipedalis (L.) verdc.)*",** embodies the results of bonafide research work carried out by me under the guidance of **Dr. H. N. Ramesh Babu**, Professor, Dept. of Botany and Seed technology, Sahyadri Science College, Kuvempu University, Shivamogga. And under the Co-Guidance of **Dr. Nagarajappa Adivappar**, Associate Professor (Horticulture), Zonal Agricultural and Horticultural Research Station, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga.

I further declare that the results of this work have not been previously submitted for any other diploma or degree either in this or any other university.

Date : 26/05/23
Place: Shivamogga

(Manjesh, M)

KUVEMPU UNIVERSITY

Sahyadri Science College
(Constituent College of Kuvempu University)

Dr. H. N. Ramesh Babu
Professor and Research Guide

Dept. of Botany and Seed Technology
Sahyadri Science College, Shivamogga
Kuvempu University, Shankaraghatta
Jnana Sahyadri, Shankaraghatta-577451,
Shivamogga District, Karnataka, India.

Email: rameshbabuhn29@gmail.com
Mobile : 9448343123

CERTIFICATE

This is to certify that thesis entitled **"EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN (*Vigna unguiculata ssp. sesquipedalis (L.) verdc.)*"**, submitted by **Mr. Manjesh, M**. to Kuvempu University for the award of the Degree of **Doctor of Philosophy in Applied Botany**, is a record of original work carried out by him under my guidance. I further declare that the results of this work have not been previously submitted for any other diploma or degree either in this or any other university.

Date : 26/5/23
Place: Shivamogga

(H.N. Ramesh Babu)

KELADI SHIVAPPA NAYAKA UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL SCIENCES, SHIVAMOGGA, Karnataka
Zonal Agricultural and Horticultural Research Station, Shivamogga

Dr. Nagarajappa Adivappar
Associate Professor (Horticulture) and Co -Guide
Zonal Agricultural and Horticultural Research, Station,
KSN University of Agricultural and Horticultural Sciences, Shivamogga

CERTIFICATE

This is to certify that thesis entitled **"EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN (*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*)"** submitted by **Mr. Manjesh, M.** to Kuvempu University, Jnana Sahyadri, Shankaraghatta for the award of the degree of **Doctor of Philosophy in Applied Botany**, is a record of original work carried out by him under my **Co-Guidance**. I further declare that the results of this work have not been previously submitted for any other diploma or degree either in this or any other university.

Date : 26/5/23
Place: Shivamogga

(Nagarajappa Adivappar)

Office : 08282256301
Fax: 08282256255
Mobile: 09731728364

KUVEMPU UNIVERSITY

Dr. Y. L. Krishnamurthy
Professor and Chairman

Department of P.G. Studies and
Research in Applied Botany,
Jnana Sahyadri, Kuvempu University,
Shankaraghatta, Shivamogga-577451,
Karnataka, India.

CERTIFICATE

This is to certify that thesis entitled **"EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN (*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*)"** submitted to Kuvempu University for the award of the Degree of **Doctor of Philosophy in Applied Botany** by **Mr. Manjesh, M.** is the result of bonafide research work carried out by him under the guidance of **Dr. H. N. Ramesh Babu**, Professor, Dept. of Botany and Seed technology, Sahyadri Science College, Kuvempu University, Shivamogga. And under the Co-Guidance of **Dr. Nagarajappa Adivappar**, Associate Professor (Horticulture), Zonal Agricultural and Horticultural Research Station, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India.

Date : 26/5/25
Place: Shivamogga

(Y. L. Krishnamurthy)

Office: 08282256301
Fax: 08282256255

KUVEMPU UNIVERSITY

The Chairman
Department of P.G. Studies and
Research in Applied Botany,
Jnana Sahyadri, Kuvempu University,
Shankaraghatta, Shivamogga-577451,
Karnataka, India.

COURSE WORK COMPLETION CERTIFICATE

This is to certify that **Mr. Manjesh, M.,** is a bonafide research scholar of this department, has satisfactorily completed the course work requirements which is part of his Ph.D. Programme.

Date: ***CHAIRMAN***

Place:

Ouriginal
by Turnitin

Document Information

Analyzed document	KU-RTH-BOT-MANJESH-M-23.pdf (D166997896)
Submitted	5/15/2023 2:33:00 PM
Submitted by	Walmiki R H
Submitter email	walmiki_rh@rediffmail.com
Similarity	10%
Analysis address	walmiki_rh.kuvempu@analysis.urkund.com

Sources included in the report

SA	**A-2019-027-M.pdf** Document A-2019-027-M.pdf (D112336253)	4
W	URL: https://www.thepharmajournal.com/archives/2021/vol10issue10/PartG/10-10-46-364.pdf Fetched: 6/4/2022 4:00:36 PM	2
SA	**Lakshman.pdf** Document Lakshman.pdf (D136683138)	4
SA	**Shardha Magar.pdf** Document Shardha Magar.pdf (D150919706)	6
SA	**Chapter-II Review of literature.docx** Document Chapter-II Review of literature.docx (D142236043)	6
SA	**Deepak_Potdar__Agril._Chem._and_Soil_Science_Ph.D._15-01-01-01-01_2018.pdf** Document Deepak_Potdar__Agril._Chem._and_Soil_Science_Ph.D._15-01-01-01-01_2018.pdf (D46245629)	3
W	URL: https://www.thepharmajournal.com/archives/2022/vol11issue2/PartC/11-1-255-460.pdf Fetched: 2/26/2022 10:51:16 AM	1
SA	**venky part 1 plg.docx** Document venky part 1 plg.docx (D110895611)	14
SA	**20MSH001 5.5.23.docx** Document 20MSH001 5.5.23.docx (D165876405)	9
SA	**sudhakar singh.pdf** Document sudhakar singh.pdf (D110716044)	10
SA	**Chapter II Review of Literature.docx** Document Chapter II Review of Literature.docx (D107114647)	2
SA	**Akanksha.pdf** Document Akanksha.pdf (D118756126)	14

Ouriginal by Turnitin

W	URL: https://www.thepharmajournal.com/archives/2023/vol12issue2/PartAT/12-2-561-729.pdf Fetched: 3/26/2023 7:09:05 PM	1
SA	**2. Review literature Savita.docx** Document 2. Review literature Savita.docx (D142686191)	6
SA	**CHAPTER - 2.2.docx** Document CHAPTER - 2.2.docx (D143163353)	1
SA	**CHAPTER - 2.2.docx** Document CHAPTER - 2.2.docx (D143163577)	1
SA	**CHAPTER - 2.2.docx** Document CHAPTER - 2.2.docx (D143161710)	1
SA	**CHAPTER - 2.2.docx** Document CHAPTER - 2.2.docx (D143515115)	1
SA	**CHAPTER - 2.2.docx** Document CHAPTER - 2.2.docx (D143934450)	1
SA	**Monika Jaiswal M.Sc. (ag) thesis mungbean.pdf** Document Monika Jaiswal M.Sc. (ag) thesis mungbean.pdf (D53905192)	9
SA	**Monika Jaiswal M.Sc. (ag) greengram.pdf** Document Monika Jaiswal M.Sc. (ag) greengram.pdf (D53963525)	7
SA	**monika jaiswal 17june.docx** Document monika jaiswal 17june.docx (D53941563)	8
SA	**Review and literature_22_06_2021.doc** Document Review and literature_22_06_2021.doc (D112530360)	6
SA	**Review and literature_22_09_2021.doc** Document Review and literature_22_09_2021.doc (D113176768)	6
SA	**Rev of Lit 2nd check.docx** Document Rev of Lit 2nd check.docx (D106980700)	4
SA	**Thesis Msc Agriculture (Agronomy) Dhanwant Singh, Uni. Roll No. 186327.pdf** Document Thesis Msc Agriculture (Agronomy) Dhanwant Singh, Uni. Roll No. 186327.pdf (D100481923)	1
W	URL: http://gkvsociety.com/control/uploads/1581119.pdf Fetched: 11/2/2021 6:41:31 AM	3
SA	**Jitendra Meena (2).docx** Document Jitendra Meena (2).docx (D40402848)	4
W	URL: https://www.fspublishers.org/published_papers/44012_..pdf Fetched: 8/16/2021 12:54:05 PM	2
W	URL: https://www.researchgate.net/figure/Effect-of-treatments-on-growth-and-yield-attributes-of-oni... Fetched: 4/23/2020 7:42:43 AM	2
SA	**monika jaiswal 18 june.pdf** Document monika jaiswal 18 june.pdf (D53968169)	3

ACKNOWLEDGEMENT

With feelings of satisfaction, I take this opportunity to share some of the moments associated with my research work and preparation of this thesis. I would like to express my heartfelt gratitude to all seen and unseen helping hands reaching out to me during my endeavour to reach a milestone. It is sense of pride to have worked under the guidance of ***Dr. H.N. Ramesh Babu,*** *Professor****,*** *Department of Botany and Seed technology, & Distance Director, Kuvempu University, Shankaraghatta, Shivamogga, the esteemed chairman, for his constant encouragement, I am most thankful to him for his excellent guidance, encouragement, keen interest throughout the course of this investigation..*

*It gives me great pleasure to express my heartfelt thanks to Co-guide****,*** ***Dr. Nagarajappa Adivappar,*** *Associate Professor (Hort.) Zonal Agricultural and Horticultural Research Station, Shivamogga for his constructive criticism, inspiration, guidance and moral support are highly appreciated and remembered.*

Thanks to ***Directorate of Research*** *and* ***Directorate of Extension****, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga for providing support to conduct the research at Zonal Agricultural and Horticultural Research Station, Navile, Shivamogga, Karnataka.*

It's my fortune to gratefully acknowledge my deep sense of pride and dignity. I extend heartfelt thanks towards ***Dr. N. Rajeshwari****, Professor of Botany and Principal, Sahyadri science college Shivamogga.* ***Dr. T.S. Aghora*** *, Principal Scientist, Division of Vegetable Science, Indian Institute of Horticulture Research, Banglore.* ***Dr. Srinivasa, V.*** *Professor and Head, Department of Vegetable science, College of Horticulture, Mudigere****.*** ***Dr. Sarvagna Salimat****, Assistant professor (Soil science) College of Agriculture, Shivamogga for their inspiring guidance, valuable suggestions and sensible criticism in ameliorating mammoth help and bountiful cooperation.*

On my personal note, I would like to express my deep sense of respect to my beloved Father ***Sri. K.M. Manjappa,*** *and mother* ***Smt****.* ***T. Lakshmi*** *for their ultimate blessings, abundant love and affection, moral encouragement, constant support and personal sacrifice during the academic carrier, my gratitude is too deep for words. The constant love and support of my sister* ***Mrs. Nethra, M*** *is sincerely acknowledged and* *all my family members for their bound less affection, words of encouragement, selfless sacrifice and unshakable confidence respond in me that had a direct effect in completing this work.*

I am ever indebted to Dr. Chaitanya, H.S, Scientist (Horticulture) KSNUAHS, Shivamogga , Dr. Kiran Kumar, G. N , Senior Assistant Director of Horticulture, Sagara and Miss. Niharika, B. H., Research scholar, Who were always willing to help in need and I admire their distinguished helping nature.

I wish to extend my sincere thanks to my Ph.D batchmates Mr.Manjunath, K, Mr. Ashok, Mr. Kanthraj, Ms.Sowmya, Ms. Srusti, Mrs. Nalini and senior friends Dr. Sunil Kumar,T.V., Dr. Ashrith. K. N, Dr. Narsimhamurthy, H.B., Dr.Sudeep,H.P, Dr. B.H.Bhaganna, Dr. Akshay angdi, Dr. Basavaraj dalawai for their timely help, constant moral support, motivation and encouragement which helped me in the successful completion of my research and thesis work.

I owe special thanks from depth of my heart to Mr.Arun, H.V, Mr.Nandish, Ms.Ashwini, L.K., Mrs.Sudha and Mr.Mylaranna who were always willing to help me in need and I admire their distinguished helping nature.

I extend my sincere thanks to the Department of Applied Botany, Kuvempu university, Shankaragatta, Shivamogga for giving me an oppurtunity to complete my Doctroral degree, Ph.D in Applied Botany. The presentation that follows is the work assited by many seen and unseen hands and minds, I am thankful to all of them.

Finally, I thank ALMIGHTY GOD for the good health, essential strength and knowledge he has afforded me through my education trajectory.

My fading memory prevents me to acknowledge so many other people in various walks of life who helped me at one or other stage of my life, of late, I acknowledge their cooperation.

Shivamogga
May, 2023

ACRONYMS/ ABBREVIATIONS

%	Per cent
@	At
°C	Degree celsius
S. Em ±	Standard Error of Mean
CD	Critical Difference
pH	Power of Hydrogen ion
cm	Centimeter
Cv.	Cultivar
et al.	Co-workers
g	Gram
i.e.	That is
kg	Kilogram
mg	Miligram
t	Ton
viz.	Namely
DAS	Days after sowing
MT	Metric tons
&	And
Fig.	Figure
ha.	Hectare
RDF	Recommended Dose of Fertilizers
FYM	Farm Yard Manure
VS	Vegetable Special
HYV	High Yielding Varieties
POP	Package of Practice
EMC	Effective Microbial Consortia
RCBD	Randomized Complete Block Design
IIHR	Indian Institute of Horticulture Research
ICAR	Indian Council of Agriculture Research
ISTA	International Seed Testing Association

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CONTENTS OF THE THESIS

1.INTRODUCTION

Among different vegetables, leguminous crops play an important role as it is the major source of vegetable protein which is required for human health. They also provide minerals, vitamins and fibres. It constitute about 10-12% of the Indian diet. According to World Health Organization (WHO) recommendation, the intake of leguminous vegetables should be 80g/day/capita. Similarly, leguminous vegetables are lesser prones to climatic changes and helps in maintaining soil health and thus, are important contributors of profitable cropping system.

According to Verdcourt (1970) cowpea has five subspecies, which are *cylindrica, sesquipedalis, dekindtiana, unguiculata and menensis*. Among them, *cylindrica, sesquipedalis* and *unguiculata* are cultivated species whereas, *dekindtiana* and *menensis* are wild ones. *Vigna unguiculata ssp. sesquipedalis* is a legume cultivated for its green pods. It is known as the Yardlong bean, long-podded cowpea, asparagus bean and snake bean. Despite the common name, the pods are actually about half a yard long. It is originated in West Africa. It is a vigorous climbing vine. The plant is subtropical/tropical and most widely grown in the warmer parts of South Asia, South-East Asia, Southern China and India. (FAO 1993; Piluek 1994). It is one of the most nutritious leguminous vegetable crop. Fresh pods are used as a green vegetable. Pods are rich in protein, Vitamin A (865 IU), Potassium (240 mg) & Calcium (50 mg) per 100 g edible pods (USDA, 2019).

Its chromosome number is 2n = 2x = 22 and belongs to the sub family – *Papilionaceae* and family – *Leguminosae.* It has indeterminate growth habit and leaves are trifoliate and green in colour. Flowers are of papilionaceous type with violet colour. Pods are long, slender and pendent with sparely arranged bold seeds. The pods have great demand in Gulf countries and large quantities are exported to the Middle East.

It enriches soil fertility by fixing atmospheric nitrogen. The factors attributed for low yield of Yardlong bean is mainly growing of Yardlong beans under less fertile soil with low inputs or improper application of fertilizers. Nowadays increasing cost of inorganic fertilizers and reduction in soil health with chemical fertilizers, it is essential to replace inorganic fertilizers through organic for sustainable agriculture. Organic sources of the plant nutrients have been reported to improve growth, yield and soil fertility status.

Use of inorganic fertilizers alone though increases the production at a faster rate, it may not sustain the productivity in long run and affects soil health. Moreover inorganic fertilizers are costly and their imbalanced use deteriorate soil physico-chemical environment. At the same time large quantities of organic sources of nutrients are not exploited in crop production. These organic sources of nutrients are cheaper, ecofriendly, improve soil properties and can substitute nutrient requirement of crops partially. Hence integrated use of inorganic fertilizers, organic manures and low cost nutrient sources such as biofertilizers is the better option for sustainable production and maintenance of soil health. In this regard, dependency on chemical fertilizers need to be reduced and as these chemical fertilizers are imported from foreign countries which further adds more production cost per unit area to farmers. In order to minimize the usage of chemical fertilizers and to reduce the burden on expense of nation and to promote environment friendly organic sources of nutrient, it is imperative to switch over to organic amendments which will largely reduce the dependency on chemical fertilizers.

Keeping in view the popularization of high yielding varieties and hybrids of various vegetable crops, it may not be possible to completely replace the chemical fertilizers, but the possibility of reducing the dose of inorganic fertilizers by substituting some part of nutrients with biofertilizers is always there. For this, the doses of fertilizers need to be gradually reduced and should be balanced by increasing the use of optimum quantity of organic manures and biofertilizers. Microbial inoculation in vegetable crops has resulted in significant improvement in growth, yield and quality (Leelarani, 2015). The use of biofertilizers has currently attained a special significance in crop production to address the sustainability problem and tremendous success has been achieved in several economic crops.

Reliance on the increased use of chemical fertilizers and associated hazards put back attention on organic sources which are effective in promoting health and productivity of the soil. Integrated management of chemical fertilizers and organic wastes may be an important strategy for sustainable production of crops. This may not only improve the efficiency of chemical fertilizers along with their minimal use in crop production besides increasing crop yield and improving available major and minor nutrients (Rautaray *et al*., 2003). Over the years inorganic fertilizers have been widely used worldwide to support and optimize the growth of vegetables. However, the use of organic fertilizer has gained more importance globally in the last few decades, due to efforts made for the conservation of agriculture. Organic fertilizers have been shown to help preserve natural resources and reduce degradation of ecosystem (Mader *et al.* 2002; Francis and Daniel, 2004).

India has made spectacular breakthrough in production and consumption of fertilizers during the last four decades. Moreover the imbalance and continuous use of chemical fertilizers has adverse effect on physical, chemical and biological properties of soil and there by affecting the sustainability of crop production, besides causing hazardous to human health and environmental pollution (Virmani, 1994).Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase in the usage of organics which needed to check the yield and quality levels.

Bio-fertilizers are inputs containing microorganisms which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes. The use of bio-fertilizers are more eco-friendly in nature. They can play a significant role in fixing atmospheric nitrogen, production of plant growth promoting substances and making phosphorus available to plants by bringing about favourable change in soil micro-environment leading to solubilisation of insoluble organic phosphate sources. Fixed phosphate can be dissolved by microbial organic acids. The application of bio-fertilizer is very essential because the insoluble phosphate which is not directly available to plants usually comprises around 95-99 per cent of the total soil phosphorous (Upadhaya *et al*. 1999).

The major components of organic nutrient management system involves the organic manures with variable nutrient release patterns mainly compost, green manures, vermicompost, crop residue and bio-fertilizers along with natural soil reserves. The basic concept underlying the principle of integrated nutrient management is to maintain or adjust plant nutrient supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients. Integrated nutrient management not only aims at reducing the use of inorganic fertilizers, but also helps in restoring the soil organic matter, enhances nutrient use efficiency and maintains soil quality in terms of physical, chemical and biological properties.

However, so far very limited attempts have been made to study the various production practices for Yardlong bean in Karnataka. It is multiple harvest crop and the growth of plant is dependent on nutrient supply. The recommendation regarding fertilizer dose will help the farmers to maximize yield of Yardlong bean and in turn it also will help to increase the returns. The increased use of chemical fertilizers to increase vegetable production has been widely recognized but its long run impact on soil health, ecology and other natural resources are detrimental which affect living organisms including beneficial soil microorganisms and human being. The increasing costs of chemical fertilizers, which are needed by the high yielding varieties (HYV) are adding to the cost of cultivation in Indian agriculture (Panwar *et al*. 2010).

In this context the study will include integration of different levels of organic and inorganic nutrients for getting high productivity in Yardlong bean which in turn helps the farmers to get higher returns. Hence, with this background and keeping in view the above facts, an experiment entitled **"Effect of Integrated Nutrient Management on yield and quality of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis (L.) verdc*.)"** is carried out with the following objectives.

- To study the effect of integrated nutrient management on growth and pod yield parameters.
- To study the impact of integrated nutrient management on seed yield and quality traits.
- To workout the cost benefit ratio of using organic and chemical fertilizers.

2.REVIEW OF LITERATURE

Importance of legumes in agriculture needs no further emphasis, as they are valuable source of human nutrition and soil fertility. The available literature on the Effect of Integrated Nutrient Management on yield and quality of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis (L.) verdc*.) has been reviewed in this chapter.

Attempt has been made to cite as much literature as possible on Yardlong bean but due to paucity of adequate experimental evidences, similar research work on other related crops of legume group/other families has also been reviewed, wherever felt necessary. Since the literature on this research experiment is very meagre therefore related research findings on the other vegetable crops and horticulture crops have also been incorporated under the following sub headings.

2.1 Effect of integrated nutrient management on growth and pod yield parameters:

Balachandran *et al.* (2005) conducted a field experiment at Nagpur (Maharashtra) to study the effect of seed inoculation with *Rhizobium* and phosphate solubilizing bacteria (*Pseudomonas* and *Bacillus* sp.) on greengram. Results revealed that ½ RDF + 5 tonnes pressmud + *Rhizobium* + PSB improved the yield and yield contributing parameters viz., 100-seed weight, length of pod, number of seeds per pod, number of pods per plant and harvest index.

Singh *et al*. (2006) conducted a field experiment to study the effect of NPK and biofertilizers *Rhizobium*, phosphate-solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) on nodulation, yield attributes and uptake of nutrient by pea (*Pisum sativum*). The data showed significantly higher number of nodules and their fresh weight with the treatment *Rhizobium*+VAM+PSB+75% of recommended NPK, Inoculation of *Rhizobium*+VAM+PSB along with 75% NPK recorded significantly higher yield attributes and finally seed yield over each and all treatments. Use of bio fertilizers *Rhizobium*+PSB and *Rhizobium*+VAM along with 50% NPK gave yield equal to 100% of recommended NPK.

Kishanswaroop (2006) inoculated Rhizobium along with the application of 80 kg P, 60 kg K, and 20 kg N/ha led to the highest yield of green pods per ha as compare to other tretaments.

Singh *et al.* (2007) revealed that application of 30 kg N and 60 kg P2 O5 per ha and *Rhizobium* inoculation significantly increased the plant height (52.34 cm and 52.58 cm), number of pods per plant (59.39 and 57.55), weight of the pod (1.87 g and 1.89 g) and length of the pod (30.44 cm and 32.80 cm) at 30, 60 and 90 days as compare to application of 60 kg N and 90 kg P2 O5 per ha and Rhizobium inoculation in cowpea.

Rathore *et al.* (2007) conducted a field experiment to examine the impact of chemical and biofertilizers on growth, yield and uptake of nutrients in cluster bean. integrated combination of nutrients by chemical fertilisers and biofertilizers resulted in significant improvements in growth, production and nutrient uptake were seen. The association between *Rhizobium* and the phosphate-solubilizing bacteria considerably increased the seed yield.

Sammanuria *et al.* (2009) reported that the growth, yield attributes and yield increased significantly due to inoculation of clusterbean with bio-fertilizers. Combined inoculation of Rhizobium and PSB was more promising from productivity and profitability point of view as compared to their sole inoculation. Integrated use of 75% RDF with *Rhizobium* + PSB inoculation was the best for cluster bean.

Kausale *et al.*, (2009) observed that nodule number, dry matter per plant, pod and haulm yield of groundnut crop increased with application of 100% RDF (25: 50 N and P kg/ha), 10 t FYM/ha and Rhizobium or PSB seed inculcation.

Subbarayappa *et al.* (2009) opined that application of 100 per cent RDF + FYM significantly increased growth and yield parameters followed by 75 per cent RDF + FYM respectively.

Patel and Singh (2009) revealed that application of 20 kg N + 40 kg P2 O5 per ha along with *Rhizobium* seed inoculation gave significantly higher plant height (48.18 cm), maximum nodulation per plant (9.60), number of clusters per plant (34.83), number of pods per plant (34.83) as compare to other treatments.

Sharma *et al.* (2010) studied the effect of nutrient management on growth parameters of China aster under protected conditions taking different combinations of chemical fertilizers, FYM, vermicompost and triple inoculation of *Azotobacter*, PSB and mycorrhizae. Result revealed that the integrated use of the recommended doses of NPK with vermicompost and triple inoculation with *Azotobacter* + PSB + VAM gave maximum growth and the enriched manures and biofertilizers were found to increase both yield and quality.

Rather *et al.* (2010) studied the effect of application of biofertilizers {*Rhizobium*, *Azotobacter* and phosphate solubilizing bacteria (PSB)} on growth and yield of field pea (*Pisum sativum* L.). Co-inoculation of all the three bio-fertilizers showed significantly higher growth characters as compared to absolute control, increased plant height (45.26 cm), number of nodules/ plant (38.46), and yield of grain and straw of pea increased by co-inoculation.

Patel e*t al*. (2010) conducted a field experiment during late *Kharif* season to study the effect of integrated nutrient management on growth attributes of clusterbean cv. Pusa Navbahar. The results revealed that integrated use of inorganic fertilizer, bio-fertilizer and organic manure enhanced the growth of cluster bean. Higher yield and yield attributes were recorded in the treatment of 100% RDF (25 kg N + 50 kg P_2O_5 ha^{-1}) + FYM @ 10 t ha^{-1} + seed treatment with *Rhizobium* followed by 100% RDF + Vermicompost @ 2 t ha-1 + seed treatment with *Rhizobium*.

Meera *et al.* (2010) observed applying two split doses of poultry manure along with inorganic fertilisers at a rate of 20:30:10 kg N, P, and K per hectare significantly increased plant height (106.8 cm), dry matter production (9.678 kg/ha) and number of branches per plant (16.50), when compared to other organic and inorganic treatments.

Jadhav *et al.* (2011) reported that plant height (50.77 cm) and number of branches per plant (4.51) were found significantly increase with 20 kg N + 40 kg P2 O5 per ha along with *Rhizobium* seed inoculation in cowpea. Earliness in flowering was observed with *Rhizobium* inoculation with 10 kg per ha N and higher level of phosphorus 40 kg per ha.

Choudhary *et al*. (2011) observed that application of 25 kg N+ 50 kg P2O5+ 40 kg K2O along with *Rhizobium*, VAM and PSB recorded higher pod yield, kernel yield, haulm yield (21.46, 14.63, 46.56 q ha^{-1} respectively) over RDF i.e. 25 kg N, 50kg P2O5, 40kg K2O (12.47, 8.41, 26.43 q ha^{-1}) in groundnut.

Bapidas and Waga (2011) opined that growth parameters like plant height (25.60 cm), number of leaves (28.60), branches per plant (20.20) and yield parameters like number of pods per plant (14.64), diameter (4.71 cm) and length of pods (23.09 cm) was increased with the treatment of 75 per cent RDF + Vermicompost + Rhizobium

+ PSB was found significant over control and RDF alone. Maximum nitrogen and phosphorus uptake by plant was found significant in treatment 75 per cent RDF + Vermicompost + Rhizobium + PSB.

Sepehya *et al*. (2012) reported that application of FYM or vermicompost @ 10 t/ha in combination with 75% NPK (on par with 100% NPK) produced significantly higher yields of garden pea due to the beneficial effect of combined use of organics with balanced inorganic fertilization to the extent of 75% NPK.

Chate *et al.* (2012) evaluated the effect of integrated nutrient management on yield of French bean. Among various treatments of inorganic, organic and bio fertilizer sources of plant nutrients and their combinations, the application of 150% NPK along with ZnSO4 (25 kg/ha), FeSO4 (25 kg/ha), *Rhizobium* and PSB @ 250 g/ 10 kg seed) resulted in significantly higher grain yield.

Prasad *et al.* (2013) revealed that application of Rhizobium and PSB along with phosphorus at 80 kg per ha for cowpea showed increase in plant height (14.34 cm, 32.49 cm and 87.40 cm), number of leaves (7.13, 31.80 and 136.73), number of branches (3.60 and 31.80) and number of nodules per plant (19.87) at 15, 30 and 45 days interval respectively.

Siti *et al.* (2015) conducted experiment to examine the effects of organic and inorganic fertilizers on growth and yield of Yard long bean (*Vigna unguiculata subsp. sesquipedalis L.*). Three rates (14.5 g, 11.2 g, 17.8g/plant) of organic fertilizer (poultry manure) and three rates (5 g, 3 g, 7 g/plant) of inorganic fertilizer, which is NPK blue special (12:12:17:2) were evaluated to study the growth and yield of yardlong bean. This study showed that the rate of fertilizer application for different types of fertilizers was not significant on the growth and yield parameters of Yardlong bean. The use of poultry manure at the rate of 17.8 g/plant was more suitable to elevate the growth and yield of Yardlong bean instead of using inorganic fertilizer.

Kumar and Pandita (2015) conducted the experiment on effect of integrated nutrient management on seed yield and quality in cowpea during Kharif 2012 and 2013, with two main plot treatments of inorganic fertilizers. i.e. 100% and 75% recommended dose of fertilizers (RDF) and nine sub plot integrated nutrient management (INM) treatments including control (No organic fertilizer). Main plot treatments were at par but sub plot INM treatments differed significantly with plant height, number of pods/plant and pod length.

Baljinder Singh *et al.* (2016) conducted an experiment at Amritsar during early *kharif* season to study the effect of integrated nutrient management on growth, yield and yield attributing characters in cluster bean the results revealed that the treatment 75% of recommended dose of inorganic fertilizers and 25% RDF through vermicompost along with biofertilizers (*Rhizobium* at 25 g kg^{-1} seed + PSB at 5 kg ha^{-1}) recorded significantly highest pod yield (159.58 g $plant^{-1}$).

Jayashri Barcchiya *et al.* (2016) carried out experiment during Rabi season of 2013-14 at vegetable farm, College of Horticulture, Mandsaur (Gwalior) to study the effect of integrated nutrient management on growth and yield parameters in French bean). It was noticed that application of nutrient levels and varieties had significant influence on growth, yield and yield parameters. Nutrient level N4 [Vermicompost (10t/ha) + N (50kg/ha) + Rhizobium (15g/kg seed) + PSB(15g/kg seed) + P2O5(80kg/ha) + K2O (80kg/ha)] recorded the maximum plant height (57.92cm), fresh weight of shoot (43.70g), dry weight of shoot (11.33g), number of pod per plant (31.81) and pod length (15.55cm).

Avhad *et al.* (2016) conducted a field study to compare the effects of organic and inorganic fertilisers on the growth yield and quality characteristics of the tomato hybrid Phule Raja during the rabi season of 2013–14 at Rahuri. The combined use of organic and inorganic fertilisers had a substantial impact on growth metrics, yield-contributing traits and nutrient uptake, according to the results. The combined application of nutrients considerably increased the total nutrient intake of nitrogen (98.50 kg ha^{-1}), phosphorus (49.70 kg ha^{-1}), potassium (123.30 kg ha^{-1}), Fe (201.94 mg kg^{-1}), Mn (39.50 mg kg^{-1}), Cu (46.13 mg kg^{-1}) and Zn (51.67 mg kg^{-1}).

Singh *et al.* (2017) conducted experiment to determine the impact of integrated nutrient management on crop growth, yield characteristics and quality of summer mung bean. Treatment with RDF+VC 5t/ha showed the best results in terms of growth, yield characteristics, nodule number and nodule weight, as well as a 41.2 per cent greater grain yield than the control and also highest protein content (22.3%), and nutrient uptake (85.65:9.47:75.33::N:P: kg/ha).

Mudji Santosa *et al.* (2017) studied the influence of organic and inorganic fertilizers growth and yield of green bean (*Phaseolus vulgaris* L.) was conducted in Andisol soil, Batu, East results revealed that highest growth obtained with organic and inorganic combination of 100 kg N ha^{-1}, 30 kg P2 O5 ha^{-1} and 100 kg K2O ha^{-1}. The lowest growth and yield was showed by no fertilizer application.

Kumar and Biradar (2017) conducted a experiment under protected condition (Shade house) at Agriculture Research Station, University of Agriculture Sciences, Dharwad during 2015-2016 to find the response of integrated nutrient management (INM) on growth and yield of broccoli (*Brassica oleracea var. italica L.).* Results revealed that higher yield of curd of 19.5 t ha^{-1} was obtained in treatment T11-75%

RDF + FYM and VC (1:1) and they concluded that integration of biofertilizers, organic manures and reduced level of inorganic fertilizers gave better results and hence, there is a great scope of improvement in growth and yield of broccoli.

Jaisankar *et al.* (2018) evaluated the effect of organic and inorganic sources of nutrients in combination with consortium of biofertilizers on growth, yield and quality of dolichos bean [*Lablab purpureus (L) Sweet*]. Among the treatments, NP 30:50 kg ha^{-1}+ 5 t vc ha^{-1}+ BF 2.5 each kg ha^{-1} recorded significantly highest number leaves $plant^{-1}$, number of branches $plant^{-1}$, number of raceme $plant^{-1}$, pods $plant^{-1}$, pod yield $plant^{-1}$, and pod yield (9.88 t ha^{-1}).

Prabhoosingh *et al.* (2018) conducted an experiment during Kharif season 2016-17 to study the "effect of integrated nutrient management on growth and yield of Cowpea *(vigna unguiculata L.).*" at SHUATS, Allahabad. The best treatment was T8-(N1+R1 @ 100% RDF + 20g Rhizobium kg^{-1} seed) showed the increase on enrichment of soil fertility status. The maximum yield of green pod 73.49 q ha^{-1} in treatment combination T8=N1+R1 @ 100% RDF + 20g/kg seed Rhizobium.

Meena *et al.* (2018) conducted the field experiment at Lucknow during the year 2015-16 to find out the effect of integrated nutrient management (INM) on growth of okra [*Abelmoschus esculents (L.) Moench*]. Results indicated that application of treatment T13 (RDF + Vermicompost) resulted in higher growth and yield parameters of okra over the control.

Jitendrakumar *et al.* (2018) carried out a investigation at Srinagar (India) during season, 2014-2015 to study effect of integrated nutrient management on yield & growth performance of French bean (*Phaseolus Vulgaris* L.) results revealed that treatment with 100 % RDF+ Rhizobium Culture + Humic Acid recorded the highest in all observations.

Arulananth *et al.* (2018) investigated the effects of consortium biofertilizers, organic and inorganic nutrient sources on growth, yield, and quality of Dolichos bean (*Lablab purpureus (L.) Sweet*). The combined application of organic manures had a substantial impact on the Dolichos bean's growth, blooming, and yield metrics. The treatment combination of 5 t Vermicompost ha^{-1} + 75% RDF + CBF (2 kg Rhizobium ha^{-1} + 2 kg VAM ha^{-1} + 2.5 kg PSB ha^{-1}) produced the highest yield metrics and pod yield (15.5 t ha^{-1}).

Sukhlal waskel *et al.* (2019) conducted an experiment at Madhya Pradesh, India during Kharif season 2014-15. Significantly higher values of yield attributes such as fruit yield per plot and fruit yield ton per ha were observed under VC @ 10 t/ha+ 75 % RDF (NPK). However, significantly minimum values of yield attributes were observed under control FYM @ 20 t/h + 75% RDF.

Dash *et al.* (2019) conducted an experiment entitled effect of integrated nutrient management on growth and yield attributing parameters of French bean (*Phaseolus vulgaris* L.) at All India Coordinated Research Project (AICRP) on Vegetable Crops of Odisha, Bhubaneswar, India. The results revealed that application of 75% NPK through inorganic source along with 25% N through vermicompost (T3) recorded significantly higher growth parameters viz., plant height (47 cm), number of primary branches (5.53), leaf area (169.55 cm^2).

Preetham *et al.* (2020) conducted experiment in tropical rainy region of Northern Telangana Zone, India during Kharif seasons (July-September) of 2015 and 2016 to study the effect of integrated nutrient management practices on growth of baby corn (*Zea mays* L.) – Hyacinth bean (*Lablab purpureusvar typicus*) cropping system. Application of 25% N through vermicompost in conjunction with 75% RDF and bio-fertilizers to baby corn during Kharif resulted in significantly higher plant height, leaf area index, root volume, cob plant $^{-1}$, cob length, cob girth, cob width, cob weight, cob yield, stover yield, protein content and significantly lower fiber content over rest of treatments during 2015 and 2016.

Sachan *et al*. (2021) conducted a study to look at how fertilisers, both organic and inorganic, affected the development and productivity of *Phaseolus vulgaris L. in Fiji*. The growth metrics and yield characteristics were observed. Combinations of organic and inorganic fertilisers dramatically boost growth and green pod production. It was shown that applying nutrients in a blend of organic and inorganic fertilisers was more efficient than applying nutrients alone in inorganic fertilisers. The mixture of 200 kg of 100% NPK ha^{-1}) and Poultry manure @ 5 t ha^{-1} was found most effective for enhancing growth and yield.

Shabanahamid *et al.* (2021) conducted an experiment on "Productivity of French bean (*Phaseolus vulgaris L.*) as influenced by integrated nutrition and weed management" in the years 2012 and 2013. Results revealed that integrated use of nutrition with hand weeding resulted greater mean pods/plant, mean pod weight/plant, mean green pod yield, and P K uptake by a crop the highest mean plant height and leaves/plant by French bean.

Brahmbhatt *et al.* (2021) revealed that, the application of organic sources of nutrients, including 75% N (15 kg/ha) through FYM + bio fertilizers (Rhizobium + PSB + KSM) @ 2.5 kg/ha each, to cluster beans has been found to improve pod length and quality traits.

Upma *et al.* (2022) conducted a field trial to find out the effect of integrated nutrient management on cluster bean at Navsari Agricultural University during year 2021 and 2022. Among three levels of chemical source of nutrient application of 100% RDF (C1) helped in obtaining maximum values for growth parameters *viz*., plant height, number of leaves at 60 and 90 DAS, fresh biomass of plant at harvest and stem diameter, yield parameters i.e., pod length, pod width, number of clusters plant^{-1}, number of pods plant^{-1}, dry matter yield, fresh pod yield and harvest index.

2.2 Effect of integrated nutrient management on seed yied and quality parameters

Rajkhowa *et al.* (2002) elucidated that the application of 100 per cent RDF along with vermicompost @ 2.5 t per ha recorded significantly seeds per pod (12.00), 100 seed weight (4.60g) and seed yield (5.35 q ha-^{1}) and it was on par with the application of 75% or 50% RDF + Vermicomposting (2.5 t/ha) over control in greengram.

Tanwar *et al.* (2003) observed that dual inoculation of seed with PSB (*Bacillus megatherium* var. *phosphaticum*) and *Rhizobium* caused a significant increase in N and P content in seed and straw and their uptake by black gram over single inoculation and control.

Rajput and Kushwah (2005) noticed that application of 50% RDF i.e. 10 kg N, 25 kg P2O5 20 kg K2O ha^{-1} along with bio-fertilizers (Rhizobium+ PSB, 2kg/ha each) mixed FYM (25 kg/ha) resulted higher seed yield (1936 kg/ha) in pea which was at par with RDF treatment i.e. 20 kg N, 50 kg P2O5 40 kg K2O ha^{-1} (1980 kg/ha).

Dash *et al.* (2005) noted higher seed yields i.e. 1274.67 kg/ha in mothbean with combined application of RDF along with FYM @ 10 t/ha and this was on par with the treatment of RDF + vermicompost (4 t/ha) i.e. 1261.42 kg/ha. This increased seed yield might be due to enhanced partitioning efficiency and better source-sink relationship in plant.

Singh *et al.* (2007) revealed that application of 30 kg N and 60 kg P2 O5 per ha and *Rhizobium* inoculation significantly increased the seed yield (21.15 kg, 21.05 kg and 21.52 kg) at 30, 60 and 90 days as compare to application of 60 kg N and 90 kg P2 O5 per ha and Rhizobium inoculation.

Rathore *et al.* (2007) conducted a field experiment to examine the impact of chemical and biofertilizers on the growth, yield and uptake of nutrients in cluster bean (*Cyamopsis tetragonoloba (L.) Taub*). Chemical and integrated combination of nutrients by chemical fertilisers and biofertilizers, significantly improved the seed yield by increasing the association between Rhizobium and the phosphate-solubilizing bacteria.

Singh (2008) conducted a field experiment during 2005 and 2006 on sandy loam soils of arid zone of Rajasthan to study the effect of integrated nutrient management system on moth bean productivity and soil fertility. A significant increase in yield and yield parameters of moth bean was noticed with application of FYM @ 2.5 t/ha + 10 kg N/ha + PSB. The seed yield (435.0 kg ha^{-1}) and straw yield (748 kg ha^{-1}) was significantly higher as compared to the control (300 kg ha^{-1} and 504 kg ha^{-1} respectively).

Mustafa *et al.* (2008) revealed that 100 per cent recommended dose of N and P (20 and 50 kg ha^{-1} respectively) + Rhizobium + PSB gave higher seed yields (537 kg ha^{-1}) of chickpea than RDF due to balanced supply of N and P through fertilizers besides dual inoculation of Rhizobium and PSB induced cell division and cell elongation resulting in higher stature of plants. Better translocation of photosynthates from vegetative (source) to reproductive parts (sink) might have resulted in higher status of yield attributes which in turn increased seed yield.

Subbarayappa *et al*. (2009) revealed that, Integrated application of 100 per cent RDF + FYM increased the pod length (15.85 cm), seed yield (1586 kg ha^{-1}) and stover yield (5124 kg ha^{-}) and harvest index (0.23) significantly compared to control (792 kg ha^{-1} , 3426 kg ha^{-1} and 0.18, respectively) in cowpea.

Shrikant (2010) reported that the application of 100% RDF + vermicompost @ 1.25 t/ha + Rhizobium @ 375 g/ha recorded significantly higher number of pods per plant (24.20), number of seeds per pod (14.20), seed yield per plant (14.23 g), seed yield per ha (1138.89 kg), 1000 seed weight (41.95 g), germination (98.33%), seedling length (32.87 cm), seedling vigour index (3233), seedling dry weight (61.06 mg), seed protein content (23.55%) and lower electrical conductivity of seed leachate (0.737 dS/m) compared to others treatments in green gram.

Meera *et al.* (2010) observed applying two split doses of poultry manure along with inorganic fertilizers at a rate of 20:30:10 kg N, P, and K per hectare significantly increased seed yield (418.9 kg/ha) when compared to other organic and inorganic treatments in cowpea.

Koushal and Singh (2011) revealed that 50% of RDN + 50% N through FYM + PSB application in soybean resulted higher seed yield (1149.56 kg/ha) which is on par with 50% RDN + 50% N through FYM (1093.9 kg/ha) as seed yield is mainly dependent on source sink relation and the reproductive part gets more photosynthetic assimilate, because of which the increased seed yield resulted. Increase in various plant growth characters such as plant height, leaf area, total dry matter ultimately results in increase in seed yield.

Jadhav *et al*. (2011) reported that seed yield (16.10 kg), maximum nodulation (6.52), and protein content (19.18 percent) were found significantly increase with 20 kg N + 40 kg P2 O5 per ha along with Rhizobium seed inoculation.

Kumar *et al*. (2012) reported that application of 100% RDN through urea + Rhizobium + PSB in cluster bean recorded significantly higher seed yield (910 kg/ha) than other treatments and was on par with the treatments 75% RDN through urea + 25% RDN through FYM + Rhizobium + PSB and 50% RDN through urea + 50% RDN through FYM + Rhizobium + PSB. The higher seed yield under the treatments of INM as compared to alone application of chemical fertilizers might be due to improvement in physico-chemical properties of soil and constant and optimum supply of nutrients by the soil enhanced the growth and yield attributing characters in cluster bean.

Danielnyoki and Patrick (2014) revealed that Rhizobium inoculation and supplementation of phosphorus independently or in combination had positive effects on seed yield (953 kg and 1054 kg/ha) and stover yield (2579 kg and 2577 kg/ha) as compare to control (2075 and 5556 kg/ha).

Kumar and Pandita (2015) conducted the experiment on effect of integrated nutrient management on seed yield and quality in cowpea during *Kharif* 2012 and 2013, with two main plot treatments of inorganic fertilizers. i.e. 100% and 75% recommended dose of fertilizers (RDF) and nine sub plot integrated nutrient management (INM) treatments including control (No organic fertilizer). Main plot treatments were at par but sub plot INM treatments differed significantly higher seed yield, number of seeds/pod, 1000-seed weight, seed germination and vigour indices. Integrated use of inorganic fertilizers + Vermicompost 2.5 t ha^{-1} (4.76, 4.16 q ha^{-1}) performed significantly better than the control (3.32, 2.79 q ha^{-1}) for seed yield and its attributes as well as seed quality parameters during Kharif 2012 and 2013, respectively.

Ashwanikumar and Pandita (2016) reported that INM treatments differed significantly in seed yield (4.71 kg/ha^{-1}), number of seeds per pod (12.5) and 1000-seed weight (102.7g) as compare to control condition (no organic fertilizer).

Mohanty *et al.* (2017) conducted the experiment on integrated nutrient management in French bean results revealed that application of 75% RDF along with 25% vermicompost and lime application produced a good environment supporting very good growth of French bean to produce significantly higher marketable seed yield during rabi season under coastal agro climatic condition of Odisha.

Kumar *et al*. (2018) conducted field experiment at Kanpur with the view to find out the effect of integrated nutrient management on growth, yield and economics of chickpea. On the basis of experimental results, it was found that highest grain yield (26.60 qha^{-1}) was recorded with the treatment where R.D.F. + V.C. @ 5.0 ton/ha + Rhizobium culture + PSB was applied, followed by treatment where R.D.F. + V.C @ 3.0 ton/ha + Rhizobium culture + PSB Trichoderma was applied (26.01 qha^{-1}) which were also significantly at par.

2.3 Effect of integrated nutrient management on economic parameters:

Selvi and Thiageshwari (2002) studied the effect of integrated nutrient management on yield of brinjal reported that the integrated nutrient application yielded higher net return over the application of NPK alone. Treatment with 50 % N + 25 % poultry manure recorded the highest benefit cost ratio. (7.72: 1).

Harikrishna *et al.* (2002) conducted a field experiment on yield and economic analysis as influenced by integrated nutrient management at Dharwad, Karnataka, India on tomato cv. 'Megha (L-15)'. They recorded the highest net income of Rs. 78565 ha^{-1} and benefit: cost ratio of 2.72: 1 with the application of Biofertilizer, FYM 25 t ha^{-1} +

75 % RDN. They also recorded the lowest net income of Rs. 37684 ha^{-1} and benefit: cost ratio of 1.67: 1 with the treatment of FYM alone.

Subbarayappa *et al.* (2009) opined that higher net returns and higher B:C ratio was recorded in 100 per cent RDF + FYM 40:60: 80 kg + 10 t FYM/ha followed by 75 per cent RDF + FYM (20:45:60 kg + 5 t FYM/ha) respectively.

Patel *et al.* (2010) conducted a field experiment during late Kharif season to study the effect of integrated nutrient management on economics of cluster bean cv. Pusa Navbahar. Application of FYM @ 10 t ha^{-1} + *Rhizobium* inoculation integrated with chemical fertilizer (100% RDF) fetched maximum net returns (Rs. 1,16, 640 ha^{-1}) and BCR (6.21).

Ashwani Kumar and Pandita (2015) conducted experiment on effect of integrated nutrient management on seed yield and quality in cowpea during kharif 2012 and 2013, with two main plot treatments of inorganic fertilizers i.e. 100% and 75% recommended dose of fertilizers (RDF) and nine sub plot integrated nutrient management (INM) treatments including control (No organic fertilizer). The mean cost benefit ratios (2.04, 1.90) were highest for combination of biofertilizer inoculation (Rhizobium + PSB) + VAM 10 Kg ha^{-1} +inorganic fertilizers 100% and 75% RDF, respectively.

R.I. Patel *et al.* (2017) conducted field experiment during three consecutive seasons of *Rabi* 2013-14, 2014-15 and 2015-16 at Pulses Research Station, S.D. Agricultural University, Sardarkrushinagar, Gujarat to study the effect of integrated crop management in rajmash. Growth attributes of rajmash were significantly affected by different management practices during all the years . INM treatment effect was measured on seed yield of rajmash, among them application of 100 kg N + 40 kg P2O5/ha along with seed inoculation with *Rhizobium* + PSB (250 g/8 kg seed) gives the higher yield and result revealed that combined application of INM secured the highest net returns of Rs. 48617 /ha with highest benefit cost ratio of 1.71 as compared to other treatments.

Hemantkumar *et al.* (2018) conducted field experiment to find out the effect of integrated nutrient management on growth, yield and economics of chickpea. R.D.F. + V.C @ 3.0 ton/ha + Rhizobium culture + PSB Trichoderma was applied (26.01 qha^{-1}) which were also significantly at par. B:C ratio was also highest in treatments where R.D.F + V.C. @ 3.0 ton/ha + Rhizobium culture + PSB Trichoderma (2.56) were applied. The minimum net profit (Rs.40328.75/ha) was received in control plots.

Sindhuja *et al.* (2021) carried out a investigation during Rabi season of 2018-19 to evaluate the effect of various sources of nutrients including organic, inorganic and biofertilizers on economics of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis*). The results revealed that the application of 75% RDN through inorganic+25% RDN through vermicompost + biofertilizers (Rhizobium + PSB) fetched maximum net returns (Rs. 2,14,097.50 ha^{-1}) and BCR (4.01).

Brahmbhatt *et al.* (2021) revealed that, the application of organic sources of nutrients, including 75% N (15 kg/ha) through FYM + biofertilizers (Rhizobium + PSB + KSM) @ 2.5 kg/ha each to cluster beans has been found to improve soil nutrient status, economic return (329170), net profit (252680), and B: C of 4.30.

3.MATERIALS AND METHODS

The present investigation on "**Effect of Integrated Nutrient Management on yield and quality of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis (L.) verdc*.)**" was conducted at Zonal Agricultural and Horticultural Research Station (ZAHRS), Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Navile, Shivamogga, Karnataka. The details of material and methods adopted during the research programme are described briefly in this chapter.

3.1 Geographical location

The experiment was conducted at Zonal Agricultural and Horticultural Research Station (ZAHRS), Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences (KSNUAHS), Navile, Shivamogga, Karnataka, India which is situated at 13^0 58 North latitude and 75^0 34 East latitude with an altitude of 650 meters above mean sea level. It comes under agro-climatic region-4 and zone-VII (Southern Transition Zone) of Karnataka. Experimental layout was depicted in (Figure 1).

3.2 Details of the experiment

3.2.1 Experimental site: Naturally Ventilated Poly House (NVPH)

The experiment was laid out in a naturally ventilated polyhouse of 1000 m^2 area (Plate 1). Its frame was made up of galvanized iron pipe and covered with 200-micron UV stabilized polyethylene sheet and the two sides were covered with insect net for natural ventilation to protect against insect pests. Besides this insect net, a rollable flap of polyethylene sheet was provided outside the insect net to regulate the requirements of temperature and humidity depending on the season and weather conditions. The shade net with 50 per cent shade was laid out at above the head space inside the greenhouse to manage the light intensity and temperature during summer.

The experiment was laid out in randomised complete block design (RCBD) with eight treatments (Table 2) with three replications. As there is no standardized recommended dose of fertilizer (RDF) for Yardlong bean in Karnataka, recommended dose of fertilizer of cowpea (25:75:60 NPK, kg ha^{-1}) is considered for formulating treatments. (Since Yardlong bean is sub species of cowpea). Farmyard manure (FYM) is applied at the rate of 25 t/ha. The variety Arka Mangala which was released from ICAR- Indian Institute of Horticulture Research (ICAR- IIHR), Bangalore was taken for study. Seeds are treated with Effective Microbial Consortia viz., *Azospirillium, Bacillus megaterium* and *Frateuria aurania* for each 10 ml were taken. Foliar spray of vegetable special micronutrient formulation (5g/L) which is released from ICAR-IIHR, Bangalore was sprayed uniformly on entire crop canopy at 30 and 60 days after sowing. All the recommended package of practices except nutrient management was followed to all the treatments. The required dose of fertilizers as per treatment schedule were calculated and supplied to plants through different sources like Urea, Single super phosphate, Muriate of potash. Cultural operations were performed as per the recommendations. Sowing of healthy treated seed was done with a spacing of 60 cm × 45 cm. Twenty four plants from each treatment were selected randomly for observation of data.

Table 1. Details of experiment:

Particulars	Details
Crop	Yardlong bean
Location of the experiment	ZAHRS, KSNUAHS, Shivamogga
Test variety	Arka Mangala
Design	RCBD
No. of treatments	8
No. of replications	3
Spacing	60 cm × 45 cm
Recommended dose of fertilizer	25:75:60 kg ha^{-1} (N:P:K)
Farm yard manure	25 t/ha

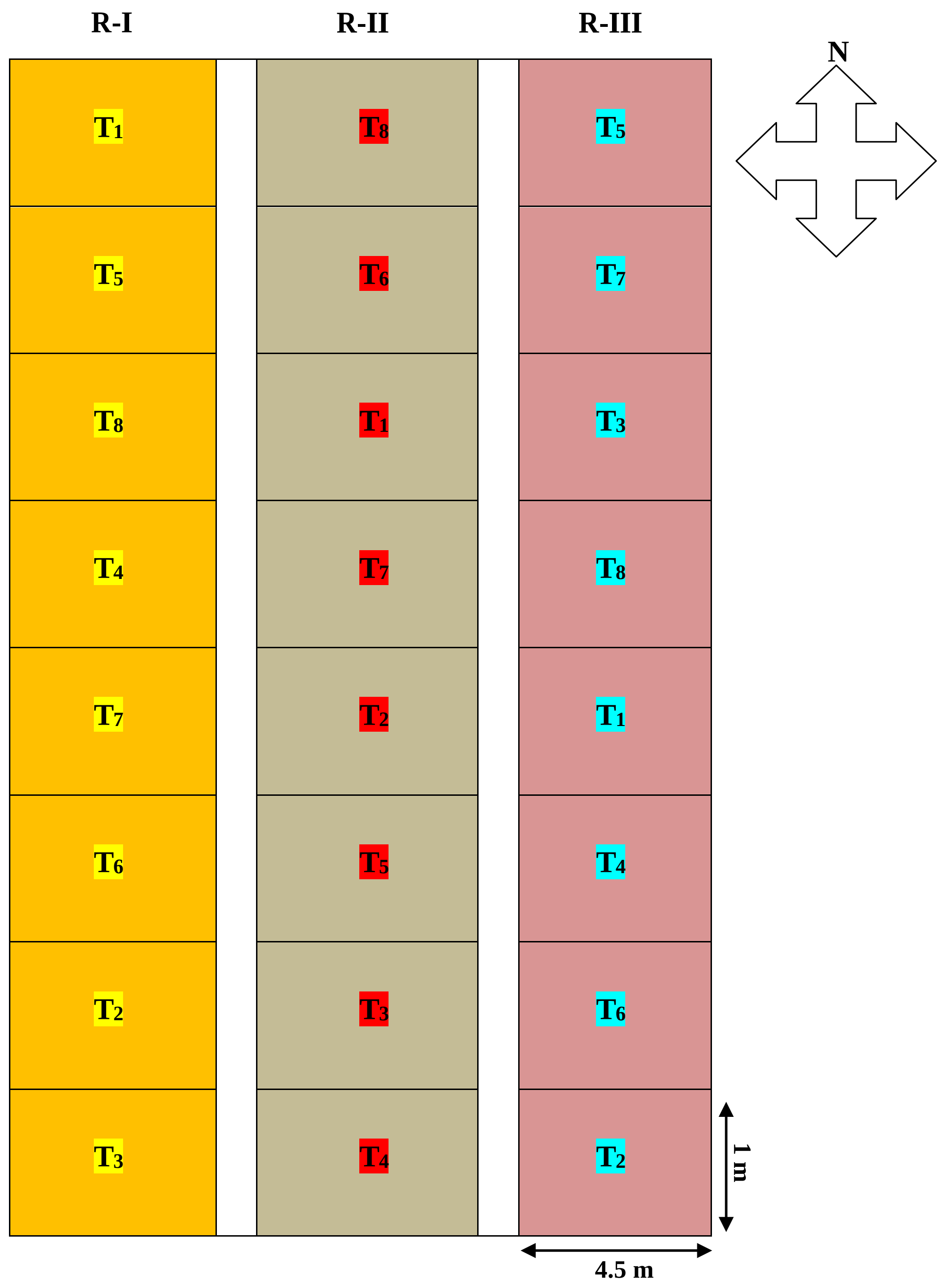


Fig. 1. Layout of the experimental site

3.3 Salient features of Variety Arka Mangala

It is pole type, vigorous, photo insensitive. Pod matures in 60 days. Potential pod yield is 25 t/ha and pods are green with smooth surface. Duration of crop is 90-100 days.

3.4 Soil characteristics of experimental site

Composite soil samples was collected from the experimental area before sowing at 15 cm depth and analysed for physical and chemical characters. The mechanical analysis was done for the composite sample of top 30 cm surface layer. The results of the soil analysis along with methods employed are presented in the **appendix I.**

Table 2. Details of the experimental treatments.

Notations	Treatment details
T_1	100 % Recommended Dose of Fertilizer-RDF (Control),
T_2	100 % RDF + Effective Microbial Consortia (EMC)+ Vegetable Special (VS)
T_3	125 % RDF
T_4	150 % RDF
T_5	175 % RDF
T_6	125 % RDF + EMC+ VS
T_7	150 % RDF + EMC+ VS
T_8	175 % RDF + EMC+ VS

NOTE:

- RDF- Recommended Dose of Fertilizer: 25:75:60 NPK, kg ha^{-1}

  (Ref: POP Horticulture page no. 87, UHS, Bagalkot, Karnataka)

- EMC- Effective Microbial Consortia : *Azospirillium* + PSB (*Bacillus megaterium*) + KSB (*Frateuria aurantia*)- 10 ml/kg of seed

- VS- Vegetable Special (5g/L) - Micro nutrient formulation developed from IIHR, Bangalore, Karnataka.

3.5 Cultivation details

The details regarding various cultural operations carried out during the course of investigation are furnished here.

3.6 Preparation of the land

The experimental plot was thoroughly ploughed, levelled and individual plots of (15 m x 1m) were made with strong bunds and for irrigation drip line was erected (Plate 2).

3.7 Fertilizer application

Recommended doses of nitrogen (25 kg ha^{-1}), phosphorus (75 kg ha^{-1}) and potassium (60 kg ha^{-1}) were applied during the entire crop growth period. Nitrogen, phosphorus and potassium were applied in the form of urea, Mono Ammonium Phosphate and murate of potash, respectively. Entire dose of phosphorus and potassium and half of nitrogen were applied as basal dose and the other half dose of nitrogen was applied one month after sowing as top dressing.

3.7.1 Fertilizer forms: The following were the forms of fertilizers applied through drip system and micronutrients as foliar sprays.

Water soluble fertilizers	:	19 All (19 % N: 19 % P: 19 % K)
		Urea (46 % N)
		Mono Ammonium Phosphate (12: 61: 00 %)
		Muriate of Potash (60 % K)
Micronutrients (foliar spray)	:	IIHR vegetable special (Zn- 4.5 %, B- 1 %, Fe- 2.1 %, Cu-0.10 % and Mn- 0.85 %)

Plate 1. General view of Experimental site - Naturally ventilated polyhouse

Plate 2. Land preparation & Ferilizer application

Plate 3. Yardlong bean seed treatment with Effective Microbial Consortia

3.8 Sowing and imposition of treatments

The sowing of crop was taken on the experimental site. Quantity of seeds required for each treatment based on the spacing was calculated and utilized for sowing. The seeds were dibbled manually at 3 cm depth in the soil as per the specified spacing.

3.9 Irrigation

The crop was irrigated immediately after sowing for better and uniform germination. Subsequently the irrigations were given at three days interval through drip depending upon moisture condition of experimental plot and to maintain uniform soil moisture throughout the crop growth period.

3.10 Gap filling

Five days after sowing the gap filling was done in order to maintain per cent population in all the plots as per the treatment details.

3.11 Thinning

After ten days of sowing thinning was done by retaining one healthy seedling per hill and thereby optimum plant population was maintained.

3.12 Plant protection

The crop was sprayed two plant protection sprays at 30 days after sowing with Dimethoate (1.7 ml per litre) and 45 days after sowing with Imidacloprid (0.5 ml per litre) to manage sucking pests.

3.13 Harvesting

The pods were manually harvested at tender stage. Twenty four labeled plants per plot were harvested separately for recording the observations (Plate 6).

Plate 4. General view of Yardlong bean crop (30 DAS) at experimental site

3.14 Collection of experimental data

A total of 24 healthy and normal plants were selected at random in each plot. (Eight plants were taken in each replication) and tagged with a label for recording various biometric observations. The procedure followed for measuring various growth and yield parameters are given below.

3.14.1 Growth parameters

3.14.1.1 Plant height

The plant height was measured from base of the stem at ground level to the tip of the main shoot having fully opened top leaf from the tagged plants. The mean of the twenty four plants was recorded in centimeters at 15 and 30 days after sowing.

3.14.1.2 Number of branches per plant

The number of primary branches was counted on 30^{th} day after sowing from the tagged plants and mean number of primary branches per plant was taken.

3.14.1.3 Number of days taken for initiation of flower

Number of days taken for first flower appearance from days after sowing was recorded.

3.14.1.4 Days to 50 per cent plants to flower

The number of days taken to flowering of 50 per cent of the plants in the net plot was recorded.

3.14.1.5 Number of days taken for first pod harvesting

Number of days taken for first picking of green tender pods from days after sowing was recorded.

3.14.2 Yield parameters

3.14.2.1 Number of pods per plant

The number of pods present in twenty four randomly tagged plants was counted from individual plants. The average was calculated and expressed as number of pods per plant.

3.14.2.2 Pod length

Twenty four pods from each plot were randomly selected and their length was measured from the base of the pod to tip of the pod. The average was computed and expressed as pod length in centimeters (cm).

3.14.2.3 Pod girth

Pod girth of randomly twenty four pods were selected and measured in each treatment and replication. Average was worked out and recorded as pod girth in centimeters (cm).

3.14.2.4 Average pod weight per plant

Twenty four plants are selected randomly and harvested pods were weighed and average was taken and expressed in grams

3.14.2.5 Pod yield per plant

Weight of the pods per plant from each picking was recorded from tagged twenty four plants from each treatment until the final harvest. The cumulative of all the harvests was taken as yield per plant in kilograms.

3.14.2.6 Pod yield per plot

The weight of pods from all the pickings from plants accommodated in net plot was added and recorded as yield per m^2 and expressed in kilograms.

3.14.2.7 Pod yield per 1000 m^2

A pod yield obtained from net plot is computed for 1000 m^2 and expressed in kilogram per 1000 m^2.

3.14.3 Agronomic parameters

3.14.3.1 Leaf area

The leaf area of five selected plants was estimated by disc method and expressed in cm^2 $plant^{-1}$.

3.14.3.2 Total dry matter accumulation

Total dry matter was computed by adding leaf dry weight, stem dry weight and pod dry weight and expressed in g $plant^{-1}$.

3.14.3.3 Crop growth rate (CGR)

Crop growth rate is defined as the rate of dry matter production per unit ground area per unit time (Watson, 1952). It is expressed in (g m^{-2} day^{-1}) and calculated by using the formula.

$$\mathrm{CGR} = \frac{W_2 - W_1}{(t_2 - t_1)} \times \frac{1}{P}$$

Where,

W_1 and W_2 = dry matter production per plant at time t_1 and t_2 respectively

P = spacing

3.14.3.4 Net assimilation rate (NAR)

Net assimilation rate is the rate of dry matter produced per unit leaf area per unit time. It was calculated by using the formula given by (Gregory, 1926) and expressed as g dm^{-2} day^{-1}.

$$\mathrm{NAR} = \frac{W_2 - W_1}{(t_2 - t_1)} \times \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1}$$

Where,

L_1 and W_1= leaf area and total dry weight of the plant (g) at time t_1.

L_2 and W_2= leaf area and total dry weight of the plant (g) at time t_2.

t_2 and t_1 = time intervals in days

3.14.3.5 Relative growth rate (RGR)

It is the rate of increase in dry weight $unit^{-1}$ dry weight already present and is expressed as g g^{-1} day^{-1}. Relative growth rate at various stages was calculated by using the formula given by Radford (1967).

$$\mathrm{RGR} = \frac{\log_e W_2 - \log_e W_1}{(t_2 - t_1)}$$

Where, W_1= Total dry weight of plant at time t_1

W_2= Total dry weight of plant at time t_2

t_2 and t_1 = Time intervals in days

3.14.4 Seed parameters

3.14.4.1 Germination percent (%)

The germination test was conducted in the laboratory by using between paper method as per ISTA rules (1966).One hundred seeds in four replicates were placed on germination paper and rolled towels were incubated in germination chamber maintained at 25 ± 1°C and 90 per cent relative humidity (Plate 7). The germinated seedlings were evaluated on eighth day and percentage germination was expressed based on normal seedlings.

$$\text{Germination (\%)} = \frac{\text{Total no. of seeds x 100}}{\text{Total no. of seeds germinated}}$$

3.14.4.2 Shoot length

Ten seedlings taken at randomly from each treatment and replication were separated carefully from the paper towel of laboratory germination test and shoot length of seedlings was measured using metric scale on the germination table. The mean shoot length of ten seedlings in each treatment and replication was calculated and expressed in centimeters.

3.14.4.3 Root length

Ten seedlings taken at randomly from each treatment and replication were separated carefully from the paper towel of laboratory germination test and root length of seedlings was measured using metric scale on the germination table. The mean root length of ten seedlings in each treatment and replication was calculated and expressed in centimeters.

3.14.4.4 Seedling length

Ten seedlings taken at randomly from each treatment and replication were separated carefully from the paper towel of laboratory germination test and total length of seedlings after removing the cotyledons was measured using metric scale on the germination table. The mean length of ten seedlings in each treatment and replication was calculated and expressed in centimeters.

3.14.4.5 Total dry weight

Five Plants from each treatment and replication were taken and kept in the hot air oven at 85±1°C for 24 hours. The dry weight (mg) was calculated.

3.14.4.6 Seed index (100 seed weight)

Hundred seeds were counted from the sample drawn randomly from the inally winnowed and cleaned produce of each plot and their weight was recorded as seed index.

3.14.5 Economic analysis

Cost of growing Yardlong bean under different environments and plant densities was worked out. Profits realized by the sale of produce was worked out by taking into account the existing price of inputs and produce at local markets.

3.14.5.1 Gross returns

Gross returns were calculated on the basis of their prevailing market sale rate and the yield produced ha^{-1}.

3.14.5.2 Net returns

Net returns were arrived after deducting the cost of cultivation from the gross returns of the marketable produce on hectare basis and expressed in rupees ha^{-1}.

Net returns = Gross returns – cost of cultivation

3.14.5.3 Benefit: Cost ratio

It was obtained by dividing gross returns with cost of cultivation ha^{-1}.

$$B:C = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.15 Statistical analysis

The data collected from the experiment at different growth stages were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' test was at five per cent. The critical difference (CD) values are given at five per cent level of significance, wherever the 'F' test was significant.

4.RESULTS AND DISCUSSION

The results of the present investigation "**Effect of Integrated Nutrient Management on yield and quality of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*)"** conducted during *Kharif* season in 2020-21 and 2021-22 at Zonal Agricultural and Horticultural Research Station (ZAHRS), Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences (KSNUAHS), Navile, Shivamogga, Karnataka are presented in this chapter.

4.1 Effect of Integrated Nutrient Management on growth and pod yield attributes of Yardlong bean

Integrated nutrient management had significant effect on the growth and yield traits of Yardlong bean. Mean performance for growth attributing traits viz., plant height, number of branches, days to initiation of flowering, days taken to first harvest was higher in *Kharif* 2020-21 than *Kharif* 2021-22. Individual parameter wise results is as follows.

4.1.1 Growth parameters

4.1.1.1 Plant height (cm)

It was observed that significantly higher plant height at 30 DAS (249.58 cm, 246.33 cm) was noticed with the T7 which is on par with T8 (246.42 cm, 242.08 cm) followed by T6 (243.90 cm, 239.82 cm), T5 (240.50 cm, 236.92 cm), T2 (239.40 cm, 235.83 cm), T4 (235.08 cm, 233.58 cm) and T3 (232.52 cm, 230.33 cm) whereas, the minimum plant height was noticed under T1 control (230.17 cm, 227.09 cm) in *Kharif* 2020-21 & 2021-22 respectively.

Significant differences were observed in pooled plant height among treatments studied in the present investigation (Table 3). Among treatments average pooled plant height was 238.10 cm and highest (247.96 cm) was recorded in the T7 which is on par with T8 (244.25 cm) followed by T6 (241.86 cm), T5 (238.71 cm), T2 (237.62 cm), T4 (234.33 cm), T3 (231.43 cm) whereas, the minimum plant height was noticed under control (228.63 cm).

Significantly higher plant height at 30 DAS (249.58 cm, 246.33 cm) was noticed (Fig.2) with the T_7 may be due to the application of major nutrients through different levels of chemical fertilizers, increased the photosynthetic activity, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height and also increase in plant height might be due to the application of nitrogenous fertilizers applied through inorganic fertilizers supplied nutrients in the early stages, whereas in later stages, the mineralized N from organic manures and atmospheric N fixation by *Rhizobium* contributed to N availability to crop. Another reason for increase in vine length is result of PSB bio fertilization. Hence, there was continuous supply of nutrients throughout the crop growth period. The results of the present investigation showed are in line with findings of Dash *et al.* (2019) who reported that, integrated use of fertilizers results in significant increase in growth parameters as compare to sole application of chemical fertilizer / organic fertilizer and also stated that it might be due to more availability and uptake of nutrients, specifically nitrogen which is important element for better cell enlargement and cell division which leads to increased plant growth, during trial for initial requirement of nitrogen would be met from inorganic sources as it would be available instantly to the plant. Later organic nitrogen will be mineralized slowly but steadily and supplied required quantity of available nitrogen during progressive crop growth period. This results also confirmed by Mohanty *et al*. (2017) in French bean, Singh (2017) in Mungbean, Sindhuja (2021) in Yardlong bean.

Table 3. Plant height (cm) at 30 DAS as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	230.17	227.09	228.63
T_2	RDF + EMC+ VS	239.40	235.83	237.62
T_3	125% RDF	232.52	230.33	231.43
T_4	150% RDF	235.08	233.58	234.33
T_5	175% RDF	240.50	236.92	238.71
T_6	125% RDF + EMC+ VS	243.90	239.82	241.86
T_7	150% RDF + EMC+ VS	249.58	246.33	247.96
T_8	175% RDF + EMC+ VS	246.42	242.08	244.25
MEAN		239.70	236.50	238.10
SEM±		1.73	1.92	1.57
CD @5%		5.25	5.82	4.77

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

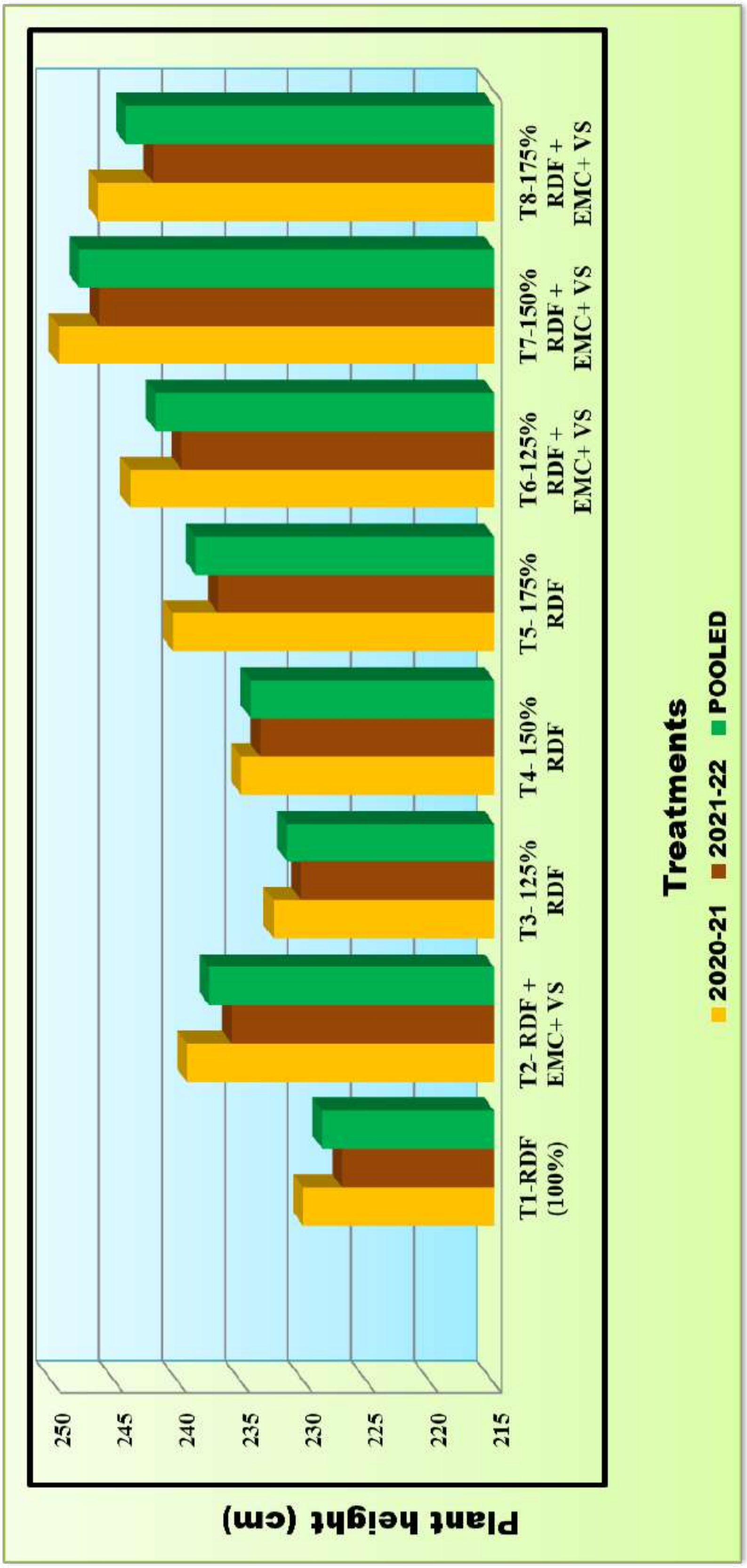


Fig.2. Plant height (cm) at 30 DAS as influenced by integrated nutrient management.

4.1.1.2 Number of primary branches per plant

Data presented in Table 4 revealed that the number of primary branches per plant were significantly maximum with T7 (8.67, 8.42) which was found to be on par with T8 (8.12, 7.92) followed by T6 (7.87, 7.75), T5 (7.25, 7.08), T2 (7.25, 6.96), T4 (6.75, 6.58) and T3 (6.33, 6.25). While, minimum number of branches per plant was recorded under T1-control (6.17, 5.83) in 2020-21 & 2021-22 respectively.

Pooled number of primary branches at 30 DAS varied from 6.00 to 8.54 with mean of 7.20. Maximum pooled number of branches (8.54) was observed in T7 (8.54) which was found to be on par with T8 (8.02) and T6 (7.81) followed by T5 (7.17), T2 (7.10), T4 (6.67) and T3 (6.29). While, minimum number of branches per plant was recorded under T1-control (6.00) in 2020-21 & 2021-22 respectively (Fig.3).

Differences among treatments might be due to the application of phosphorus through inorganic fertilizer and microbial inoculation of seed, which increased the availability of phosphorus in root zone, which in turn resulted in better growth and development of roots and shoots and also helped in better nodulation. Meera *et al.* (2010) opined that application of organic manure in two split doses along with inorganic fertilizers results in significant increase in plant height, dry matter production, number of branches per plant. Similar results were reported by Sajitha *et al*. (2016) in dolichos bean, Mohanty *et al.* (2017) in French bean and Singh (2017) in Mungbean.

Table 4. Number of primary branches at 30 DAS as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	6.17	5.83	6.00
T_2	RDF + EMC+ VS	7.25	6.96	7.10
T_3	125% RDF	6.33	6.25	6.29
T_4	150% RDF	6.75	6.58	6.67
T_5	175% RDF	7.25	7.08	7.17
T_6	125% RDF + EMC+ VS	7.87	7.75	7.81
T_7	150% RDF + EMC+ VS	8.67	8.42	8.54
T_8	175% RDF + EMC+ VS	8.12	7.92	8.02
	MEAN	7.30	7.10	7.20
	SEM±	0.27	0.28	0.26
	CD @5%	0.82	0.85	0.79

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

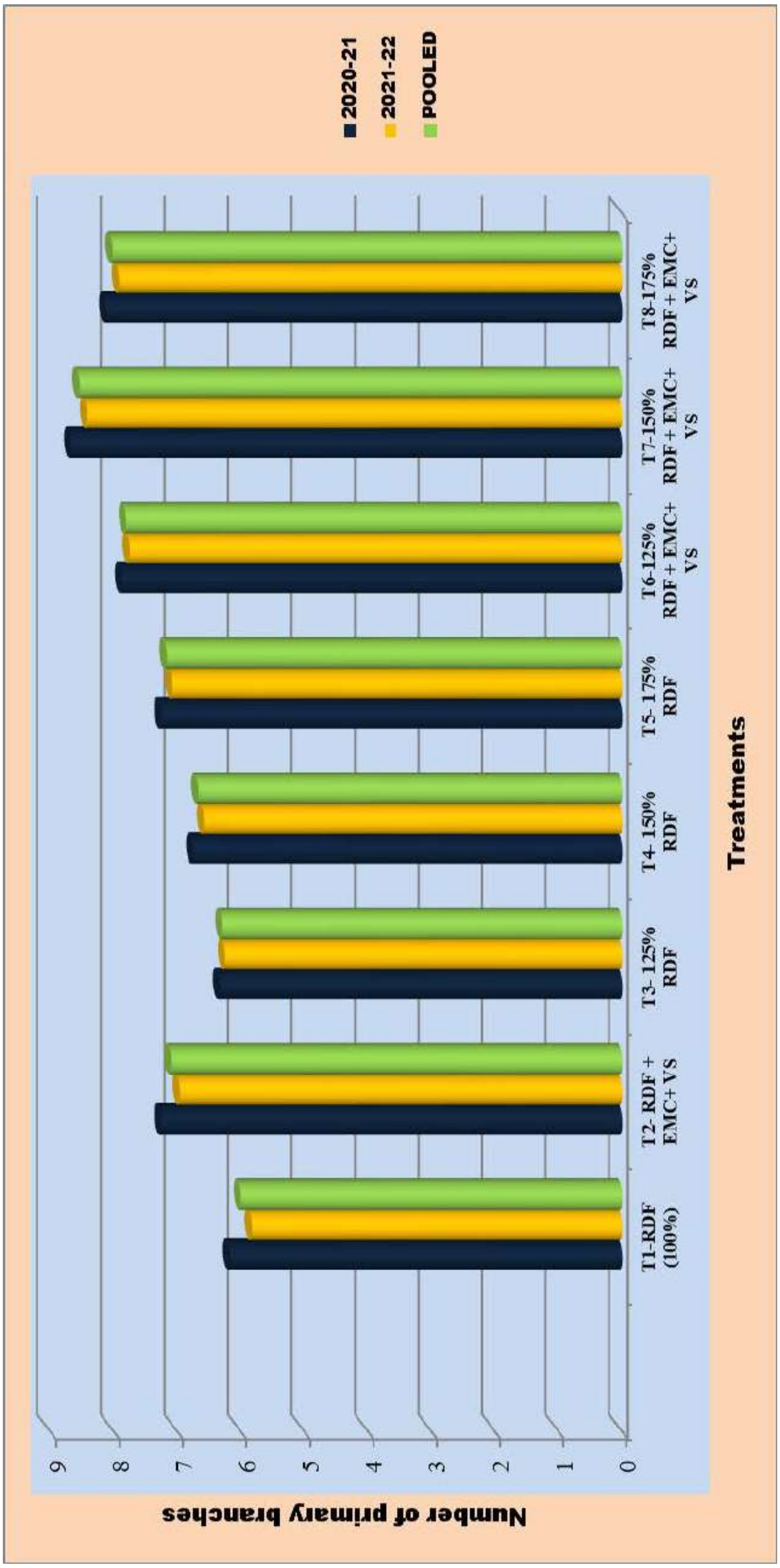


Fig.3. Number of primary branches at 30 DAS as influenced by integrated nutrient management

4.1.1.3 Number of days taken for initiation of flowering

It is evident from the data in Table 5 that, significantly minimum number of days to first flowering was recorded in treatment T7 (38.50 d, 38.08 d) and it was at par with T8 (38.92 d, 38.50 d), while the maximum number of days to first flowering was recorded in control (41.17 d, 40.92 d) in 2020-21 & 2021-22 respectively.

The range of pooled initiation of flowering among the treatments analysed in the present investigation was 38.29 to 41.04 (Fig.4). Among the treatments minimum pooled number of days to first flowering was recorded in treatment T7 (38.29 d) and it was on par with T8 (38.71 d) which is followed by T6 (39.08 d), T5 (39.73 d), T2 (39.70 d), T4 (40.20 d) and T3 (40.34 d), while the maximum number of days to first flowering was recorded in control (41.04 d).

Application of organic and inorganic fertilizers as well as by *Rhizobium* and PSB treatment increased availability of nitrogen and phosphorus might have resulted in minimum number of days for first flowering. Similar results were observed by chauhan *et al*. (2016) in cowpea, Jadhav *et al.* (2011) in cowpea and Sharma *et al.* (2010) in China aster.

Table 5. Days to initiation of flowering as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	41.17	40.92	41.04
T_2	RDF + EMC+ VS	39.87	39.53	39.70
T_3	125% RDF	40.60	40.08	40.34
T_4	150% RDF	40.47	39.93	40.20
T_5	175% RDF	39.82	39.65	39.73
T_6	125% RDF + EMC+ VS	39.25	38.92	39.08
T_7	150% RDF + EMC+ VS	38.50	38.08	38.29
T_8	175% RDF + EMC+ VS	38.92	38.50	38.71
	MEAN	39.82	39.45	39.64
	SEM±	0.37	0.37	0.33
	CD @5%	1.13	1.12	1.01

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

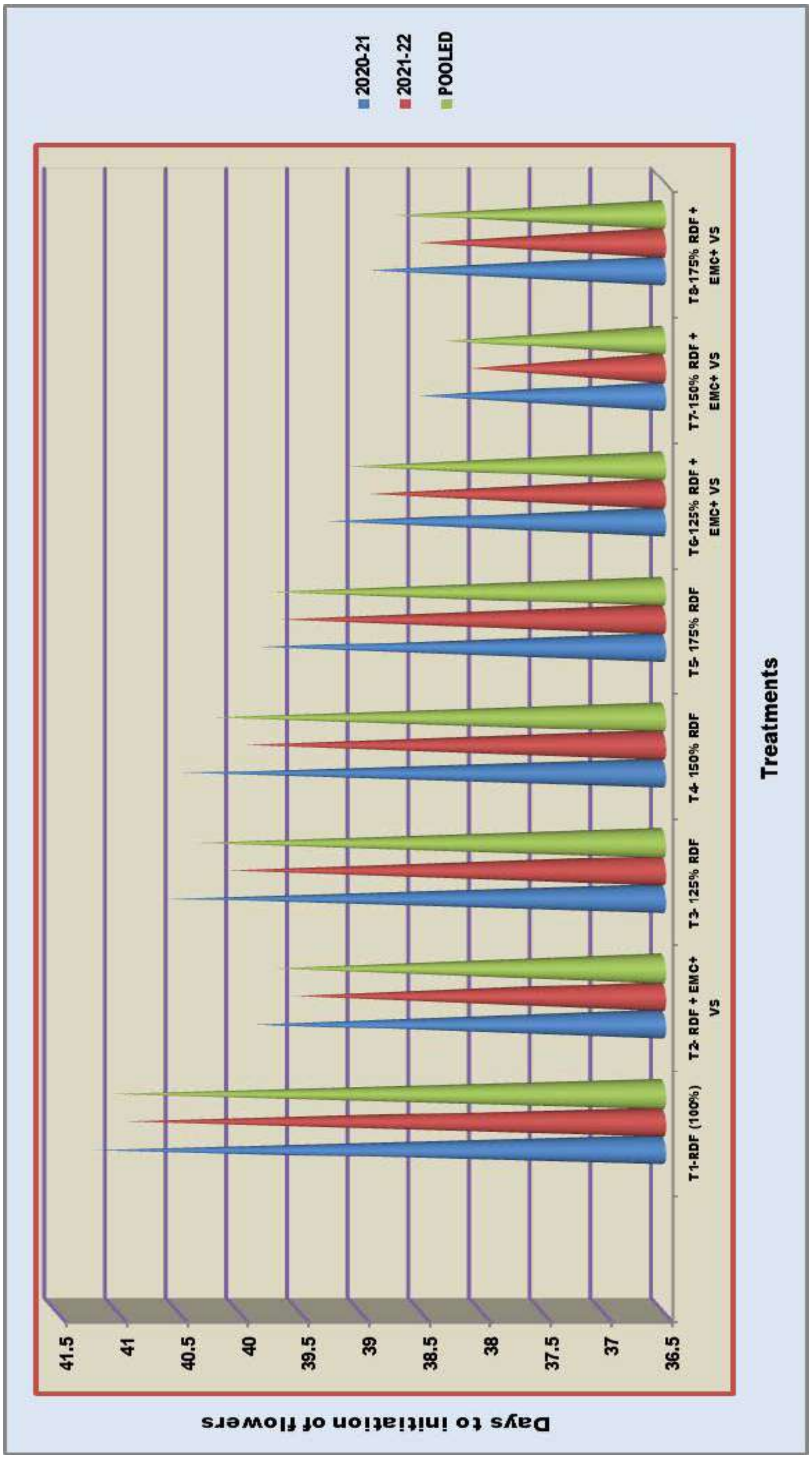


Fig.4. Days to initiation of flower as influenced by integrated nutrient management.

4.1.1.4 Number of days taken for 50 per cent flowering

The data shows that minimum number of days to 50% flowering was recorded in T7 (43.75 d, 43.22 d) and it is on par with T8 (43.92 d, 43.50 d), while the maximum number of days was recorded in control (44.90 d, 44.37 d) in 2020-21 & 2021-22 respectively.

Significant differences were observed in pooled minimum 50 per cent flowering among treatments studied in the present investigation (Table 6). Among treatments average days was 44.14 d and minimum (43.48 d) was recorded in the T7 which is on par with T8 (43.71 d) and followed by T6 (43.84 d), T5 (43.99 d), T2 (44.34 d), T4 (44.56 d), T3 (44.55 d). Whereas, the maximum number days 50 per cent was noticed under control (44.63 d).

This trend is may be due to the application of organic and inorganic fertilizers as well as by seed treatment with microbial consortia increased availability of nitrogen and phosphorus might have resulted in minimum number of days for 50% flowering. These findings are in accordance with work done by Sahu (2014) in French bean and Jubinchauhan *et al*. (2016) in cowpea.

Table 6. Days to 50 percent flowering as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	44.90	44.37	44.63
T_2	RDF + EMC+ VS	44.58	44.10	44.34
T_3	125% RDF	44.72	44.38	44.55
T_4	150% RDF	44.60	44.52	44.56
T_5	175% RDF	44.33	43.65	43.99
T_6	125% RDF + EMC+ VS	44.18	43.50	43.84
T_7	150% RDF + EMC+ VS	43.75	43.22	43.48
T_8	175% RDF + EMC+ VS	43.92	43.50	43.71
	MEAN	44.37	43.90	44.14
	SEM±	0.28	0.30	0.25
	CD @5%	0.84	0.91	0.77

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.1.1.5 Number of days taken for first pod harvest

It is evident from the data in Table 7 that significantly lowest (53.08 d, 52.58 d) number of days to first harvest 45 DAS recorded in the T7 which is followed by T8 (53.62 d, 52.83 d), T6 (53.92 d, 53.45 d), T5 (54.28 d, 53.75 d), T2 (54.47 d, 54.00 d), T4 (54.67 d, 54.32 d) and T3 (54.95 d, 54.50 d) whereas, maximum number of days for first harvest after 45 DAS was noticed under control (55.17 d, 54.83 d) in *Kharif* 2020-21 & 2021-22 respectively.

There were significant differences in pooled days to first harvest 45 DAS among treatments and ranged from 52.83 days to 55.00 days. Among the treatments minimum days for first harvest after 45 DAS observed in T7 (52.83 d) which was on par with T8 (53.23 d) followed by T6 (53.68 d), T5 (54.02 d), T2 (54.23 d), T4 (54.49 d) and T3 (54.73 d). However, the maximum number of days for first harvest after 45 DAS was recorded under control (55.00 d). The minimum number of days required for the pod harvest in T7 may be attributed by early flowering and these results are in line with Sahu (2014) in French bean and Jubinchauhan *et al*. (2016) in cowpea.

Table 7. Days to first harvest as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	55.17	54.83	55.00
T_2	RDF + EMC+ VS	54.47	54.00	54.23
T_3	125% RDF	54.95	54.50	54.73
T_4	150% RDF	54.67	54.32	54.49
T_5	175% RDF	54.28	53.75	54.02
T_6	125% RDF + EMC+ VS	53.92	53.45	53.68
T_7	150% RDF + EMC+ VS	53.08	52.58	52.83
T_8	175% RDF + EMC+ VS	53.62	52.83	53.23
	MEAN	54.27	53.78	54.03
	SEM±	0.31	0.27	0.27
	CD @5%	0.95	0.81	0.81

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia,

VS- Vegetable Special

4.1.2 Yield parameters.

4.1.2.1 Number of pods per plant

The data presenting in Table 8 revealed that maximum number of pods per plant was recorded in the treatment T7 (25.50, 24.83) which was on par with T8 (24.21, 23.75) followed by T6 (23.12, 22.79), T5 (22.08, 21.33), T2 (21.92, 20.75), T4 (21.50, 20.33) and T3 (20.25, 19.67). However, the minimum number of pods per plant was recorded under control (19.00, 18.33) during 2020-21 and 2021-22 respectively.

Pooled maximum number of pods per plant varied from 18.67 to 25.17 with mean of 21.84. Maximum pooled number of pods per plant (25.17) was observed in **T7** which was followed by T8 (23.98), T6 (22.96), T5 (21.71), T2 (21.33), T4 (20.92) and T3 (19.96). While, minimum pooled number of pods per plant was recorded in T1-control (18.67).

The results showed an increase in pods per plant (Fig.5). It might be due to the application of organic and inorganic fertilizers as well as by Microbial consortia treatment (Rhizobium and PSB). The treatment was responsible for more vegetative and reproductive growth of plant due to release of more nutrient and organic acids, from the soil and thereby utilizing more nutrient and moisture from the soil in turn leads to increased photosynthesis. Biofertilizers are involved in the various endogenous hormonal functions in the plant tissues and responsible for enhanced pollen germination and pollen tube growth and ultimately increased the podset as well as increased numbers of pods per plant (Mal *et al.* 2014). Similar results were observed by Mishra. (2003) and Senthilkumar and Sivagurunathan (2012) observed higher number of pods in cowpea by combined inoculation of *Rhizobium*, Phosphobacteria and *Azospirillum*.

Table 8. Number of pods per plant as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	19.00	18.33	18.67
T_2	RDF + EMC+ VS	21.92	20.75	21.33
T_3	125% RDF	20.25	19.67	19.96
T_4	150% RDF	21.50	20.33	20.92
T_5	175% RDF	22.08	21.33	21.71
T_6	125% RDF + EMC+ VS	23.12	22.79	22.96
T_7	150% RDF + EMC+ VS	25.50	24.83	25.17
T_8	175% RDF + EMC+ VS	24.21	23.75	23.98
	MEAN	22.20	21.47	21.84
	SEM±	0.40	0.36	0.33
	CD @5%	1.21	1.09	1.00

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia,

VS- Vegetable Special

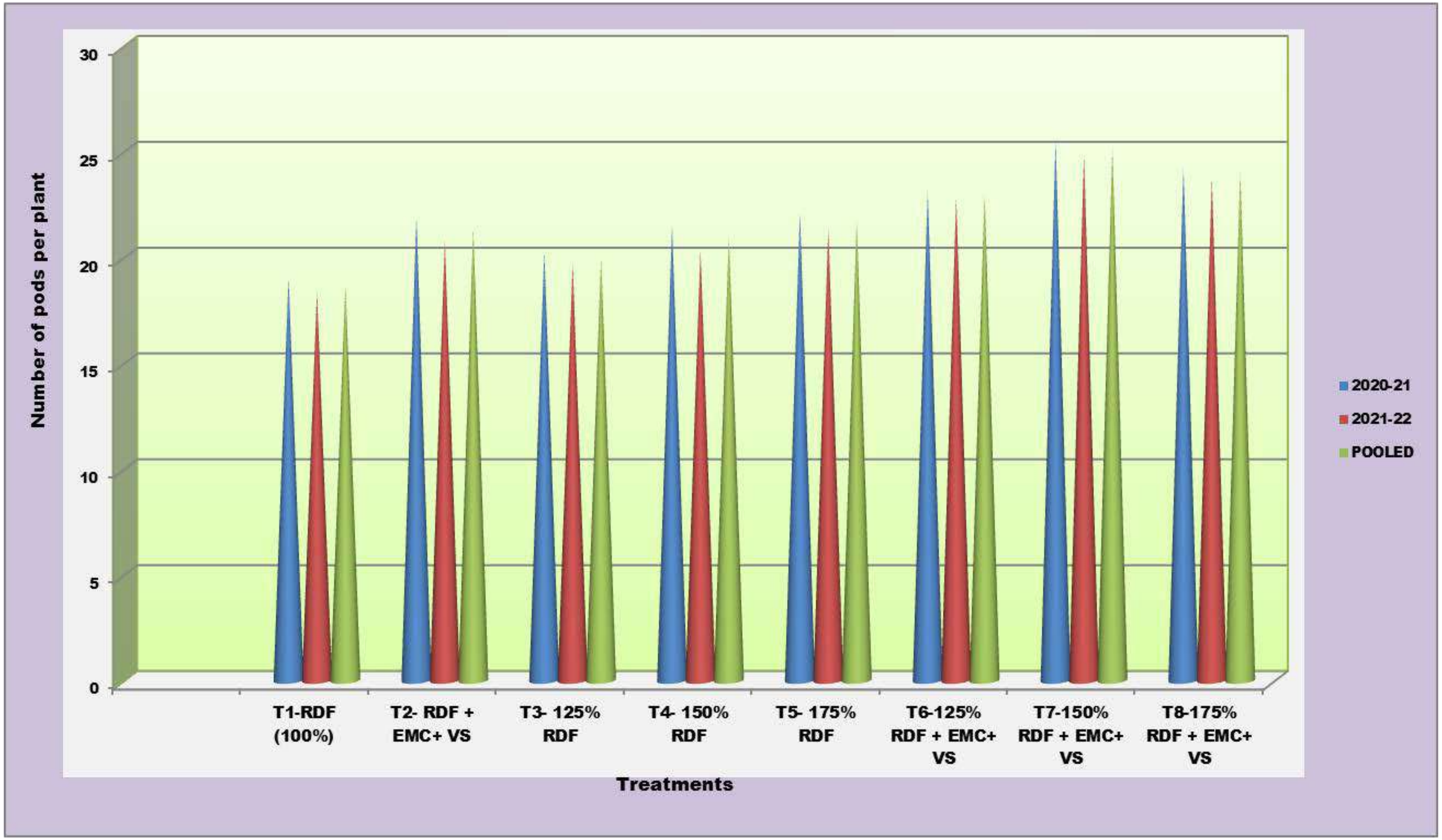


Fig.5. Number of pods per plant as influenced by integrated nutrient management

4.1.2.2 Pod length

Data presented in the Table 9 reveals that significantly highest pod length was noticed T7 (75.11 cm, 74.00 cm) followed by T8 (73.58 cm, 73.33 cm), T6 (73.12 cm, 72.12 cm), T5 (72.17 cm, 71.17 cm), T2 (71.33 cm, 70.50 cm), T4 (70.50 cm, 69.83 cm) and T3 (69.42 cm, 68.75 cm) whereas, lowest was noticed in T1 (68.33 cm, 67.92 cm) in 2020-21 and 2021-22 respectively.

It was observed from the figure 6 that significantly higher pooled pod length (74.56 cm) was observed in the T7 which is followed by T8 (73.46 cm) T6 (72.62 cm), T5 (71.67 cm), T2 (70.92 cm), T4 (70.17 cm) and T3 (69.08 cm) whereas, the minimum pooled pod length was noticed under T1-control (68.13 cm).

The results of present investigation proves that increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and resulted in increased yield attributes. This may be due to increased supply of major plant nutrients. Nitrogen accelerates the development of growth and reproductive phases and protein synthesis, thus promoting pod length. Similar results have been reported by Kumar *et al*. (2009), Singh *et al*. (2011).

Table 9. Pod length (cm) as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	68.33	67.92	68.13
T_2	RDF + EMC+ VS	71.33	70.50	70.92
T_3	125% RDF	69.42	68.75	69.08
T_4	150% RDF	70.50	69.83	70.17
T_5	175% RDF	72.17	71.17	71.67
T_6	125% RDF + EMC+ VS	73.12	72.12	72.62
T_7	150% RDF + EMC+ VS	75.11	74.00	74.56
T_8	175% RDF + EMC+ VS	73.58	73.33	73.46
	MEAN	71.70	70.95	71.32
	SEM±	0.36	0.37	0.33
	CD @5%	1.10	1.14	1.00

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia,

VS- Vegetable Special

Fig.6. Pod length (cm) as influenced by integrated nutrient management.

4.1.2.3 Pod girth

Data presented in the table 10 reveals the similar trend in pod girth was noticed as pod length among treatments highest pod girth observed in T7 (4.08 cm, 3.88 cm) followed by T8 (3.85 cm, 3.62 cm), T6 (3.64 cm, 3.57 cm), T5 (3.52 cm, 3.44 cm), T2 (3.43 cm, 3.39 cm), T4 (3.48 cm, 3.40 cm), T3 (3.39 cm, 3.26 cm) whereas least was observed with T1 (3.30 cm, 3.23 cm) in 2020-21 and 2021-22 respectively.

Significant differences were observed in pooled pod girth among treatments studied in the present investigation. Among treatments average pooled pod girth was 3.53 cm and maximum (3.98 cm) was recorded in the T7 which is on par with T8 (3.74 cm), T6 (3.60 cm) and T5 (3.48 cm), followed by T2 (3.41 cm), T4 (3.44 cm), T3 (3.33 cm). Whereas, the minimum pod girth was noticed in control (3.26 cm). Increased pod girth may effected by high supply of plant growth nutrients as same mentioned in pod length. These results are in line with Kumar *et al*. (2009), Singh *et al*. (2011) .

Table 10. Pod girth (cm) as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	3.30	3.23	3.26
T_2	RDF + EMC+ VS	3.43	3.39	3.41
T_3	125% RDF	3.39	3.26	3.33
T_4	150% RDF	3.48	3.40	3.44
T_5	175% RDF	3.52	3.44	3.48
T_6	125% RDF + EMC+ VS	3.64	3.57	3.60
T_7	150% RDF + EMC+ VS	4.08	3.88	3.98
T_8	175% RDF + EMC+ VS	3.85	3.62	3.74
	MEAN	3.59	3.47	3.53
	SEM±	0.07	0.10	0.08
	CD @5%	0.21	0.31	0.23

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.1.2.4 Average pod weight

Average pod weight revealed significant difference among treatments (table 11), highest pod weight (36.08 g, 35.00 g) recorded in the T_7 and followed by T8 (34.53 g, 34.08 g), T6 (34.67 g, 33.75 g), T5 (33.17 g, 32.17 g), T2 (32.25 g, 31.75 g), T4 (31.25 g, 29.75 g), T3 (30.67 g, 29.50 g) Whereas, the lowest average pod weight was noticed in control treatment (29.38 g, 28.92 g) in *Kharif* 2020-21 & 2021-22 respectively.

The range of pooled average pod weight among the treatments analysed in the present investigation was 29.15 g to 35.54 g. Among the treatments maximum average pod weight was recorded in treatment T7 (35.54 g) which is followed by T8 (34.31 g), T6 (34.21 g), T5 (32.67 g), T2 (32.00 g), T4 (30.50 g), T3 (30.08 g), while the lowest pooled average pod weight was recorded in control (29.15 g).

Highest average pod weight with 150 % RDF + EMC+ VS may be due to favourable effects of nitrogen on overall metabolic processes of the plant and beneficial effects on growth. The findings are in agreement with the findings of Chandrakar *et al*. (2001), Gohari *et al*. (2010), Samawat and Borah (2001) and Singh *et al*. (2011) in cowpea.

Table 11. Average pod weight (g) as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	29.38	28.92	29.15
T_2	RDF + EMC+ VS	32.25	31.75	32.00
T_3	125% RDF	30.67	29.50	30.08
T_4	150% RDF	31.25	29.75	30.50
T_5	175% RDF	33.17	32.17	32.67
T_6	125% RDF + EMC+ VS	34.67	33.75	34.21
T_7	150% RDF + EMC+ VS	36.08	35.00	35.54
T_8	175% RDF + EMC+ VS	34.53	34.08	34.31
	MEAN	32.75	31.86	32.31
	SEM±	0.40	0.41	0.31
	CD @5%	1.22	1.23	0.95

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.1.2.5 Yield per plant

Data presented in the table 12 revealed that among the treatments T7 recorded highest yield per plant (685 g, 643.33 g) which is followed by T8 (635 g, 598.33 g), T6 (573.33 g, 536.67 g), T5 (528.33 g, 493.33 g), T2 (495 g, 466.75 g), T4 (448.42 g, 408.33 g) and T3 (407.83 g, 383.42 g) whereas, the lowest yield per plant observed in the control treatment (383.50 g, 358.58 g) during 2020-21 and 2021-22 respectively.

It was observed from the Figure 7 that significantly higher pooled pod yield per plant (664.17 g) was observed in the T7 which is followed by T8 (616.67 g), T6 (555.00 g), T5 (510.83 g), T2 (480.88 g), T4 (428.38 g), T3 (395.63 g) whereas, the lowest pooled pod yield per plant was noticed under T1-control (371.04 g).

Significantly higher pod yield per plant by treatment consisted with 150 % RDF + EMC+ VS may be due to increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and resulted in increased yield attributes (Pod length, Pod girth, Yield of plant). Another probable reason could be efficient and greater partitioning of metabolites and adequate transformation of nutrients. The results are in concurrence with the findings of Saikia *et al*. (2018) in French bean who reported that increase is due to the supply of N and P through organic manures and inorganic fertilizers along with Rhizobium and PSB and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased pod yield. There are many studies revealed that Microbial inoculation to seed increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately increased yield (Sardana et al., 2006). These findings are in accordance with Arulananth and Rameshkumar (2018) in Dolichus bean, Sardana *et al*. (2006) and Das *et al.* (2011) in cowpea and Singh *et al.* (2006) in pea.

Table 12. Yield per plant (g) as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	383.50	358.58	371.04
T_2	RDF + EMC+ VS	495.00	466.75	480.88
T_3	125% RDF	407.83	383.42	395.63
T_4	150% RDF	448.42	408.33	428.38
T_5	175% RDF	528.33	493.33	510.83
T_6	125% RDF + EMC+ VS	573.33	536.67	555.00
T_7	150% RDF + EMC+ VS	685.00	643.33	664.17
T_8	175% RDF + EMC+ VS	635.00	598.33	616.67
	MEAN	519.55	486.09	502.82
	SEM±	11.44	13.18	11.87
	CD @5%	34.71	39.97	36.01

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

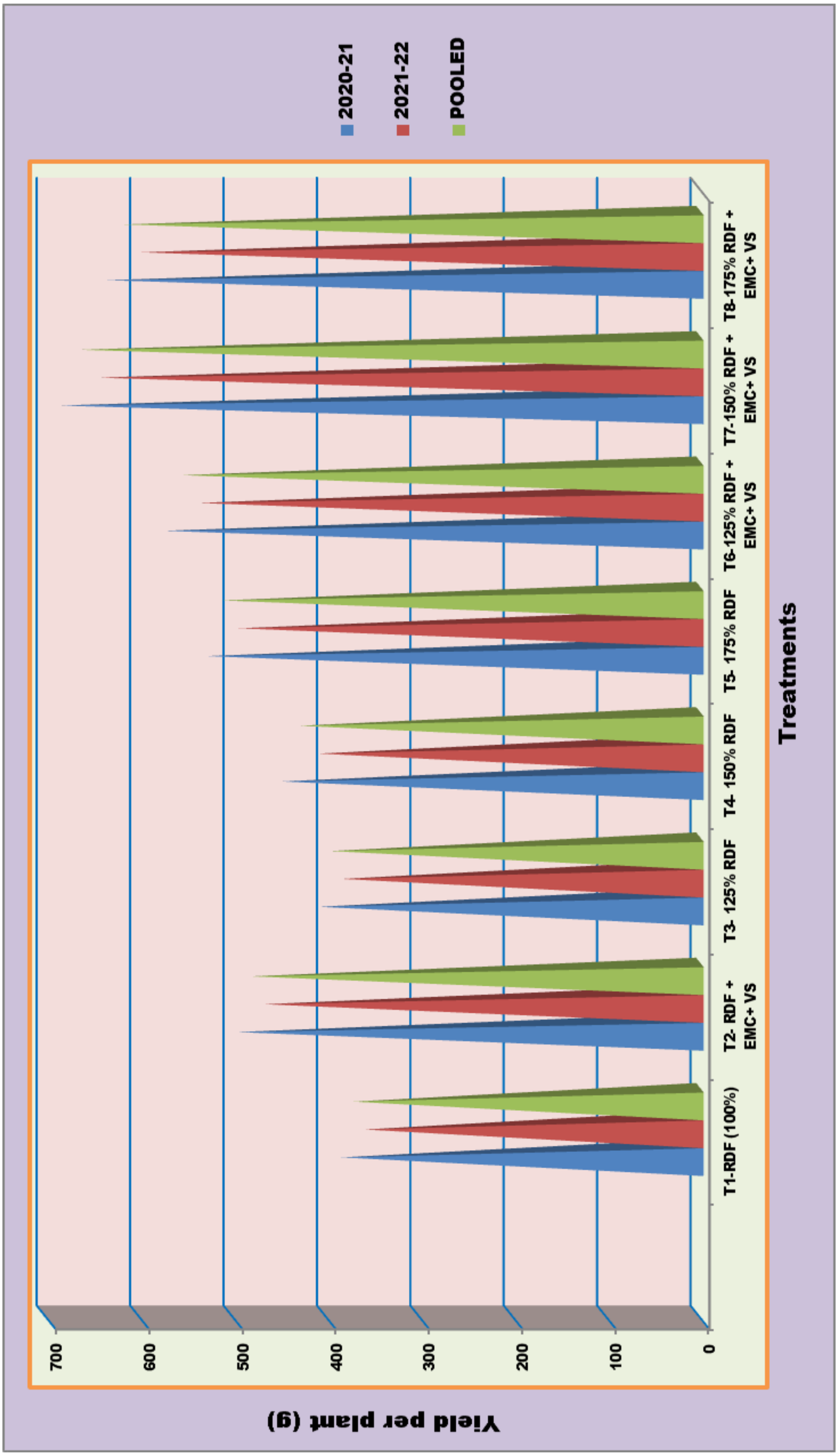


Fig.7. Yield per plant (g) as influenced by integrated nutrient managemen

4.1.2.6 Pod yield per 1000 m^2

The maximum pod yield per 1000 m^2 was observed in T7 (2208.50 kg, 2135.42 kg) it was followed by treatment T8 (2151.92 kg, 2065.67 kg), T6 (2093.08 kg, 1989.67 kg) , T5 (1976.08 kg, 1898 kg), T2 (1858.75 kg, 1777.83 kg), T4 (1760.08 kg, 1657.64 kg) and T3 (1662.60 kg, 1598 kg) while, minimum pod yield per 1000 m^2 was observed in control T1 (1583.33 kg, 1506.67 kg) during 2020-21 & 2021-22 respectively (table 13). Significant differences were observed in pooled pod yield per 1000 m^2 among treatments studied in the present investigation (Fig.8). Among treatments average pooled pod yield per 1000 m^2 was 1870.20 kg and maximum (2171.96 kg) was recorded in the T7 which is followed by T8 (2108.79 kg), T6 (2041.38 kg), T5 (1937.04 kg), T2 (1818.29 kg), T4 (1708.86 kg) and T3 (1630.30 kg). Whereas, the minimum pooled pod yield per 1000 m^2 was observed in control (1545.00 kg). This may be attributed by combined application of organic and inorganic fertilizers was highly beneficial in increasing the yield level as compared to fertilizers alone. The increased yield is attributed to the solubilization effect of plant nutrients due to the addition of FYM as evinced by increased up take of N, P, K, and micronutrients by the crop. These findings are in line with Arulananth and Rameshkumar (2018) in Dolichos bean, Sardana *et al*. (2006) and Das *et al.* (2011) in cowpea and Singh *et al.* (2006) in pea.

Table 13.Yield per 1000 m^2 (kg) as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	1583.33	1506.67	1545.00
T_2	RDF + EMC+ VS	1858.75	1777.83	1818.29
T_3	125% RDF	1662.60	1598.00	1630.30
T_4	150% RDF	1760.08	1657.64	1708.86
T_5	175% RDF	1976.08	1898.00	1937.04
T_6	125% RDF + EMC+ VS	2093.08	1989.67	2041.38
T_7	150% RDF + EMC+ VS	2208.50	2135.42	2171.96
T_8	175% RDF + EMC+ VS	2151.92	2065.67	2108.79
	MEAN	1911.79	1828.61	1870.20
	SEM±	24.51	28.72	18.47
	CD @5%	74.35	87.12	56.03

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia,

VS- Vegetable Special

Fig.8. Yield per 1000 m^2 (kg) as influenced by integrated nutrient management.

Plate 5. Treatmentwise harvesting of pods at experimental site

Plate 6. Best treatment T7: 150 % RDF + EMC + VS

4.1.3 Agronomical parameters

4.1.3.1 Leaf area

It was observed from the data presented in table 16 that significantly higher leaf area at 30 DAS (99.67 cm, 94.43 cm) was noticed with the T7 which is on par with T8 (97.45 cm, 92.27 cm) followed by T6 (95.13 cm, 90.38 cm), T5 (92.87 cm, 87.78 cm), T2 (89.77 cm, 84.63 cm), T4 (85.42 cm, 81.50 cm) and T3 (82.18 cm, 77.78 cm) Whereas, the minimum leaf area after 30 DAS was noticed under control (78.25 cm, 75.75 cm) in *Kharif* 2020-21 & 2021-22 respectively.

Significant differences were observed in pooled leaf area 30 DAS among treatments studied in the present investigation. Among treatments average pooled leaf area 30 DAS was 87.83 cm and maximum (97.05 cm) was recorded in the T7 which is on par with T8 (94.86 cm) which is followed by T6 (92.76 cm), T5 (90.33 cm), T2 (87.20 cm), T4 (83.46 cm) and T3 (79.98 cm). Whereas, the minimum leaf area after 30 DAS was recorded in control (77.00 cm).

Table 16. Leaf area (cm) (30 DAS) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	78.25	75.75	77.00
T_2	RDF + EMC+ VS	89.77	84.63	87.20
T_3	125% RDF	82.18	77.78	79.98
T_4	150% RDF	85.42	81.50	83.46
T_5	175% RDF	92.87	87.78	90.33
T_6	125% RD +EMC+ VS	95.13	90.38	92.76
T_7	150% RDF+EMC+ VS	99.67	94.43	97.05
T_8	175% RDF+ EMC+VS	97.45	92.27	94.86
	MEAN	90.09	85.57	87.83
	SEM±	1.27	1.22	1.07
	CD @5%	3.84	3.71	3.24

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

It is evident from the data in table 17 that, higher leaf area at 60 DAS (190.55 cm, 186.51 cm) was noticed with the T7 which is on par with T8 (187.75 cm, 182.33 cm) followed by T6 (182.74 cm, 178.13 cm), T5 (179.05 cm, 175.33 cm), T2 (177.48 cm, 171.85 cm), T4 (175.02 cm, 167.21 cm) and T3 (172.31 cm, 162.55 cm). Whereas, the minimum plant height was noticed in control (168.08 cm, 160.45 cm) in *Kharif* 2020-21 & 2021-22 respectively.

It was observed from the figure 9 that significantly higher pooled leaf area at 60 DAS (188.53 cm) was observed in the T_7 which is on par with (185.04 cm) followed by T6 (180.44 cm), T5 (177.19 cm), T2 (174.67 cm), T4 (171.11 cm) and T3 (167.43 cm) whereas, the pooled lowest leaf area at 60 DAS was noticed under T1-control (164.27 cm).

Probable reasons for enhanced more number of leaves, may be due to promotive effects of macro nutrients on vegetative growth which ultimately lead to more photosynthetic activities and higher uptake of nutrients from the soil resulting in greater photosynthetic activity cause an increased leaf area index. These findings are in agreement with the findings of Wagh *et al.* (2011) reported that the growth parameters the plant height, number of leaves, leaf area and leaf area index were significantly increased to a greater extent by the treatment 75 percent RDF + Vermicompost + Rhizobium + PSB as compared to RDF alone. Similar findings are in line with Koushal and Singh (2011) in soyabean, Abayomi *et al.* (2008) in cowpea and Msaakpa (2016) in cowpea.

Table 17. Leaf area (cm) (60 DAS) of Yardlong bean as influenced by integrated nutrient management.

		Leaf area 60 DAS		
	Treatments	**2020-21**	**2021-22**	**Pooled**
T_1	RDF (100%)	168.08	160.45	164.27
T_2	RDF + EMC+ VS	177.48	171.85	174.67
T_3	125% RDF	172.31	162.55	167.43
T_4	150% RDF	175.02	167.21	171.11
T_5	175% RDF	179.05	175.33	177.19
T_6	125% RD +EMC+ VS	182.74	178.13	180.44
T_7	150% RDF+EMC+ VS	190.55	186.51	188.53
T_8	175% RDF+ EMC+VS	187.75	182.33	185.04
	MEAN	179.12	173.05	176.08
	SEM±	1.70	1.52	1.17
	CD @5%	5.16	4.61	3.54

NOTE: RDF- Recommended Dose of Fertilizer, EMC- Effective Microbial Consortia, VS- Vegetable Special

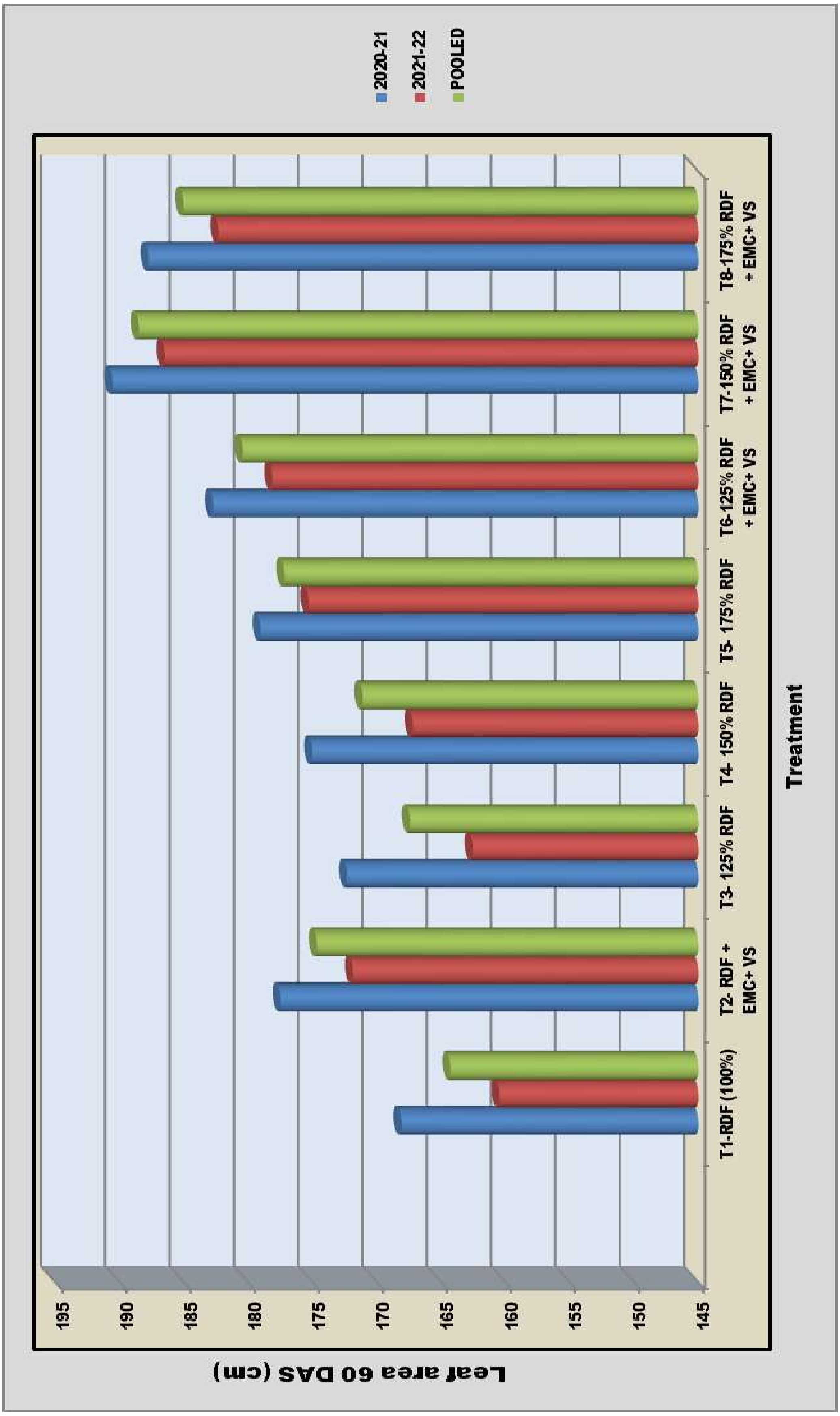


Fig.9. Leaf area (cm) 60 DAS as influenced by integrated nutrient management

4.1.3.2 Total dry weight

Total dry weight revealed significant difference among treatments, highest dry weight (109.23 g, 105.67 g) recorded in the T7 which is on par with T8 (106.75 g, 101.12 g) and T6 (103.75 g, 99.25 g) followed by T5 (100.45 g, 95.52 g), T2 (95.78 g, 89.86 g), T4 (91.01 g, 85.80 g), T3 (87.37 g, 84.17 g) Whereas, the minimum plant height was noticed under control (84.06 g, 79.12 g) in *Kharif* 2020-21 & 2021-22 respectively.

There were significant differences in pooled total dry matter accumulation among treatments and ranged from 81.59 g to 107.45 g (table 15). Among the treatments highest total dry matter accumulation observed in T7 (107.45 g) which was on par with T8 (103.93 g) followed by T6 (101.50 g), T5 (97.99 g), T2 (92.82 g), T4 (88.40 g) and T3 (85.77 g). However, the lowest pooled total dry matter accumulation was recorded under control (81.59 g).

This could be due to the higher uptake of nutrients from the soil resulting in greater photosynthetic activity to the increased the dry matter production. The efficacy of inorganic fertilizer is much pronounced when it is combined with organic manures. The increased vegetative growth and the balanced C:N ratio might have increased the synthesis of carbohydrates, which ultimately promoted yield. The important factors considered to reaping better production were mainly due to supply of nutrients in balanced form and in adequate amount. The increased growth in terms of plant height, dry matter accumulation and number of branches per plant might also provided better sites for pod formation. These results are in line with findings of Amujoyegbe and Alofe, (2003) reportedapplication Nitrogen at 40 kg/ha to cowpea plants significantly increased in plant.

growth, dry matter content, yield and its quality as well as the nutritional value of seeds. Kabir *et al.* (2007) opined that application of 0 + 60 + 40 kg NPK per ha-1 showed maximum number of nodules and higher dry matter production respectively. Shivarn *et al.* (2015) reported similar results application of nitrogen and phosphorus @ 40 and 80 kg per ha^{-1} resulted in maximum and significantly higher plant height, dry matter accumulation, chlorophyll content, total effective fresh and dry weight of nodules per plant, seed and stover yield. The similar results reported by Anilkumar singh *et al.* (2007) revealed that application of 30 kg N and 60 kg P_2O_5 per ha and Rhizobium inoculation significantly increased in number of nodules, dry matter production, leaf area index and number of pods per plant.

Table 15. Total dry weight (g) of Yardlong bean as influenced by integrated nutrient management.

	TREATMENTS	2020-21	2021-22	Pooled
T_1	RDF (100%)	84.06	79.12	81.59
T_2	RDF + EMC+ VS	95.78	89.86	92.82
T_3	125% RDF	87.37	84.17	85.77
T_4	150% RDF	91.01	85.80	88.40
T_5	175% RDF	100.45	95.52	97.99
T_6	125% RD +EMC+ VS	103.75	99.25	101.50
T_7	150% RDF+EMC+ VS	109.23	105.67	107.45
T_8	175% RDF+ EMC+VS	106.75	101.12	103.93
	MEAN	97.30	92.56	94.93
	SEM±	1.97	1.74	1.53
	CD @5%	5.98	5.26	4.63

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.1.3.3 Crop growth rate (CGR): (g m^{-2} day^{-1})

Data presented in the Table 18 indicates that, significantly higher crop growth rate (6.98, 6.72) was noticed with the T7 which is followed by T8 (6.00, 5.95) T6 (5.39, 5.02), T5 (4.93, 4.50), T2 (4.69, 4.28), T4 (3.98, 3.60) and T3 (3.72, 3.43) whereas, the minimum crop growth rate was noticed under control (3.50, 3.32) in *Kharif* 2020-21 & 2021-22 respectively.

Pooled crop growth rate varied from 3.41 to 6.85 with mean of 4.75. Maximum pooled crop growth rate (6.85) was observed in T7 which was followed by T8 (5.98), T6 (5.20), T5 (4.71), T2 (4.49), T4 (3.79) and T3 (3.58). While, the minimum crop growth rate was recorded under control treatment (3.41). It is established fact that organic manures improve the physical and biological properties of soil including supply of almost all the essential plant nutrients for growth and development of plants. Thus, balanced nutrition under favourable environment might have helped in production of new tissues and development of new shoots which have ultimately increased the plant height, dry matter accumulation and number of branches per plant ultimately crop growth rate. These results are in agreement with those of Das *et al.* (2002), Kumar *et al.*, (2003) and Yadav *et al.*, (2004) who observed higher crop growth rate due to application of fertilizers, manures, and bioinoculants in combination.These results are in line with the findings of Ma *et al.* (2001) in lupin, Upma Gamit *et al.* (2022) in cluster bean and Kausale *et al.* (2009) in ground nut.

Table 18. Crop growth rate (g m^{-2} day^{-1}) **of Yardlong bean as influenced by integrated nutrient management.**

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	3.50	3.32	3.41
T_2	RDF + EMC+ VS	4.69	4.28	4.49
T_3	125% RDF	3.72	3.43	3.58
T_4	150% RDF	3.98	3.60	3.79
T_5	175% RDF	4.93	4.50	4.71
T_6	125% RD +EMC+ VS	5.39	5.02	5.20
T_7	150% RDF+EMC+ VS	6.98	6.72	6.85
T_8	175% RDF+ EMC+VS	6.00	5.95	5.98
	MEAN	4.90	4.60	4.75
	SEM±	0.19	0.17	0.15
	CD @5%	0.57	0.51	0.46

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.1.3.4 Net assimilation rate (NAR): (g dm^{-2} day^{-1}**)**

It is evident from the data in Table 20 that significantly highest net assimilation (1.47, 1.29) recorded in the T7 which is followed by T8 (1.16, 1.01), T6 (1.05, 0.98), T5 (0.99, 0.91), T2 (0.92, 0.87), T4 (0.86, 0.78) and T3 (0.78, 0.70) whereas, the minimum NAR was noticed under control (0.70, 0.65) in *Kharif* 2020-21 & 2021-22 respectively.

Pooled data revealed that significantly higher net assimilation rate (1.38) was observed in the T7 which is followed by T8 (1.08), T6 (1.02), T5 (0.95), T2 (0.89), T4 (0.82) and T3 (0.74) whereas, the minimum net assimilation rate was noticed under T1-control (0.67).

Net assimilation rate significantly higher in T7 may be attributed by increased potash availability. Thakur and Patel (1998) also reported that application of potassium is applied in split doses along with FYM improved CGR on account of increased LAI (leaf area index) and NAR. Results are in line with the findings of Ma *et al*. (2001) in lupin, Upma *et al.* (2022) in cluster bean and Kausale *et al.* (2009) in ground nut.

Table 20: Net assimilation rate (g dm^{-2} day^{-1}) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	0.70	0.65	0.67
T_2	RDF + EMC+ VS	0.92	0.87	0.89
T_3	125% RDF	0.78	0.70	0.74
T_4	150% RDF	0.86	0.78	0.82
T_5	175% RDF	0.99	0.91	0.95
T_6	125% RD +EMC+ VS	1.05	0.98	1.02
T_7	150% RDF+EMC+ VS	1.47	1.29	1.38
T_8	175% RDF+ EMC+VS	1.16	1.01	1.08
	MEAN	0.99	0.90	0.94
	SEM±	0.09	0.07	0.07
	CD @5%	0.28	0.21	0.20

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.1.3.4 Relative growth rate (RGR) : g g^{-1} day^{-1}

Relative growth rate revealed significant difference among treatments and highest (23.00, 22.59) recorded in the T7 which is followed by T8 (22.27, 21.18), T6 (21.49, 20.33), T5 (19.99, 19.43), T2 (19.50, 18.94), T4 (18.88, 18.04) and T3 (18.32, 17.55) whereas, the minimum plant height was noticed under control (17.66, 16.98) in *Kharif* 2020-21 & 2021-22 respectively.

The range of pooled relative growth rate among the treatments analysed in the present investigation was 17.32 to 22.80 (table 19). Among the treatments maximum relative growth rate was recorded in treatment T7 (22.80) which is followed by T8 (21.72), T6 (20.91), T5 (19.71), T2 (19.22), T4 (18.46) and T3 (17.94), while the lowest pooled relative growth rate was recorded in control (17.32). Results are in line with the findings of Ma *et al.* (2001) in lupin, Upma Gamit *et al.* (2022) in cluster bean and Kausale *et al.* (2009) in ground nut.

Table 19: Relative growth rate (g g^{-1} day^{-1}) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	17.66	16.98	17.32
T_2	RDF + EMC+ VS	19.50	18.94	19.22
T_3	125% RDF	18.32	17.55	17.94
T_4	150% RDF	18.88	18.04	18.46
T_5	175% RDF	19.99	19.43	19.71
T_6	125% RD +EMC+ VS	21.49	20.33	20.91
T_7	150% RDF+EMC+ VS	23.00	22.59	22.80
T_8	175% RDF+ EMC+VS	22.27	21.18	21.72
	MEAN	20.14	19.38	19.76
	SEM±	0.17	0.32	0.16
	CD @5%	0.52	0.96	0.49

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.2 To study the impact of Integrated Nutrient Management on seed yield and quality traits

4.2.1 Seed yield:

The data mentioned in Table 14 indicates that, seed yield per hectare was significantly influenced by integrated nutrient management. Among the treatments T7 recorded highest seed yield per 1000 m^2 (147.25 kg, 142.25 kg) which is followed by T8 (143.17 kg, 137.50 kg), T6 (139.33 kg, 132.33 kg), T5 (131.58 kg, 126.17 kg), T2 (123.50 kg, 118.08 kg), T4 (117.17 kg, 110.25 kg) and T3 (110.33 kg, 106.17 kg) whereas, the lowest seed yield observed in the control treatment (105.08 kg, 100.33 kg) during 2020-21 and 2021-22 respectively.

Significant differences were observed in pooled seed yield among treatments studied in the present experiment (Fig.10). Among treatments average seed yield was 124.41 kg. Highest seed yield 144.75 kg recorded in the T7 followed by T8 (140.33 kg), T6 (135.83 kg), T5 (128.88 kg), T2 (120.79 kg), T4 (113.71 kg) and T3 (108.25 kg). Whereas, the lowest seed yield was noticed in control (102.71 kg). This may be due to favourable effects of nitrogen on overall metabolic processes of the plant and might be due to its contribution in supplying additional plant nutrients and increasing solubility of native soil nutrients. The another probable reason could be efficient and greater partitioning of metabolites and adequate transformation of nutrients to developing plant structures. As a result, almost all yield attributes of crop resulted into significant improvement due to organic manures and fertilizer in combination. The findings are in agreement with the findings of Abayomi *et al.* (2008) opined that application of 150 kg NPK per ha^{-1} significantly increase the plant height, number of pods per plant, pod yield, seed yield, number of flowers and total dry matter in cowpea. Danielnyoki and Patrick, (2014) revealed that *Rhizobium* inoculation and supplementation of phosphorus independently or in combination had positive effects on seed yield. Further, the fact that Rhizobium inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield. The findings of this investigation confirm the observations of earlier workers Mohanty *et al*. (2017) in French bean, Singh (2017) in Mungbean, Kumar *et al*. (2018) in Chick pea.

Table 14. Seed yield (kg) of Yardlong bean as influenced by integrated nutrient management.

	TREATMENTS	2020-21	2021-22	Pooled
T_1	RDF (100%)	105.08	100.33	102.71
T_2	RDF + EMC+ VS	123.50	118.08	120.79
T_3	125% RDF	110.33	106.17	108.25
T_4	150% RDF	117.17	110.25	113.71
T_5	175% RDF	131.58	126.17	128.88
T_6	125% RD +EMC+ VS	139.33	132.33	135.83
T_7	150% RDF+EMC+ VS	147.25	142.25	144.75
T_8	175% RDF+ EMC+VS	143.17	137.50	140.33
	MEAN	127.18	121.64	124.41
	SEM±	1.69	1.90	1.29
	CD @5%	5.14	5.77	3.91

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

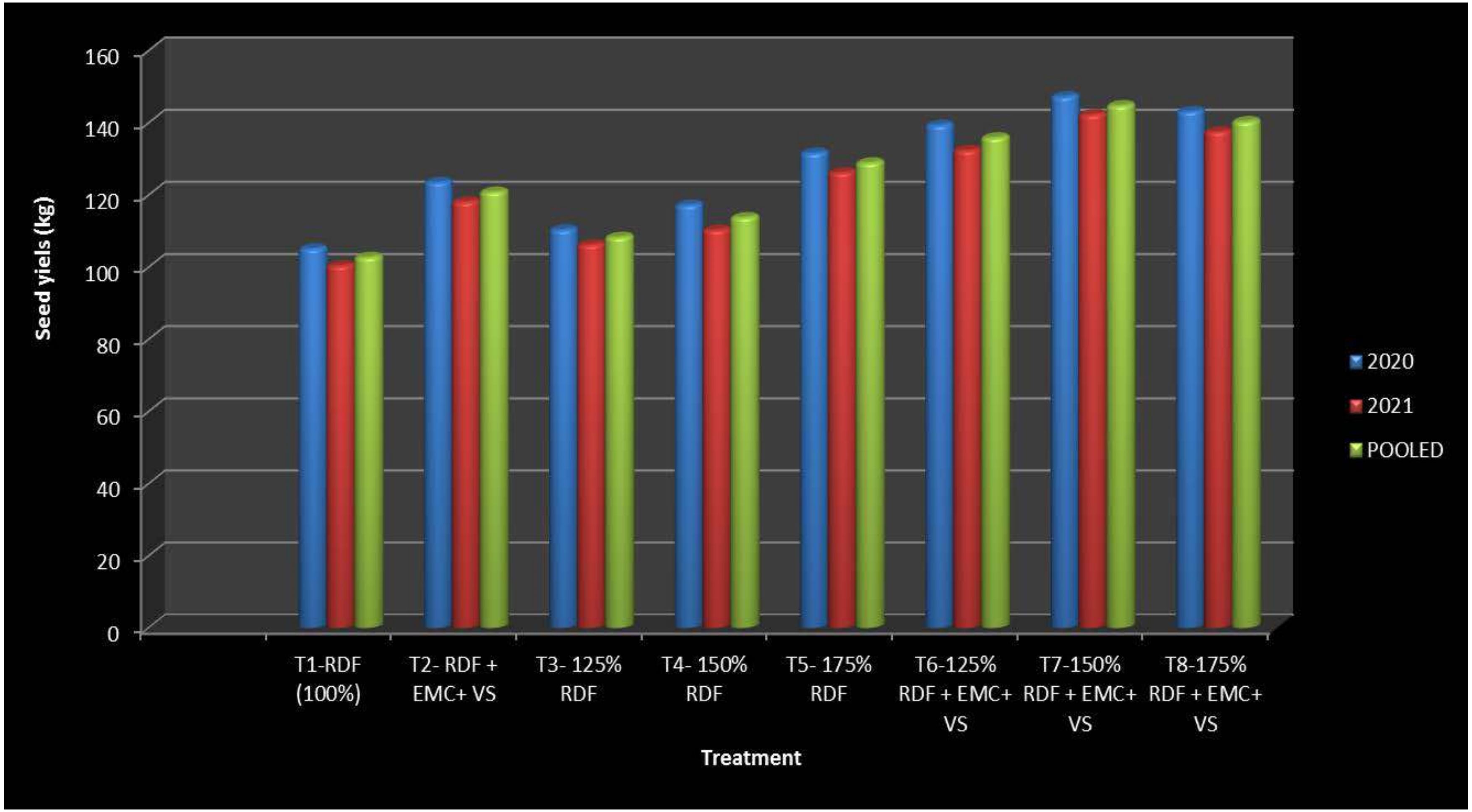


Fig.10. Seed yield (kg) as influenced by integrated nutrient management.

4.2.2 Seed germination percent (%)

In general, mean performance for seed germination (%) was higher in *Kharif* 2020-21 than 2021-22 (table 22). Results revealed that Application of 150% RDF + Effective Microbial Consortia (EMC)+ Vegetable Special (VS)**,** the treatment T7 gave highest seed germination percentage (91.00, 89.33) followed by T8 (89.67, 88.00), T6 (88.33, 86.67), T5 (87.33, 85.00), T2 (86.67, 84.67), T4 (86.00, 83.67), T3 (85.33, 82.33) Whereas, the lowest germination percentage observed under control T1 (83.33, 81.00) during 2020-21 & 2021-22 respectively.

Significant differences were observed in pooled germination percentage among treatments studied in the present investigation (Fig.11). Among treatments average germination percentage was 86.15 and maximum germination percentage of 90.17 was recorded with the T7 which is on par with T8 (88.83 %) followed by T6 (87.50 %), T5 (86.17 %), T2 (85.67 %), T4 (84.83 %) and T3 (83.83 %). Whereas, the minimum germination percentage was observed in control (82.17 %).

The enhanced seed germination and seed vigour may be due to the favourable C/N ratio and better availability of nutrients. Similar findings regarding integrated use of different chemical and biofertilizers and vermicompost showed significant increase in per cent germination, root-shoot length of seedlings and SVI compared to non-treated plants. It has already been reported by Senthilkumar and Sivagurunathan (2012) in cowpea, Dar *et al*. (2010) in okra, Mishra and Jain (2013) in *Andrographis paniculata* (Kalmegh) It is evident from the results that application of 150% RDF + Vegetable Special (VS) and inoculation with Effective Microbial Consortia showed positive effect on seed quality.

Table 22. Seed germination percent (%) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	83.33	81.00	82.17
T_2	RDF + EMC+ VS	86.67	84.67	85.67
T_3	125% RDF	85.33	82.33	83.83
T_4	150% RDF	86.00	83.67	84.83
T_5	175% RDF	87.33	85.00	86.17
T_6	125% RD +EMC+ VS	88.33	86.67	87.50
T_7	150% RDF+EMC+ VS	91.00	89.33	90.17
T_8	175% RDF+ EMC+VS	89.67	88.00	88.83
	MEAN	87.21	85.08	86.15
	SEM±	0.78	0.51	0.54
	CD @5%	2.36	1.55	1.65

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

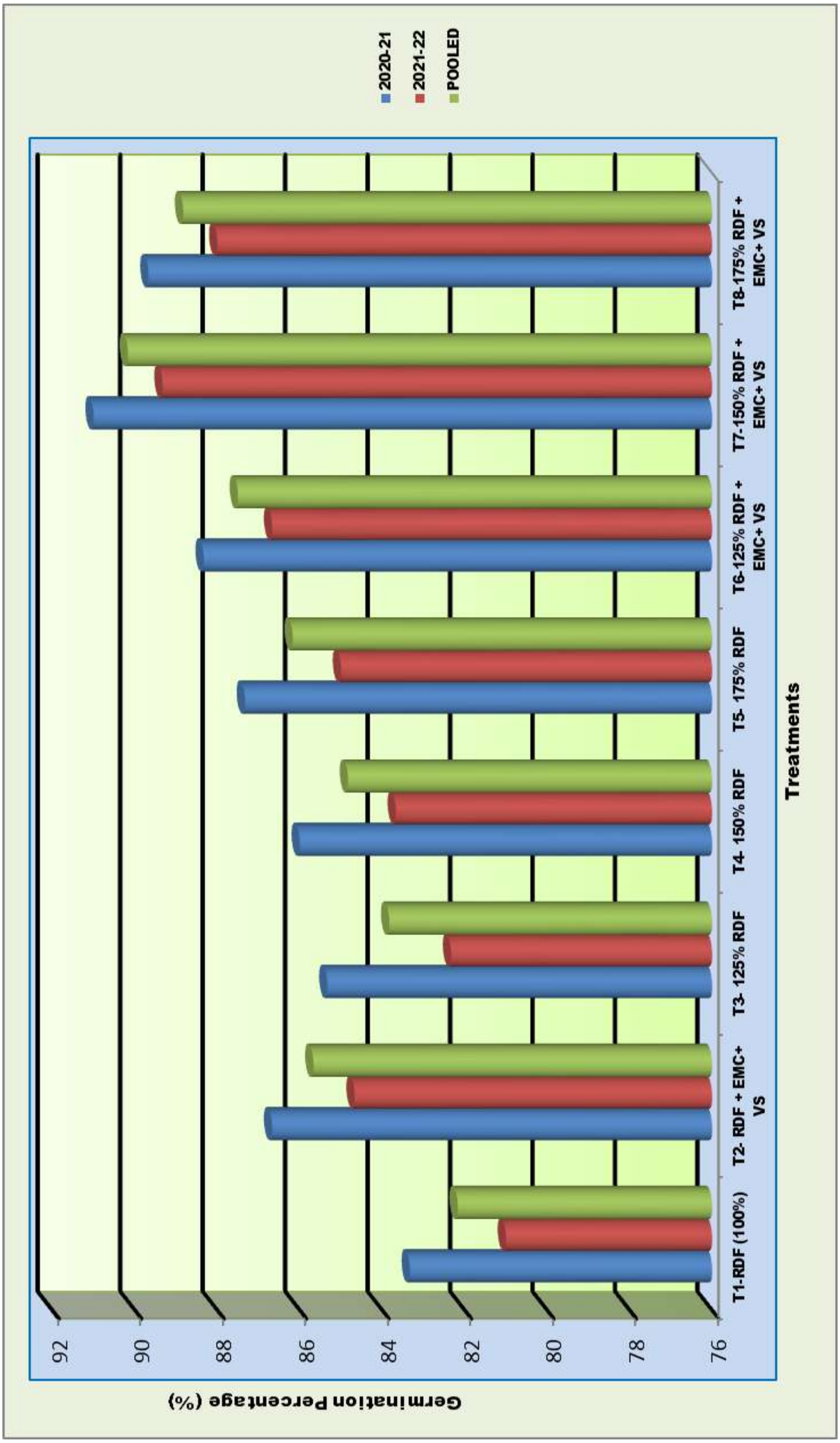


Fig.11. Seed germination percent as influenced by integrated nutrient management

4.2.2 100 seed weight (Seed index)

It is evident from the data presented in table 21 that, significantly maximum 100 seed weight was observed in T7 (23.42 g, 22.17 g) it was followed by treatment T8 (22.97 g, 21.90 g), T6 (21.53 g, 20.05 g), T5 (20.62 g, 19.50 g), T2 (19.20 g, 18.62 g), T4 (18.25 g, 17.20 g), T3 (17.38 g, 17.13 g) while, minimum 100 seed weight was observed in control T1 (16.53 g, 15.65 g) during 2020-21 & 2021-22 respectively.

It was observed from the that significantly higher pooled 100 seed weight (22.79 g) was observed in the T7 which is on par with T8 (22.43 g) and followed by T6 (20.79 g), T5 (20.06 g), T2 (18.91 g), T4 (17.73 g), T3 (17.26 g) whereas, the lowest pooled 100 seed weight was noticed under T1-control (16.09 g).

The results of present experiment prove that increased supply and higher uptake of nutrients by plants might have stimulated the rate of physiological processes in plant and resulted in increased seed yield. Another probable reason could be efficient and greater partitioning of metabolites and adequate transformation of nutrients. The results are in concurrence with the findings of Saikia *et al*. (2018) in French bean who reported that increase is due to the supply of N and P through organic manures and inorganic fertilizers along with Rhizobium and PSB and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased seed yield. Present results are in line with Kumar and Pandita (2015) and Ashwanikumar and Pandita (2016) in cowpea and Shrikant (2010) in green gram.

Table 21. 100 Seed weight (g) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	16.53	15.65	16.09
T_2	RDF + EMC+ VS	19.20	18.62	18.91
T_3	125% RDF	17.38	17.13	17.26
T_4	150% RDF	18.25	17.20	17.73
T_5	175% RDF	20.62	19.50	20.06
T_6	125% RD +EMC+ VS	21.53	20.05	20.79
T_7	150% RDF+EMC+ VS	23.42	22.17	22.79
T_8	175% RDF+ EMC+VS	22.97	21.90	22.43
	MEAN	19.99	19.03	19.51
	SEM±	0.18	0.14	0.13
	CD @5%	0.54	0.42	0.38

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.2.3 Shoot length

Data in the table 23 indicates that shoot length was highest in T7 (5.97 cm, 5.53 cm) it was followed by treatment T8 (5.67 cm, 5.03 cm), T6 (5.37 cm, 4.78 cm), T5 (5.17 cm, 4.50 cm), T2 (4.98 cm, 4.30 cm), T4 (4.83 cm, 4.27 cm) and T3 (4.57 cm, 4.03 cm) whereas, lowest was noticed under control T1(3.93 cm, 3.65 cm) during 2020-21 & 2021-22 respectively.

The range of pooled shoot length among the treatments analysed in the present investigation was 3.79 cm to 5.75 cm (table 23). Among the treatments maximum shoot length was recorded in treatment T7 (5.75 cm) which is on par with T8 (5.35 cm) followed by T6 (5.08 cm), T5 (4.83 cm), T2 (4.64 cm), T4 (4.55 cm), T3 (4.30 cm), while the lowest pooled shoot length was recorded in control (3.79 cm).

It is evident from the data presented in the table 23 shoot length of seedling increased with application of chemical fertilizer and bio fertilizer as seed treatment. The results indicated significant difference for shoot length among the treatments. Similar findings reported by Vikram and Hamzehzarghani (2008) who recorded improvement in root and shoot length of mungbean with PSB inoculation and also reported by Ratpiore *et al.* (2007) in cluster bean, Mustafa *et al.* (2008) in chickpea and Shrikant *et al*. (2010) in greengram .

Table 23. Shoot length (cm) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	3.93	3.65	3.79
T_2	RDF + EMC+ VS	4.98	4.30	4.64
T_3	125% RDF	4.57	4.03	4.30
T_4	150% RDF	4.83	4.27	4.55
T_5	175% RDF	5.17	4.50	4.83
T_6	125% RD +EMC+ VS	5.37	4.78	5.08
T_7	150% RDF+EMC+ VS	5.97	5.53	5.75
T_8	175% RDF+ EMC+VS	5.67	5.03	5.35
	MEAN	5.06	4.51	4.79
	SEM±	0.16	0.17	0.14
	CD @5%	0.49	0.52	0.44

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.2.4. Root length

Data in the table 24 depicts that, highest root length observed in T7 (11.03 cm, 10.72 cm) followed by T8 (10.35 cm, 10.33 cm), T6 (10.17 cm, 9.92 cm), T5 (9.92 cm, 9.67 cm), T2 (9.75 cm, 9.58 cm), T4 (9.50 cm, 9.30 cm) and T3 (9.08 cm, 9.00 cm), whereas minimum was noticed in T1 (8.17 cm, 7.87 cm) during 2020-21 and 2021-22 respectively.

It was observed from the figure 23 that significantly higher pooled root length (10.88 cm) was observed in the T7 which is on par with T8 (10.34 cm) and followed by T6 (10.04 cm), T5 (9.79 cm), T2 (9.67 cm), T4 (9.40 cm) and T3 (9.04 cm) whereas, the minimum pooled root length was noticed under T1-control (8.02 cm). Significant increase in the root length may be due to the availability of all nutrients essential for growth.

Similar findings reported by Vikram and Hamzehzarghani (2008) who recorded improvement in root and shoot length of mungbean with PSB inoculation and also reported by Ratpiore *et al.* (2007) in cluster bean, Mustafa *et al.* (2008) in chickpea and Shrikant *et al*. (2010) in greengram

Table 24. Root length (cm) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	8.17	7.87	8.02
T_2	RDF + EMC+ VS	9.75	9.58	9.67
T_3	125% RDF	9.08	9.00	9.04
T_4	150% RDF	9.50	9.30	9.40
T_5	175% RDF	9.92	9.67	9.79
T_6	125% RD +EMC+ VS	10.17	9.92	10.04
T_7	150% RDF+EMC+ VS	11.03	10.72	10.88
T_8	175% RDF+ EMC+VS	10.35	10.33	10.34
	MEAN	9.75	9.55	9.65
	SEM±	0.26	0.21	0.19
	CD @5%	0.80	0.64	0.57

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

4.2.5 Seedling length

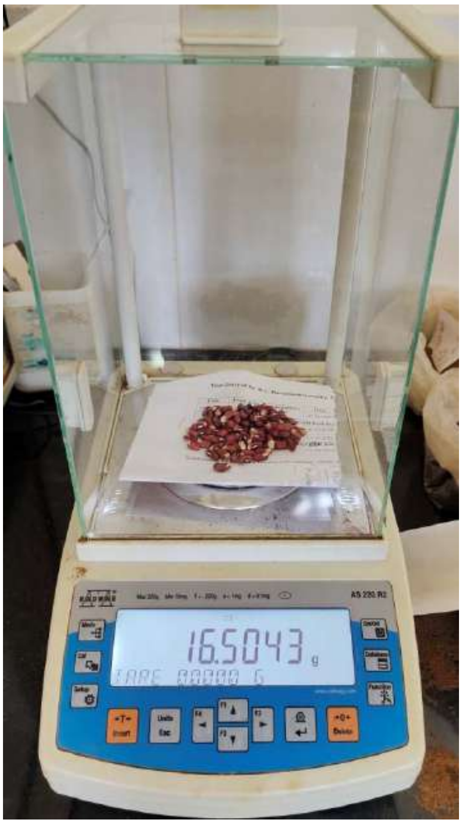
Significantly highest seedling length noticed (table 25) in T7 (15.95 cm, 15.42 cm) followed by T8 (15.67 cm, 15.30 cm), T6 (15.35 cm, 14.97 cm), T5 (14.33 cm, 14.12 cm), T4 (12.63 cm, 11.52 cm), T2 (12.00 cm, 11.62 cm), T3 (11.83 cm, 11.20 cm), whereas lowest was observed in control T1 (11.50 cm, 10.67 cm) in 2020-21 and 2021-22 respectively.

Significant differences were observed in pooled seedling length among treatments studied in the present investigation. Among treatments average pooled seedling length was 13.38 cm and maximum (15.68 cm) was recorded in the T7 which is on par with T8 (15.48 cm) and followed by T6 (15.16 cm), T5 (14.23 cm), T4 (12.08 cm), T2 (11.81 cm) and T3 (11.52 cm) Whereas, the minimum pooled seedling length was observed in control (11.08 cm).

Table 25: Seedling length (cm) of Yardlong bean as influenced by integrated nutrient management.

	Treatments	2020-21	2021-22	Pooled
T_1	RDF (100%)	11.50	10.67	11.08
T_2	RDF + EMC+ VS	12.00	11.62	11.81
T_3	125% RDF	11.83	11.20	11.52
T_4	150% RDF	12.63	11.52	12.08
T_5	175% RDF	14.33	14.12	14.23
T_6	125% RD +EMC+ VS	15.35	14.97	15.16
T_7	150% RDF+EMC+ VS	15.95	15.42	15.68
T_8	175% RDF+ EMC+VS	15.67	15.30	15.48
	MEAN	13.66	13.10	13.38
	SEM±	0.16	0.11	0.10
	CD @5%	0.48	0.34	0.30

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS-VegetableSpecial



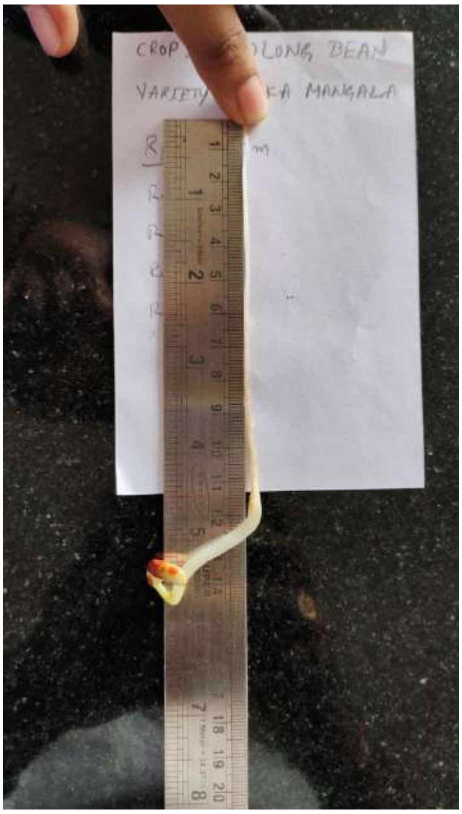


Plate 7. Yardlong bean seed weight and root length measurement

4.3 To work out the cost benefit ratio of using organic and chemical fertilizers:

There is a great variation in cost economics of Yardlong bean cultivation due to application of different levels of chemical fertilizers in combination with biofertilizers was observed (Table 26).

4.3.1. Gross returns

Combined use of 150% RDF + Effective Microbial Consortia+ Vegetable Special given the significantly highest mean gross return with the treatment T7 (Rs. 66255, 64062.50) followed by T8 (Rs. 64557, 61970), T6 (Rs. 62792.50, 59590) , T5 (Rs. 59282.50, 56940), T2 (Rs. 55762.50, 53335), T4 (Rs. 52802.50, 49729.20), T3 (Rs. 49878, 47940) whereas lowest recorded under control T1-100% RDF (Rs. 47500, 45200) during 2020-21 and 2021-22 respectively.

Significant differences were observed in pooled gross returns among treatments studied in the present investigation. Among treatments average pooled gross returns was Rs. 56106.08 and maximum (Rs. 65158.75) was recorded in the T7 which is followed T8 (Rs. 63263.75), T6 (Rs. 61241.25), T5 (Rs. 58111.25), T2 (Rs. 54548.75), T4 (Rs. 51265.85) and T3 (Rs. 48909.00). Whereas, the minimum pooled gross returns was observed in control (46350.00). This result in conformity with Sindhuja *et al*. (2021), Hemant Kumar *et al*. (2018).

4.3.2. Net returns

The highest mean net returns (Rs. 44644, 44251.50) was obtained with T7 followed by T8 (Rs.42714, 41927), T6 (Rs. 41315.50, 40013), T5 (Rs. 37839.50, 37357), T2 (Rs. 34467.50, 33840), T4 (Rs. 31591.50, 30318.20), T3 (Rs. 28801, 28663), while the lowest was noticed with control T1 (Rs. 26605, 26105) during 2020-21 and 2021-22 respectively.

It was observed that significantly higher pooled net returns (Rs. 44447.75) was observed in the T7 which is followed by T8 (Rs. 42320.75), T6 (Rs. 40664.25), T5 (Rs. 37598.25), T2 (Rs. 34153.75), T4 (Rs. 30954.85), T3 (Rs. 28732.00) whereas, the lowest pooled net returns was noticed under T1-control (Rs. 26355.00). Similar findings of enhanced profitability by use of INM treatments was reported by Subbarayappa *et al.* (2009) in cowpea and Rajput *et al.* (2009) in French bean.

4.3.3 B:C

An appraisal of data presented in Table 26 revealed that T7 accrued maximum B:C value (3.07, 3.23) followed by T8 (2.96, 3.09), T6 (2.92, 3.03) , T5 (2.76, 2.90), T2 (2.62, 2.74), T4 (2.49, 2.56), T3 (2.37, 2.49) whereas, the lowest B:C was recorded under control T1 (2.27. 2.37) during 2020-21 & 2021-22 respectively.

It was observed that significantly higher pooled B:C ratio (3.15) was observed in the T7 which is followed by T8 (3.02), T6 (2.98), T5 (2.83), T2 (2.68), T4 (2.53) and T3 (2.43) whereas, the lowest pooled B:C ratio was noticed under T1-control (2.32).

This is due to higher total green pod yield of Yardlong bean recorded in integrated treatment T7. These results are in agreement with the findings reported by Patel *et al.* (2010) who reported that, Application of FYM @ 10 t ha^{-1} + *Rhizobium* inoculation integrated with chemical fertilizer (100% RDF) fetched maximum net returns (Rs. 1,16,640 ha^{-1}) and BC (6.21) in clusterbean cv. Pusa Navbahar. This result in conformity with Sindhuja *et al*. (2021), Hemant Kumar *et al*. (2018).

Table 26: Economic parameters of Yardlong bean as influenced by Integrated nutrient management.

		Gross return (Rs/-)			Net return (Rs/-)			B:C		
	Treatments	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	RDF (100%)	47500.00	45200.00	46350.00	26605.00	26105.00	26355.00	2.27	2.37	2.32
T_2	RDF + EMC+ VS	55762.50	53335.00	54548.75	34467.50	33840.00	34153.75	2.62	2.74	2.68
T_3	125% RDF	49878.00	47940.00	48909.00	28801.00	28663.00	28732.00	2.37	2.49	2.43
T_4	150% RDF	52802.50	49729.20	51265.85	31591.50	30318.20	30954.85	2.49	2.56	2.53
T_5	175% RDF	59282.50	56940.00	58111.25	37839.50	37357.00	37598.25	2.76	2.90	2.83
T_6	125% RD +EMC+ VS	62792.50	59690.00	61241.25	41315.50	40013.00	40664.25	2.92	3.03	2.98
T_7	150% RDF+EMC+ VS	66255.00	64062.50	65158.75	44644.00	44251.50	44447.75	3.07	3.23	3.15
T_8	175% RDF+ EMC+VS	64557.50	61970.00	63263.75	42714.50	41927.00	42320.75	2.96	3.09	3.02
MEAN		57353.81	54858.34	56106.08	35997.31	35309.34	35653.33	2.68	2.80	2.74
SEM±		735.32	861.64	554.20	735.32	862.26	549.87	0.03	0.04	0.03
CD @5%		2230.36	2613.51	1681.00	2230.36	2615.39	1667.87	0.10	0.13	0.08

NOTE: RDF- Recommended Dose of Fertilizer, EMC-Effective Microbial Consortia, VS- Vegetable Special

5.SUMMARY AND CONCLUSION

The present investigation entitled “Effect of Integrated Nutrient Management on yield and quality of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis (L.) verdc*.) ” was conducted in Zonal Agricultural and Horticultural Research Station (ZAHRS), Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Navile, Shivamogga, Karnataka during 2020-2022 **w**ith the following objectives;

- To study the effect of integrated nutrient management on growth and pod yield parameters.
- To study the impact of integrated nutrient management on seed yield and quality traits.
- To workout the cost benefit ratio of using organic and chemical fertilizers.

The experiment was laid out in Randomised Complete Block Design (RCBD) with eight treatments (Table 2) and three replications. As there is no standardized recommended dose of fertilizer (RDF) for Yardlong bean in Karnataka, recommended dose of fertilizer of cowpea (25:75:60 NPK, kg ha^{-1}) is considered for formulating treatments. The variety Arka Mangala which was released from ICAR- Indian Institute of Horticulture Research (ICAR- IIHR), Bangalore was taken for study. Seeds are treated with Effective Microbial Consortia viz., *Azospirillium, Bacillus megaterium* and *Frateuria aurania* for each 10 ml were taken. Foliar spray of vegetable special micronutrient formulation (5g/L) which is released from ICAR-IIHR, Bangalore was sprayed uniformly on entire crop canopy at 30 and 60 days after sowing. All the recommended package of practices except nutrient management was followed to all the treatments. The required dose of fertilizers as per treatment schedule were calculated and supplied to plants through different sources like Urea, Single super phosphate, Muriate of potash. Cultural operations were performed as per the recommendations. Sowing of healthy treated seed was done with a spacing of 60 cm × 45 cm. Twenty four plants from each treatment were selected randomly for observation of data.

Among growth parameters highest plant height and number of primary branches, minimum number of days taken flowering observed in treatment 7 (T7) consisted 150 % RDF + EMC + VS followed by T8 (150 % RDF + EMC+ VS). This may be attributed by application of major nutrients through different levels of chemical fertilizers, increased the photosynthetic activity, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height and number of primary branches and application of organic and inorganic fertilizers as well as by Rhizobium and PSB treatment increased availability of nitrogen and phosphorus might have resulted in minimum number of days for first flowering.

Maximum pods per plants, pod length, pod girth, average pod weight, pod yield per plant and pod yield per 1000m^2 noticed in Treatment 7 consisted 150 % RDF + EMC+ VS and followed by T8 (150 % RDF + EMC+ VS) while, lowest in control. This may be due to the increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and resulted in increased yield attributes and also due to the efficient and greater partitioning of metabolites and adequate transformation of nutrients.

Lowest leaf area, total dry matter accumulation, crop growth rate, net assimilation rate and relative growth rate observed in control treatment, while highest in Treatment 7 consisted 150 % RDF + EMC+ VS and followed by T8 (150 % RDF + EMC + VS) and it may be due to integrated nutrient management increased the leaf area, which invariably enhances solar absorption there by faster photosynthesis helped in more dry matter accumulation.

It is established fact that organic manures improve the physical and biological properties of soil including supply of almost all the essential plant nutrients for growth and development of plants. Thus, balanced nutrition under favourable environment might have helped in production of new tissues and development of new shoots which have ultimately increased the plant height, dry matter accumulation and number of branches per plant ultimately overall crop growth rate.

Significantly highest seed yield, seed index, germination percent, shoot length, root length and seedling length were observed in treatment with (T7) 150 % RDF + EMC+ VS, while lowest in control (T1). This may be due to favourable effects of nitrogen on overall metabolic processes of the plant and might be due to its contribution in supplying additional plant nutrients and increasing solubility of native soil nutrients. The enhanced seed germination and seed vigour may be due to the favourable C/N ratio and better availability of nutrients. The probable reason could be efficient and greater partitioning of metabolites and adequate transformation of nutrients to developing plant structures. As a result, almost all yield attributes of crop resulted into significant improvement due to organic manures and chemical fertilizer in combination. Further, the fact that *Rhizobium* inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield. Highest gross returns, net returns and B: C ratio observed in treatment with (T7-3.15) 150 % RDF + EMC+ VS, while lowest in control (T1-2.32). This might be due to higher agronomic and yield parameters recorded in integrated treatment T7.

Conclusion

The results obtained in the present study on growth, yield and economic parameters as influenced by integrated nutrient management indicated the following points of practical importance. Based on the results of two year experimentation, it is concluded that conjunctive application of 150% Recommended Dose of Fertilizer (37.50 : 112.50 : 90 N:P:K kg/ha), Seed inoculation with Effective Microbial Consortia (*Azospirillium, Bacillus megaterium* and *Frateuria aurania* for each 10 ml) and spraying of micronutrient (5g/L) -Vegetable Special (IIHR) were found to be the most promising treatment. Since, this treatment combination fetched appreciably higher yield and net returns in Yardlong bean as compared to sole application of either chemical fertilizer or other combination of fertilizers.

Major outcome of the present study are as follows.

- Integrated Nutrient Management practices (Organic and inorganic combination) increased the growth and yield attributes of Yardlong bean.
- The evaluation of production economics revealed that growing of Yardlong bean by following treatment T_7 – 150% RDF + Effective Microbial Consortia + Vegetable Special (IIHR) could be the most remunerative option with a highest benefit: cost of 3.15.
- Among compared treatments, T_7 – 150% RDF + Effective Microbial Consortia + Vegetable Special (IIHR) micronutrient spray, was found to achieve the maximum productivity (21.71 t/ha) and about 71.16 percent yield increment over control which in turn gives high returns to the growers.

Future line of work:

- Since there is no recommended dose of fertilizer in cultivation of Yardlong bean in Karnataka there is a need to conduct Multi Location Trails (MLT's) under different agro climatic zones of Karnataka for inclusion in the package of practise recommendation.
- Need to conduct farm trails under different agro climatic zones of Karnataka
- Studies are required to understand the nutrient uptake and soil microbial load under integrated nutrient management.
- There is a need to create awareness about integrated nutrient management among farming community by conducting Front Line Demonstrations (FLD's) and awareness programme by the Krishi Vigyan Kendras.

6. REFERENCES

1. Abayomi, Y. A., Ajibadc, T. V., Sammucl, O. F. and Saadudccn, B. F. (2008). Growth and yield responses of cowpea (*Vigna unguiculata* L.) genotypes to nitrogen fertilizer in the Southern Guinea Savanna Zone of Nigeria. *Asian Journal of Plant Science,* 7 (2) : 170-176.

2. Abdul baki, A. A. and Anderson, J. D. (1973). Vigour determination in soybean seeds by multiple criteria. *Crop Science*, 13: 630-633.

3. Amujoyegbe, B. J. and Alofe, C. O. (2003). Influence of poultry manure and inorganic nitrogen fertilizer on grain yield and proximate component of two cultivars of cowpea (*Vigna unguiculata* L.). *Journal of Agriculture Research,* 4(1):37-45.

4. Anilkumarsingh, P. N., Tripathi, and Roopsingh.(2007). Effect of Rhizobium inoculation, nitrogen and phosphorus levels on growth, yield and quality of *kharif* cowpea (*Vigna unguiculata* L.). *Crop Research,* 33 (3):71-73.

5. Anonymous, (2006). Chemical composition of Yard long bean. *www.web.india.123.com.*

6. Arul Ananth, and S. Ramesh Kumar. (2018). Effect of integrated nutrient management on growth and yield of Dolichos bean *(Lablab purpureus). Annals of Plant and Soil Research,* 20(3): 302–306

7. Ashwanikumar, and V.K. Pandita, (2016). Effect of integrated nutrient management on seed yield and quality in cowpea. *Legume Research,* 39 (3):448-452

8. Avhad, A.B., Kshirsagar, D.B., Shinde, S. R. and Bhalekar, M.N. (2016). Effect of integrated nutrient management on growth, yield, quality and nutrient uptake in tomato. *Asian Journal of Science and Technology,* 7(4):2731-2733.

9. Balachandran, S., Deotale, R.D., Hatmode, C.N., Titare, P.S. and Thorat, A.W. (2005). Effect of bio-fertilizers (Pressmud, *Rhizobium* and PSB) and nutrients (NPK) on morpho-physiological parameters of greengram. *Journal of Soils and Crops*, 15(2):442-447.

10. Baljinder Singh, and Rakesh Kumar. (2016). Effect of integrated nutrient management on growth, yield and yield attributing characters in cluster bean. [*Cymopsis tetragonaloba (L.) Taub*.], *Agriculture Science Digest*, 36(4):307-310.

11. Bapidas, and Wagh, A. P. (2011). Effect of integrated nutrient management on cowpea. *Asian journal of Horticulture*, 6(2):402-405.

12. Brahmbhatt, S.K., Acharya, Mukesh Kumar, Sanjay Prajapati, and D.L. Parmar. (2021). Effect of organic sources of nutrient on quality traits, soil nutrient status and economics of cluster bean (*Cyamopsis tetragonoloba* L.). *Biological forum,* 13(2): 656-659.

13. Chandrakar, and Sarnaik, D. A. and Gupta. (2001). Effect of organic, chemical and liquid manuring in garden pea (*Pisum sativum* L.). *Journal of Agriculture sciences*, 6(2): 79-82.

14. Chate, S. P., Khandekar, B. S., and Suryavanshi, V. P., Suryawanshi, S. B. (2012). Effect of integrated nutrient management on soil properties and available nutrient status of soil at harvest of french bean (*Phaseolus vulgaris* L.) *Advanced Plant Science,* 25(1):143-145.

15. Chattopadhyaya, A. and Dutta, D. (2003). Response of vegetable cowpea to phosphorus and bio-fetilizers in old alluvial zone of West Bengal. *Legume Research*, 26(3):196-199.

16. Danielnyoki, and Patrick A. (2014). Effects of *Bradyrhizobium japonicum* and phosphorus supplementation on the productivity of legumes. *International Journal of Plant & Soil Science,* 3(7):894-910.

17. Das, P.K., Sarangi, D., Jena, M.K. and Mohanty, S. (2002). Response of greengram [*Vigna rediata* (L.) to integrated application of vermicompost and chemical fertilizers in acid lateritic soil. *Indian Agriculture*, 46:79-87.

18. Dash, Ansaba, V. L., Tripathy, and M. Pathak. (2019). Effect of integrated nutrient management on growth, yield and yield attributing parameters of French bean (*Phaseolus vulgaris*). *The pharma innovation journal*, 8(11):98-100.

19. FAO, (1993). Underexploited and Potential feed Legumes in Asia. FAO PARA Publication. FAO, Bangkok, Thailand.

20. Francis, C. A, and H. Daniel, (2004). Organic farming Encyclopedia of soils in the environment. Elsevier, Oxford, UK. 77-84.

21. Gaur, A. C. (1991). Bulky Organic Manures and Crop Residues: Fertilizers, organic matter recyclable wastes and bio-fertilizers, H.L.S. Tandon, Fertilizer development and consultation Organization, New Delhi , 29-35.

22. Giraddi, R. S. (2001). Vermitechnology (in Kannada), CAPART, GOI & University of Agriculture Science, Dharwad, Karnataka. 1-60.

23. Giraddi, R. S., Babalad, H. B. and Chandaragi, D. M. (2006). Vermicompost technology, Technical Bulletin, University of Agriculture Science, Dharwad and DBT, New Delhi, 1-6.

24. Gohari, A., Amiri, E., Gohari, M. and Bahari, B. (2010). Optimization of nitrogen and potassium fertilizer consumption in cowpea production. *Indian Journal Horticulture,* 36(3):240-244.

25. Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research with emphasis on rice. *John wiley and Sors, New York.* pp. 680.

26. Goutamkumar and M. S., Biradar. (2017). Integrated nutrient management studies for protected cultivation of broccoli (*Brassica oleracea var. italica L.). International Journal of Chemical Studies,* 5(4): 225-227.

27. Gregory, P. G. (1926). The effect of climatic conditions on the growth of Barley*, Annals of Botany,* 40: 1-26.

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

29. Hemantkumar, Ripudaman Singh, D. D. Yadav, M. Saquib, V. P. Chahal, Ruchi Yadav, and Omkar Singh Yadav.(2018). Effect of integrated nutrient management (INM) on productivity and profitability of chickpea *(Cicer arietinum L.). International Journal of Chemical Studies,* 6(6):1672-1674.

30. International Seed Testing Association (ISTA). (1996). International rules for seed testing. *Seed Science and Technology*, 24:1-335.

31. Jackson, M. L. (1973). Soil Chemical Analysis. Prentice hall of India Private Limited, New Delhi, 1: 38-82.

32. Jadhav, B. N., Kad, S. T., and Patel. (2011). Influence of *Rhizobium* seed inoculation, nitrogen and phosphorus levels on growth, seed yield and quality of cowpea cv. Pusa phalguni. *International Journal Forest Crop Improvement,* 2(2):114-117.

33. Jaisankar, and K. Manivannan. (2018). Effect of integrated nutrient management on growth, yield attributes and yield of dolichos bean (*Lablab purpureus (L) Sweet*). *Annals of Plant and Soil Research,* 20(4):391-395.

34. Jayashri Barcchiya, and S.S., Kushwah, (2017). Influence of integrated nutrient management on growth, yield parameters and yield in French bean (*Phaseolus vulgaris* L.) *Legume Research*, 40(5):920-923.

35. Jitendra Kumar, Meena, B.P., Chamola, N.C., K.K. Singh, and D.K. Rana. (2018). Effect of integrated nutrient management on yield & growth performance of French bean (*Phaseolus vulgaris* L.) under subtropical conditions of Garhwal Hills. *International Journal of Chemical Studies*, 6(2): 3356-3358.

36. Jubin Chauhan, D, H., Paithankar, Pushpendra Khichi, Vikas Ramteke, Jogdhande Srinivas and Murli Manohar Baghel. (2016). Studies on Integrated Nutrient Management in Cowpea. *Research Journal of Agricultural Sciences*, 7(2): 256-259.

37. Kabir, S. and Farid, A. T. M., Shil, N. C. and Rahman, M. (2007). Effect of different fertilizers on nodulation and yield of Cowpea. *Legume Research*, 21: 74-78.

38. Kausale, S.P., Shinde, S.B., Patel, L.K. and Borse, N.S. (2009). Effect of integrated nutrient management on nodulation, dry matter accumulation and yield of summer groundnut at South Gujarat conditions, *Legume Research,* 32(3): 227-229

39. Kishanswaroop. (2006). Effect of phosphorus, potash and rhizobium on pod yield,nutrient uptake and residual available soil NPK of vegetable cowpea. *Annals of Agriculture Research*, 27(3):250-256.

40. Koushal, S. and Singh, P. (2011). Effect of integrated use of fertilizer, FYM and biofertilizer on growth and yield performance on soybean (*Glycine max (L.) Merill*). *Research Journal of Agriculture Science*, 43:193-197.

41. Kumar, G. and Biradar, M. S. (2017). Integrated nutrient management studies for protected cultivation of broccoli (*Brassica oleracea var. italica L.*). *International Journal of Chemical Studies*, 5(4): 225-227.

42. Kumar, H., Singh, R., Yadav, D.D., Saquib, M., Chahal, V.P. and Yadav, R. (2018). Effect of integrated nutrient management (INM) on productivity and profitability of chickpea *(Cicer arietinum L.). International Journal of Chemical Studies*. 6(6):1672-1674.

43. Kumar, A. and Pandita, V. (2015). Effect of integrated nutrient management on seed yield and quality in cowpea. *Legume Research*, 39:1-6

44. Kumar, Mukesh, Patel, I. and Ali, Shaukat. (2012). Integrated nutrient management in clusterbean (*Cyamopsis tetragonoloba L. Taubert). Legume Research.* 35(2)350-353.

45. Kumar, R. P., Singh, O. N., Singh, Y., Dwivedi, S. and Singh, J. P. (2009). Effect of integrated nutrient management on growth, yield, nutrient uptake and economics of French bean (*Phaseolus vulgaris*). *Indian Journal Agriculture Science,* 79 (2): 122-128.

46. Kumar, S., Singh, R.C. and Kadian, V.S. (2003). Performance of mungbean as influenced by seed inoculation with *Rhizobium* and levels of inorganic sources of nutrients. *Indian Journal of Pulses Research*, 16(1): 67-68.

47. Leelarani, P., Balaswamy, K., Ramachandra Rao and Masthan, S.C. (2015). Evaluation of Integrated Nutrient Management practices on Growth, Yield and Economics of Green chilli cv Pusa Jwala (*Capsicum annnum L.*). *International Journal of Bioresource and Stress Management.* 6(1):76−80.

48. Ma, Q., Longnecker, N. and Atkins, C. (2001). Varying phosphorus supplies and development, growth and seed yield in narrow leafed lupin. *Plant and Soil*, 239: 79 – 85.

49. Mader, P. A., Fliessbach, D., Dubois, L., Gunst, P Fried and U, Niggli, (2002). Soil fertility and biodiversity in organic farming, *Science,* 296:1694-1697.

50. Mal, B., Mahapatra, P, and Mohanty, S. (2014). Effect of diazotrophs and chemical fertilizers on production and economics of okra *(Abelmoschus esculentus L.)* cultivars. *American Journal of Plant Sciences*, 5: 168-174.

51. Meena, D.C. and M. L., Meena, (2018). Effect of Integrated Nutrient Management on Growth Parameters of Okra [*Abelmoschus esculents (L.) Moench*]. *Chem Sci Rev Lett*, 7(26), 582-585.

52. Meera, V., Menon, D., Bhaskarreddy., P, Prameela, and Jayasreekrishnankutty, (2010). seed production in vegetable cowpea *(Vigna unguiculata L.)* under integrated nutrient management. *Legume Research*, 33 (4) : 299 – 301.

53. Mishra, S. and Jain, A. (2013). Impact of biofertilizers, chemical fertilizers and vermicompost on seed quality attributes of *A. paniculata*. *International Journal of Science and Nature*, 4(2):369-370.

54. Mohanty, G. S., Sahu, S. K. Dash, S.R., Pradhan, S., Mangaraj and S. Nahak. (2017). Integrated Nutrient Management for Seed Production in French bean (*Phaseolus vulgaris (L.). International Journal of Current Microbiology Applied Science*, 6(10):3295-3303.

55. Msaakpa, T. S. (2016). Effects of variety and poultry manure on growth and yield of selected cowpea (*Vigna unguiculata* L.) varieties at Makurdi, Nigeria. *International Journal of Science and Research*, 6(8):2250-3153.

56. Mudji Santosa, Moch Dawam, Maghfoer and Hagus Tarno. (2017). The Influence of Organic and Inorganic Fertilizers on the Growth and Yield of Green Bean, *Phaseolus vulgaris* L. Grown in Dry and Rainy Season. (2017). *Journal of Agricultural Science*, 39(3):296-302.

57. Mustafa, M.N., G. Karuna Sagar, V., Chandrika and P.M., Reddy. (2008). Growth and yield of chickpea as influenced by irrigation and nutrient management. *Legume Research*, 31(3):221-223.

58. Nagar, K. C., Meena, N. L. (2004). Effect of phosphorous, sulphur and phosphate solubilizing bacteria on yield components, yield and quality of cluster bean (*Cyamopsis tetragonoloba L. Taub.). Legume Research*, 27: 27–31.

59. Panwar, N. R., Ramesh, P., Singh. A, B. and Ramana, S. (2010). Influence of organic, chemical and integrated management practices on soil organic carbon and soil nutrient status. *Communications in Soil Science and Plant Analysis*, 41: 1073-1083.

60. Patel, C. S., Patel, J. B., Suthar, J. V., and Patel, P. M. (2010). Effect of integrated nutrient on management cluster bean *[Cyamopsis tetragonoloba (L.) Taub]* seed production cv. Pusa Navbahar. *International Journal of Agricultural Sciences*, 6(1): 206-208

61. Patel, and Singh. (2009). Yield and yield components of cowpea (*Vigna unguiculata* L.) as influenced by Sokoto phosphate rock and placement methods in the semi-arid zone of Nigeria. *Nutrient Cycling in Agro Ecosystems*, 81:255–265.

62. Patel, K.J., Singha, A.K., Nareshkumarb, G, and Archana, G. (2010). Organic-acid producing, phytate-mineralizing rhizobacteria and their effect on growth of pigeon pea (*Cajanus cajan*). *Applied Soil Ecology*, 44: 252–261.

63. Patel, Piyush Kumar Saras, C.K., Patel, Neha, V. Patel, and K.V. Rabari. (2017). Effect of integrated crop management practices on growth and yield of rajmash (*Phaseolus vulgaris* L.). *International Journal of Science, Environment and Technology*, 6(4) 2437 – 2444

64. Piluek, K. (1994). The Importance of Yardlong Bean. Proceedings of 2nd Symposium on Vegetable Legumes. *Kasetsart University Research and development Institute and ARC–AVRDC*, Bangkok, Thailand.

65. Prabhoo Singh, Narendera Swaroop , Mahesh Jajoria, and Rajendra Ola, (2018). Effect of Integrated Nutrient Management on growth and Yield of Cowpea (*Vigna unguiculata L.*) *International Journal of Current Microbiology and Applied Science*, 7: 3509-3512

66. Prasad, Rajanishkumarsingh, Yadava, R. B. and Chaurasia, S. N. S. (2013). Growth and nodulation of cowpea (*Vigna unguiculata L.*) as influenced by phosphorus levels bio-inoculants. *Vegetable Science*, 40 (2) : 204-206.

67. Preetham, K. Avil Kumar, A. Srinivas, A. Manohar Rao, and T. Ramprakash. (2020). Influence of INM practices on growth, yield and proximate characters of baby corn in baby corn (*Zea mays L.*) – Hyacinth Bean (*Lablab purpureus var. typicus*) *Cropping System International Journal of Bio-resource and Stress Management*, 11(4):327-334.

68. Radford, P. J. (1967). Growth analysis formulae their use abuse. *Crop Science*, 8: 171-175.

69. Rajkhowa, D. J., Saikia, M. and Rajkhowa, K.M. (2002). Effect of vermicompost with and without fertilizer on Greengram. *Legume Research*, 25(4): 295-296.

70. Rajput, P.K., Singh, O. N., Singh, Y., Dwivedi, S., and Singh, J.P. (2009). Effect of integrated nutrient management on growth, yield nutrient uptake and economics of French bean (*Phaseolus vulgaris*). *Indian Journal of Agricultural Sciences*, 79 (2): 122–128.

71. Rajput, R. L. and Kushwah, S. S. (2005). Effect of integrated nutrient management on the yield of field pea (*Pisum sativum L.*), *Legume Research.* 28(3):231-232.

72. Rather, S. A., Hussain, M. A. and Sharma, N. L. (2010). Effect of bio-fertilizers on growth, yield and economics of field pea (*Pisum sativum* L.). *International Journal Agriculture Science*, 6:65-68

73. Rathore,V.S., Singh,J.P., Soni, M. L. and Beniwal, R. K. (2007). Effect of nutrient management on growth, productivity and nutrient uptake of rainfed cluster bean in arid region. *Indian journal of Agriculture Science*, 77: 349-353

74. Rautaray, S., B. C. Ghosh, and B. N. Mittra. (2003). Effect of Fresh organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a Rice–Mustard cropping sequence under acid lateritic soils. *Bioresource Tech*, 90(3):275-283.

75. Rokhzadi, A., Asgharzadeh, A. and Darvish, F. and Nour Mohammadi, G. and Majidi, E. (2008). Influence of plant growth-promoting rhizobacteria on dry matter accumulation and yield of chickpea (*Cicer arietinum* L.) under field conditions. *Journal of Agricultural and Environmental Science*. 3 (2): 253-257.

76. Rubatzky, V. E. and Yamaguchi, M. (1997). World vegetables: principles, production and nutritive values. *Vegetable Science*. 27(1): 62-63.

77. Sachan, H. K., Deeksha Krishna. (2021). Effect of Organic and Inorganic Fertilization on Growth and Yield of French Bean (*Phaseolus vulgaris L.*) in Fiji, *Legume Research,* 44: 1358-1361.

78. Sahu, P. (2014). Integrated nutrient management in “Raika” French bean (*Phaseolus vulgaris L.)* M.Sc.thesis Orissa University of Agriculture and Technology, Bhubhneswar, Orissa.

79. Sahu, Gayatri, Chatterjee, Nitin and Ghosh, Goutam Kumar. (2017). Integrated nutrient management in lentil in red and lateritic soils of West Bengal. *Bulletin of Environmental Pharmacology*. *Life Science*, 6(4): 55-62.

80. Saikia, J., Saikia, L., Phookan, D. B., Nath, D. J. (2018). Effect of biofertilizer consortium on yield, quality and soil health of French bean (*Phaseolus vulgaris L*.). *Legume Research*, 41(5) 755-758.

81. Sajitha, J. P., Haripriya, K., Umamaheswari, T. and Stella, D. (2016). Effect of organic manures and biofertilizers on the productivity of garden bean *[Dolichos lablab (Roxb.) L. var. typicus*]. *Asian Journal of Horticulture*, 11 (1):129-131.

82. Saket, Sukhlal, Singh S.B., Namdeo, K.N. and Parihar, S.S. (2014). Effect of organic and inorganic fertilizers on yield, quality and nutrients uptake of lentil. *Annals of Plant and Soil Research,* 16 (3): 238-241.

83. Samawat, S. and Borah, B.C. (2001). Effect of Vermicompost and chemical fertilizers on growth and yield of cowpea. *Agriculture Science Technology*, 15(2): 83-89.

84. Sammauria, R., Yadav, Rajender, and Nagar, K. C. (2009). Performance of cluster bean (*Cyamopsis tetragonoloba*) as influenced by nitrogen and phosphorus fertilization and biofertilizers in Western Rajasthan. *Indian Journal of Agronomy*, 54. 319-323.

85. Sardana, V., Sheoran, P, and Singh, S. (2006). Effect of seed rate row spacing, Rhizobium and nutrient application on yield of lentil under dryland conditions. *Indian Journal of Pulses Research*, 19: 216–8.

86. Selvi, D. and Thiageshwari, S. (2002). Effect of Integrated Nutrient Management on growth and yield of brinjal. *Madras Agriculture Journal*, 88: 378-382.

87. Senthilkumar, P. K, and Sivagurunathan, P. (2012). Comparative effect on bacterial biofertilizers on growth and yield of green gram *(Phaseolus radiata L.)* and cow pea (*Vigna siensis Edhl.*). *International Journal of Current Microbiology Applied Science*, 1(1):34-39.

88. Shabanahamid, and Shahid Rasool. (2021). Productivity of French bean (*Phaseolus vulgaris*) as influenced by integrated nutrition and weed management. *International Journal of Advanced Technology & Science Research*, 2(2)-117-130.

89. Sharma uday, Chaudhary, S.S. and Jitender Chauhan. (2010). Effect of sources of applied nutrients on the growth, flowering and seed production of China aster under protected conditions. *Annals of Agriculture Bio Research*, 15(1): 9-11.

90. Shivarn, N. and Yadava, R. B. (2015). Growth and nodulation of cowpea (*Vigna unguiculata* L.) as influenced by phosphorus levels and bio-inoculants. *Vegetable Science*, 25 (6): 125-129.

91. Shrikant, M. (2010). Studies on integrated nutrient management on seed yield, quality and storability in green gram [*Vigna radiata* wilczek] *M.Sc. (Agri.) Thesis*, University Agriculture Science, Dharwad (India).

92. Sindhuja, G., Tsk. Kiranpatro, Salomisuneetha, N., Emmanuel and B. Chennkesavulu, (2021). Effect of integrated nutrient management on yield and yield attributes of Yardlong bean *(Vigna unguiculata (l.) Walp. ssp.*

sesquipedalis verdc.) Journal of Pharmacognosy and Phytochemistry, 10 (2): 765-767.

93. Sindhuja, Kiran Patro, and Lakshmi Narayana Reddy and Salomi Suneetha, (2021). Effect of integrated nutrient management on growth and yield of Yardlong bean *(Vigna unguiculata Walp. ssp. sesquipedalis verdc. International Journal of Research in Engineering and Science*, 9(2). 36-40.

94. Sindhuja, Kiran Patro, Salomi suneetha, N. Emmanuel and B. Chennkesavulu. (2021). Effect of integrated nutrient management on yield and quality of Yardlong bean (*Vigna unguiculata* (l.) *Walp. ssp. sesquipedalis verdc.) International Journal of Chemical Studies*, 9(2): 973-975.

95. Singh, D. K., Chand Lekh, Singh, K. N. and Singh, J. K. (2006). Effect of different biofertilizers in combination with chemical fertilizers on pea (*Pisum sativum L*.) under temperate Kashmir conditions. *Environment and ecology*, 245: 684-686.

96. Singh, A., Baoule, A. L. Ahmed, H. G. and Dikko, A. U. and Aliyu, U. (2011). Influence of phosphorus on the performance of cowpea (*Vigna unguiculata* L.) varieties in the sudan savanna of Nigeria. *Agricultural Science*, 2(3): 313-317.

97. Singh, Anil, M., Tripathi, P. and Singh, (2007). Effect of Rhizobium inoculation, nitrogen and phosphorus level on growth, yield and quality of *Kharif* cowpea (*Vigna unguiculata L. Walf*). *Crop Research*, 33:71-73

98. Singh Mandhata, Deokaran, J. S. Mishra and B. P. Bhatt, (2017). Effect of Integrated Nutrient Management on Production Potential and Quality of Summer Mungbean (*Vigna radiata L.), Journal of Krishi Vigyan*, 5(2) : 39-45

99. Siti Naimah, S. Nashriyah, M, and Mohd Noor, A. G. (2015). Effects of organic and inorganic fertilizers on growth and yield of *Vigna unguiculata subsp. sesquipedalis (verdc.*), *Journal of Tropical Plant Physiology*, 7:1-13.

100. Subbarayappa, C. T., Santhosh, S. C., Srinivasa, N, and Ramakrishnaparama, V. (2009). Effect of Integrated Nutrient Management on nutrient uptake and yield of cowpea in Southern Dry Zone soils of Karnataka. *Mysore Journal of Agricultural Sciences*, 43(4): 700-704.

101. Sukhlal Waskel, Sunil kumar Jatav, and Singh, S.S. (2019). Effect of Integrated Nutrient Management on Growth and Yield attributes of Brinjal. *International Journal of Current Microbiology Applied Science.* 8(11): 1849-1853.

102. Tomar, A., J. Saikia, O. Jamoh, and M. Mohanty. (2022). Effect of integrated nutrient management on growth and yield of dolichos bean (*Lablab purpureus*), *The Pharma Innovation Journal*, 11(11): 959-962.

103. Upadhayay, R. G. and Sharma, S, and Drawal, N. S. (1999). Effect of *Rhizobium* inoculation and graded level of P on the growth and yield of greengram. *Legume Research*, 22:277-279.

104. Upma Gamit, D. R., Bhanderi, R.V., Tank, and K.S., Vaghela. (2022). Effect of integrated nutrient management on growth and yield attributes of cluster bean under South Gujarat conditions. *The Pharma Innovation Journal*, 11(9): 1173-1178.

105. Usha, sharma, Arun, A., David. and Upendra, singh. (2018). Effect of integrated nutrient management on growth and yield of cluster bean (*Cyamopsis tetragonoloba*) var. Pusa Navbahar. *International Journal of Current Microbiology and Applied Science*, 7(7): 350-353.

106. USDA (2019). https://fdc.nal.usda.gov/fdc-app.html#/food_details/169222/nutrients

107. Verdcourt, B. (1970). Studies in the *Leguminosae -Papilionoïdeae* for the Flora of Tropical East Africa: II. *Kew bulletin*, 24(2) (235-307) DOI: 10.2307/4103051.

108. Vikram, A. and Hamzehzarghani, H. (2008). Effect of phosphate solubilizing bacteria on nodulation and growth parameters of greengram (*Vigna radiata* L. Wilczek). *Research Journal of Microbiology*, 3 (2) : 62-72

109. Virmani, S.M. (1994). The twenty first – Dr. R.V. Tamhane memorial Lecture: UNCEED Agenda 21: The new challenge for soil research. *Journal of Indian Society of Soil Science*, 42: 516-523.

110. Wagh, A. P., Dod, V. N., Nagre, P. K. and Bawkar, S. O. (2011). Effect of integrated nutrient management on cowpea. *Asian Journal of Horticulture,* 6 (2): 402-405

111. Watson, D. J. (1952). The physiological basis of variation in yield. *Advance in Agronomy*, 4:101-134.

112. Yadav, R.D., Keshwa, G.L. and Yadav, S.S. (2004). Effect of integrated use of FYM, urea and sulphur on growth and yield of isabgol (*Plantago ovata Forsk*.). *Journal of Medicinal and Aromatic Plant Science,* 25 (3): 668-671.

113. Yogeeshappa, H. (2018). Effect of nutrient management techniques on growth, yield and economics of french bean (*Phaseolus vulgaris*) in alfisol soils of Karnataka. *International Journal of Agriculture Sciences*, 10(15): 6856-6859.

APPENDICES

Appendix-I. Chemical properties of soil of the experimental site at ZAHRS Shivamogga.

	Parameters	Before experiment	After experiment	Method followed
1.	Soil pH (1:2.5)	6.9	6.9	Potentiometry (Jackson, 1973)
2.	Electrical conductivity (ds/m)	0.22	0.21	Conductometry (Jackson, 1973)
3.	Organic carbon (%)	0.38	0.38	Walkly and Blacks wetoxide method (Jackson, 1973)
4.	Available nitrogen (kg ha^{-1})	328.16	342.50	Alkaline permanganate method (Jackson, 1973)
5.	Available P_2O_5 (kg ha^{-1})	64.88	66.10	Brays extractant method (Jackson,1973)
6.	Exchangeable K_2O (kg ha^{-1})	218.10	210.75	Flame photometry (Jackson, 1973)

Appendix-II. Price of inputs and output used in calculating cost and returns

A. Inputs/ Particulars	Unit	Cost (Rs.)
1. Seeds	Half kg	400.00
2. Fertilizers		
a. Urea	kg	6.00
b. Diammonium phosphate	kg	27.00
c. Muriate of potash	kg	29.00
d. Vegetable special	kg	100.00
3. Effective Microbial Consortia	500 ml	300.00
4. Farmyard manure	ton	1,250.00
5. Labour wages	Per day	250.00
6. Mulch	1 m^2	4.00
7. Staking (Plastic thread)	kg	200.00
8. Plant protection sprays		
a. Neem oil	1000 ml	320.00
b. Imidacloprid	200 ml	540.00
c. Bavistin	250 g	275.00
B. Output		
Pod yield (Sale price)		30.00

RESEARCH PUBLICATIONS

Research papers published in UGC care/web of science journals:

1. **Manjesh, M.,** Ramesh Babu, H.N., Nagarajappa Adivappar., Rajeshwari., N. (2022). Effect of Integrated Nutrient Management on Growth and Yield Attributes of Yardlong Bean. *Journal of Farm Sciences*, 35(4): 474-478.

2. **Manjesh, M**., Ramesh Babu, H.N., Nagarajappa Adivappar., Rajeshwari., N. (2023). Influence of Integrated Nutrient Management on Productivity and Profitability of Yardlong Bean. *Indian Journal of Applied and Pure Biology*, 38(2): 449-456

Conferences participated:

1. National Conference on "**Underutilized Horticultural Genetic Resources: Conservation and Utilization**" (NCUHGR-2022) organized by ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands in collaboration with Department of Bio technology, Government of India, on 3rd and 4th June 2022: I have given oral presentation on "**Effect of Integrated Nutrient Management on Growth and Yield Attributes of Underexploited Vegetable Yardlong Bean (*Vigna unguiculata ssp. sesquipedalis* (*L.) verdc*.)"** - I received **Best oral presentation award.**

2. International Conference on "**Advances in Agriculture and Food System towards Sustainable Development Goals**" organized by University of Agricultural Sciences, Bangalore in Collaboration with Indian council of Agriculture Research, New Delhi, India on August 22-24, 2022: I have presented poster on "**Effect of Integrated Nutrient Management on productivity and profitability of underexploited vegetable Yardlong bean *(Vigna unguiculata ssp. sesquipedalis (L.) verdc.)"*.**

J. Farm Sci., 35(4): (474-478) 2022

RESEARCH PAPER

Effect of integrated nutrient management on growth and yield attributes of yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) *Verdc.*)

M. MANJESH[1], H. N. RAMESH BABU[2], NAGARAJAPPA ADIVAPPAR[3] AND N. RAJESHWARI[4]

[1,2,4] Department of Botany and Seed technology, Sahyadri Science College, Shivamogga Kuvempu University - 577 203
[3] Zonal Agricultural and Horticultural Research station, Navile Shivamogga - 577 204, Karnataka, India
E-mail: manjesh94gowda@gmail.com

(Received: October, 2022 ; Accepted: December, 2022)

Abstract: The present experiment was conducted during *Kharif* 2020-21 and 2021-22 at Zonal Agricultural and Horticultural Research Station, Shivamogga, Karnataka, to evaluate the effect of Integrated Nutrient Management on growth and yield of underexploited vegetable crop yardlong bean cv. Arka Mangala under naturally ventilated polyhouse. The experiment was laid out in randomized complete block design (RCBD) with three replications and eight treatments *viz.* T_1 - 100 % Recommended Dose of Fertilizer (RDF-25:75:60 NPK, kg ha^{-1}), T_2 -100 % RDF + Effective Microbial Consortia (EMC)+ Vegetable Special (VS) , T_3 - 125 % RDF, T_4 - 150 % RDF, T_5 - 175 % RDF, T_6 - 125 % RDF + EMC+ VS , T_7 - 150 % RDF +EMC+VS , T_8 - 175 % RDF+EMC+ VS. The integrated treatment combinations involve both organic and inorganic source of nutrients which significantly influenced the growth and yield attributes. The results from the pooled data of two year revealed that, all the growth and yield traits were markedly influenced by the integrated nutrient management practices. Among different treatments, significantly higher plant height (247.96 cm), number of primary branches (8.54), initiation of flowering (38.29 days), to fifty per cent flowering (43.48 days), to first harvest (52.83 days), number of pods per plant (25.17), pod length (74.56 cm), pod girth (3.98 cm), average pod weight (35.54 g), yield per plant (664.17 g) and higher pod yield per 1000 m^2 (2171.96 kg) were recorded with treatment 150 % RDF + EMC+ VS. Thus Integrated Nutrient Management practices increased the growth and yield attributes of Yardlong bean and among compared treatments, T_7 *-150 % RDF + Effective Microbial Consortia (EMC)+ Vegetable Special (VS), found to achieve the maximum productivity of Yardlong bean. The evaluation of production economics revealed that growing of Yardlong bean with said treatment (T_7) could be the most remunerative option with a highest benefit: cost of 3.15.

Key words: Bio fertilizers, EMC, Integrated nutrient management, Rhizobium, Yardlong bean

Introduction

Yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis L. Verdc.*) is a member of the Fabaceae family. It is an important leguminous vegetable and mostly cultivated in China, Southeast Asia, Central and West Africa (FAO 1993; Piluek 1994). The Yardlong bean is considered to be one of the popular vegetable crops in Indonesia, India Thailand, Philippines, Taiwan and China (Rachie 1985). It is one of the most nutritious leguminous vegetable crop. It is a rich and inexpensive source of vegetable protein. Fresh pods are used as a green vegetable. The pods are rich in calcium, phosphorus, sodium, and potassium and also fair amounts of vitamin A, thiamine and ascorbic acid are present (Piluek, 1994).

It enriches soil fertility by fixing atmospheric nitrogen. Because of its quick growth habit it has become an essential component of sustainable agriculture. The factors attributed for low yield of Yardlong bean is mainly growing of Yardlong beans under less fertile soil with low inputs or improper application of fertilizers. Now a days increasing cost of inorganic fertilizers and reduction in soil health with chemical fertilizers, it is essential to replace inorganic fertilizers through organic for sustainable agriculture. Organic sources of the plant nutrients have been reported to improve growth, yield and soil fertility status. Reliance on the increased use of chemical fertilizers and associated hazards put back attention on organic sources which are effective in promoting health and productivity of the soil. Integrated management of chemical fertilizers and organic wastes may be an important strategy for sustainable production of crops. This may not only improve the efficiency of chemical fertilizers along with their minimal use in crop production besides increasing crop yield and improving available major and minor nutrients (Rautaray *et al.*, 2003).

Over the years inorganic fertilizers have been widely used worldwide to support and optimize the growth of vegetables. However, the use of organic fertilizer has gained more importance globally in the last few decades, due to efforts made for the conservation of agriculture. Organic fertilizers have been shown to help preserve natural resources and reduce degradation of ecosystem (Mader *et al.* 2002; Francis and Daniel, 2004).

In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely. However, there is a need for integrated use of alternate sources of nutrients for sustaining the crop productivity. The integration of organic and inorganic sources of plant nutrients has proved superior to individual components with respect to growth, yield and quality of pulses. In this context the study will include integration of different levels of organic and inorganic fertilizers for getting high productivity in Yardlong bean which inturn helps the farmers to get higher returns.

Material and methods

The experiment was conducted to study the effect of integrated nutrient management on growth and yield attributes of Yardlong bean during *kharif* 2021 and 2022 at ZAHRS, Shivamogga, Karnataka, India. The location situated at 13^0 58

Indian J. Applied & Pure Bio. Vol. 38(2), 449-456 (2023). **ISSN: 0970-2091**
A web of Science Journal

Influence of integrated nutrient management on productivity and profitability of Yardlong Bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc.)

[1]**Manjesh, M.,** [2]**Ramesh Babu, H.N.,** [3]**Nagarajappa Adivappar and** [4]**Rajeshwari., N.**

[1,2,4]Department of Botany and Seed technology, Sahyadri Science College, Shivamogga Kuvempu University-577203 (India)
[3]Zonal Agricultural and Horticultural Research Station, Navile Shivamogga-577204, (India)
Corresponding author: manjesh94gowda@gmail.com

Abstract

A field experiment was conducted to assess the effect of inorganic fertilizer, biofertilizers, microbial consortia inoculation on yield and quality of Yardlong bean. The study was conducted under naturally ventilated polyhouse during *Kharif* 2021-22 at Zonal Agricultural and Horticultural Research Station, Shivamogga, Karnataka, The experiment was laid out in Randomized complete block design (RCBD) with three replications and eight treatments *viz.*, T_1 – 100 % Recommended Dose of Fertilizer (RDF-25:75:60 NPK, kg ha^{-1}), T_2 -100 % RDF + Effective Microbial Consortia (EMC)+ Vegetable Special (VS) , T_3 - 125 % RDF, T_4 - 150 % RDF, T_5 - 175 % RDF, T_6 - 125 % RDF + EMC+ VS , T_7 – 150 % RDF +EMC+VS , T_8 - 175% RDF+EMC+ VS. The integrated treatment combinations involve both organic and inorganic source of nutrients which significantly influenced the growth and yield parameters. The results revealed that, all the growth and yield parameters were markedly influenced by the integrated nutrient management treatments. Among different treatments, significantly higher plant height (246.33), number of primary branches (8.42), initiation of flowering (38.08d), fifty percent flowering (43.22 d), days to first harvest (52.58 d), number of pods per plant (24.83), pod length (74.00 cm), pod girth (3.88 cm), average pod weight (35.00 g), yield per plant (643.33 g) and higher pod yield per 1000 m^2 (2135.42 kg) were recorded with treatment 150% RDF + EMC+ VS. The workout of cost economics shows that growing of Yardlong bean with treatment (T_7) could be the most remunerative option with a highest benefit: cost of 3.23.Thus Integrated Nutrient Management practices increased the growth and yield of Yardlong bean and among compared treatments, **T_7 – 150% RDF + Effective Microbial Consortia (EMC) +**

“EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF YARDLONG BEAN
(*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*)”

Thesis submitted to Kuvempu University for the award of Degree of

DOCTOR OF PHILOSOPHY

in

APPLIED BOTANY

By

Mr. Manjesh , M. M.Sc. (Hort.)

Research Guide
Dr. H.N. Ramesh Babu
Professor
Dept. of Botany and Seed Technology
Sahyadri Science College, Shivamogga
Kuvempu University, Shankaraghatta
Karnataka, India

Research Co-Guide
Dr. Nagarajappa Adivappar
Associate Professor (Horticulture)
Zonal Agricultural and Horticultural Research Station, KSN University of Agricultural and Horticultural Sciences,
Shivamogga, Karnataka, India

DEPARTMENT OF POST GRADUATE STUDIES AND RESEARCH IN APPLIED BOTANY
KUVEMPU UNIVERSITY
JNANA SAHYADRI, SHANKARAGHATTA - 577451
SHIVAMOGGA DISTRICT, KARNATAKA, INDIA.

2023

The present investigation entitled "Effect of Integrated Nutrient Management on yield and quality of Yardlong bean (*Vigna unguiculata ssp. sesquipedalis (L.) verdc.*) " was conducted in Zonal Agricultural and Horticultural Research Station (ZAHRS), Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Navile, Shivamogga, Karnataka during 2020-2022 **w**ith the following objectives;

- To study the effect of integrated nutrient management on growth and pod yield parameters.
- To study the impact of integrated nutrient management on seed yield and quality traits.
- To workout the cost benefit ratio of using organic and chemical fertilizers.

The experiment was laid out in Randomised Complete Block Design (RCBD) with eight treatments (Table 2) and three replications. As there is no standardized recommended dose of fertilizer (RDF) for Yardlong bean in Karnataka, recommended dose of fertilizer of cowpea (25:75:60 NPK, kg ha^{-1}) is considered for formulating treatments. The variety Arka Mangala which was released from ICAR- Indian Institute of Horticulture Research (ICAR- IIHR), Bangalore was taken for study. Seeds are treated with Effective Microbial Consortia viz., *Azospirillium, Bacillus megaterium* and *Frateuria aurania* for each 10 ml were taken. Foliar spray of vegetable special micronutrient formulation (5g/L) which is released from ICAR-IIHR, Bangalore was sprayed uniformly on entire crop canopy at 30 and 60 days after sowing. All the recommended package of practices except nutrient management was followed to all the treatments. The required dose of fertilizers as per treatment schedule were calculated and supplied to plants through different sources like Urea, Single super phosphate, Muriate of potash. Cultural operations were performed as per the recommendations. Sowing of healthy treated seed was done with a spacing of 60 cm × 45 cm. Twenty four plants from each treatment were selected randomly for observation of data.

Among growth parameters highest plant height and number of primary branches, minimum number of days taken flowering observed in treatment 7 (T7) consisted 150 % RDF + EMC + VS followed by T8 (150 % RDF + EMC+ VS). This may be attributed by application of major nutrients through different levels of chemical fertilizers, increased the photosynthetic activity, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height and number of primary branches and application of organic and inorganic fertilizers as well as by Rhizobium and PSB treatment increased availability of nitrogen and phosphorus might have resulted in minimum number of days for first flowering.

Maximum pods per plants, pod length, pod girth, average pod weight, pod yield per plant and pod yield per 1000m^2 noticed in Treatment 7 consisted 150 % RDF + EMC+ VS and followed by T8 (150 % RDF + EMC+ VS) while, lowest in control. This may be due to the increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and resulted in increased yield attributes and also due to the efficient and greater partitioning of metabolites and adequate transformation of nutrients.

Lowest leaf area, total dry matter accumulation, crop growth rate, net assimilation rate and relative growth rate observed in control treatment, while highest in Treatment 7 consisted 150 % RDF + EMC+ VS and followed by T8 (150 % RDF + EMC + VS) and it may be due to integrated nutrient management increased the leaf area, which invariably enhances solar absorption there by faster photosynthesis helped in more dry matter accumulation.

It is established fact that organic manures improve the physical and biological properties of soil including supply of almost all the essential plant nutrients for growth and development of plants. Thus, balanced nutrition under favourable environment might have helped in production of new tissues and development of new shoots which have ultimately increased the plant height, dry matter accumulation and number of branches per plant ultimately overall crop growth rate.

Significantly highest seed yield, seed index, germination percent, shoot length, root length and seedling length were observed in treatment with (T7) 150 % RDF + EMC+ VS, while lowest in control (T1). This may be due to favourable effects of nitrogen on overall metabolic processes of the plant and might be due to its contribution in supplying additional plant nutrients and increasing solubility of native soil nutrients. The enhanced seed germination and seed vigour may be due to the favourable C/N ratio and better availability of nutrients. The probable reason could be efficient and greater partitioning of metabolites and adequate transformation of nutrients to developing plant structures. As a result, almost all yield attributes of crop resulted into significant improvement due to organic manures and chemical fertilizer in combination. Further, the fact that *Rhizobium* inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield. Highest gross returns, net returns and B: C ratio observed in treatment with (T7-3.15) 150 % RDF + EMC+ VS, while lowest in control (T1-2.32). This might be due to higher agronomic and yield parameters recorded in integrated treatment T7.

Conclusion

The results obtained in the present study on growth, yield and economic parameters as influenced by integrated nutrient management indicated the following points of practical importance. Based on the results of two year experimentation, it is concluded that conjunctive application of 150% Recommended Dose of Fertilizer (37.50 : 112.50 : 90 N:P:K kg/ha), Seed inoculation with Effective Microbial Consortia (*Azospirillium, Bacillus megaterium* and *Frateuria aurania* for each 10 ml) and spraying of micronutrient (5g/L) -Vegetable Special (IIHR) were found to be the most promising treatment. Since, this treatment combination fetched appreciably higher yield and net returns in Yardlong bean as compared to sole application of either chemical fertilizer or other combination of fertilizers.

Major outcome of the present study are as follows.

- Integrated Nutrient Management practices (Organic and inorganic combination) increased the growth and yield attributes of Yardlong bean.
- The evaluation of production economics revealed that growing of Yardlong bean by following treatment T_7 – 150% RDF + Effective Microbial Consortia + Vegetable Special (IIHR) could be the most remunerative option with a highest benefit: cost of 3.15.
- Among compared treatments, T_7 – 150% RDF + Effective Microbial Consortia + Vegetable Special (IIHR) micronutrient spray, was found to achieve the maximum productivity (21.71 t/ha) and about 71.16 percent yield increment over control which in turn gives high returns to the growers.

Future line of work:

- Since there is no recommended dose of fertilizer in cultivation of Yardlong bean in Karnataka there is a need to conduct Multi Location Trails (MLT's) under different agro climatic zones of Karnataka for inclusion in the package of practise recommendation.
- Need to conduct farm trails under different agro climatic zones of Karnataka
- Studies are required to understand the nutrient uptake and soil microbial load under integrated nutrient management.
- There is a need to create awareness about integrated nutrient management among farming community by conducting Front Line Demonstrations (FLD's) and awareness programme by the Krishi Vigyan Kendras.