NITROGEN MANAGEMENT IN VEGETABLE CHILLI GROWN IN POTS WITH MODIFIED DRIP IRRIGATION SYSTEM

BY

ANITHA V. B.Sc. (Ag.)

THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE,
KERALA AGRICULTURAL UNIVERSITY

Department of Agronomy
College of Agriculture
Vellayani, Thiruvananthapuram

1997

DECLARATION

I hereby declare that this thesis entitled "*Nitrogen management in vegetable chilli grown in pots with modified drip irrigation system*" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani

July 1997.

ANITHA.V

CERTIFICATE

Certified that this thesis entitled *"Nitrogen management in vegetable chilli grown in pots with modified drip irrigation system"* is a record of research work done independently by Smt. Anitha V, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani
11th July 1997.

Dr.V.L GEETHA KUMARI
Chairman,
Advisory Committee
Assoc.Professor of Agronomy
College of Agriculture, Vellayani
Thiruvananthapuram.

APPROVED BY

CHAIRMAN

Dr. V.L. GEETHA KUMARI

MEMBERS

Dr. G. RAGHAVAN PILLAI

Dr. M. ACHUTHAN NAIR

Dr. L. RAJAMONY

EXTERNAL EXAMINER

Prof.P.CHANDRASEKHARAN

ACKNOWLEDGEMENT

The author wishes to express her deep sense of gratitude and sincere thanks to

Dr. (Mrs) V.L Geetha Kumari, Associate Professor of Agronomy, College of Agriculture, Vellayani and Chairman of Advisory Committee for her valuable guidance, critical suggestions and constant encouragement throughout the course of this study and in the preparation of the thesis.

Dr. G.Raghavan Pillai, Professor and Head of Agronomy, College of Agriculture, Vellayani for his sustained interest in the conduct of this work.

Dr.M.Achuthan Nair, Associate Professor of Agronomy, College of Agriculture, Vellayani for his encouragement, helpful suggestions and advice rendered during the course of study.

Dr. L.Rajamony, Associate Professor of Horticulture, College of Agriculture, Vellayani, for his valuable suggestions, critical scrutiny of the manuscript and for the keen interest shown throughout the study.

Prof.P.Chandrasekharan, Professor and Head of Agronomy (Rtd.), College of Agriculture, Vellayani for his valuable guidance in the conduct of this work.

Mr.M.R.Chidananda Pillai, Professor and Head of Agronomy (Rtd.), College of Agriculture, Vellayani for his valuable suggestions in the conduct of the study.

Dr. (Mrs) P.Saraswathy, Head of Agricultural statistics, College of Agriculture, for valuable guidance in the statistical analysis of the data. *Shri.C.E Ajith Kumar*, Junior Programmer, Computer Centre, College of Agriculture for analysing the experimental data.

All my *friends* and *staff* in Agronomy department and other departments for their sincere co-operation and assistance rendered during the course of this investigation.

To my beloved *family members* for their help and inspiration given to me for the completion of the thesis.

Mr.Hari, for neatly typing and setting the thesis.

The Kerala Agricultural University for the award of fellowship for the Post-Graduate programme.

Above all, to *God Almighty* for blessing me for the successful completion of the thesis.

Vellayani.
July 1997.

ANITHA.V

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVATIONS

mm	-	Millimetre
cm	-	Centimetre
mg	-	Milligram
g	-	Gram
kg	-	Kilogram
l	-	Litre
lb	-	Pound
q	-	Quintal
t	-	Ton
ha	-	Hectare
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
DAT	-	Days after transplanting
Fig	-	Figure
DMP	-	Dry matter production
RGR	-	Relative Growth Rate
HI	-	Harvest Index
et al	-	And others
Rs	-	Rupees
Ps	-	Paise
CD	-	Critical difference
SE	-	Standard error
CV	-	Cultivar
no	-	Number
min	-	Minute
nm	-	Nanometer
OA	-	Organic amendment
Azo	-	Azospirillium

INTRODUCTION

1. INTRODUCTION

In Kerala, intensive efforts are being made to increase the vegetable production to meet the state's demand. Many of the vegetable crops are raised in summer, when water availability becomes a problem. It is observed that 30 to 35 percent of total expenditure for vegetable cultivation is accounted for irrigation.

Water and fertilizer are the two vital and costly inputs in crop production. The full potential of a crop can be exploited only with the judicious application of water and fertilizer. Among the three major nutrients, nitrogen is the most important. When studies to workout the optimum irrigation schedule for any crop is to be conducted the standardisation of optimum fertilizer schedule should also go side by side with that. More so, under drip irrigation, wherein nutrient distribution in the soil and in the root zone follows a different trend compared with the surface methods of irrigation. In view of the above, an experiment was undertaken in vegetable chilli grown in pots with modified drip irrigation system.

Water is the prime, indispensable, finite and vulnerable natural resource which determines the productivity of a crop. Hence utmost care in the management and foresight is necessary to use water judiciously and economically. Drip irrigation has been recognised by researchers as the best and most efficient method of irrigation. Roshni (1993) have developed a modified system of drip irrigation for enhancing water use efficiency of potted vegetable crops.

Next to water, nutrients limit crop productivity. The oil crisis witnessed globally in the mid seventies with shortage of fertilizers renewed the interest in the popularisation of integrated nutrient management system involving greater recycling of organics and increased use of biofertilizers into agriculture. Composting is the best method of recycling agricultural and animal wastes for agricultural use. Use of earthworms for composting helps to produce enriched compost. Vermicomposting of animal wastes and agricultural residues result in higher degree of nutrient availability. The benefit of inoculation with specific biofertilizer in crops is a composite effect of the entire nitrogen fixing system of the soil. Crop yields swing between technological thrusts and eco-climatic threats, with the best bet on ecological farming where relevance is acceptable, rationale sound and the rewards impressive.

The major sources of organics which need to be harnessed into the integrated plant nutrient supply system are crop residues and livestock excreta.

Popularising biofertilizers to augment nitrogen supply is an area requiring more research. Response of vegetable crops to Azospirillum inoculation was reported by workers like Dart (1986), Wam and Konde (1986), Balakrishnan (1988) and Subbiah (1990).

Since integrated nutrient supply and management system are the only viable approach for sustaining the food security from irrigated as well as rain-fed croping system, the investigation was taken up with the following objectives.

1. To assess the effect of levels of nitrogen on the growth and productivity of vegetable chilli grown in pots under modified drip system of irrigation.
2. To assess the effect of organic amendments on the growth and productivity of vegetable chilli grown in pots under modified drip system of irrigation .
3. To assess the effect of levels of Azospirillum inoculation on the growth and productivity of vegetable chilli grown in pots under modified drip system of irrigation.
4. To assess the effects of integrated nutrient management system in sustaining the productivity of potted chilli.
5. To work out the economics of various nutrient sources.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

This research work entitled "Nitrogen management in vegetable chilli grown in pots with modified drip irrigation system" was taken up with the objective of assessing the effect of nitrogen, organic amendments and Azospirillum inoculation on the growth and productivity of vegetable chilli. A brief review of the research work so far done and related works on allied crops are presented below under the following titles.

2.1. Effect of nitrogen on the growth, yield and quality of vegetables with special reference to chilli.

2.2. Effect of organic amendment on the growth, yield and quality of vegetables with special reference to chilli.

2.3. Effect of biofertilisers on the growth, yield and quality of vegetables, with special reference to Azospirillum.

2.4. Integrated nutrient management in vegetables.

2.1. Effect of nitrogen on the growth, yield and quality of vegetables with special reference to chilli.

2.1.1. Effect on growth characters

2.1.1.1. Height of plant

The significant influence of nitrogen on plant height was reported by several workers. Rajagopal *et al.* (1977) observed a progressive increase in plant height in chilli with the increase in nitrogen levels. Increase in plant height in chilli with enhancement of nitrogen has been reported by Ramachandran and Subbiah (1982). Joseph (1982) from his experiment on chilli for two seasons concluded that incremental doses of nitrogen increased the height of plant at all the stages of growth in both the seasons. Increase in level of nitrogen resulted in a sequential increase in plant height in chilli as noted by Srinivas (1983). According to Prabhakar *et al.* (1987) nitrogen application at the rate of 90 kg ha^{-1} recorded the maximum plant height in chilli. Similar effect of nitrogen in chilli was also observed by Shukla *et al.* (1987); Kulvinder Singh and Srivasthava (1988); Saji John (1989); Natarajan (1990); Nazeer Ahammed and Tanki (1991) and Pandey *et al.* (1992). Sajitharani (1993) showed that the maximum plant height of 106.75 cm (90DAS) was at the higher level of nutrients (330:110: 220 kg NPK ha^{-1}) in bhindi. Shirley (1996) noticed that plant height was maximum with drip irrigation at the rate of 2 litres $plant^{-1}$ day^{-1} and at higher level of nutrients (100:40:33.3 N : P_2O_5 : K_2O kg ha^{-1}) in chilli.

All these studies showed that nitrogen influenced plant height significantly.

2.1.1.2. Number of branches plant^{-1}

Increase in number of branches of plant with increase in levels of nitrogen was reported by several workers. Nitrogen application @ 160 kg ha^{-1} recorded the maximum number of branches in chilli as reported by Ramachandran and Subbiah (1981). Joseph (1982) noticed that branching in chilli was significantly increased by nitrogen application. Srinivas (1983) observed significant increase in number of branches in chilli plant with increase in nitrogen. The increase in number of branches with increased nitrogen application in chilli was also recorded by Paraminder Singh *et al.* (1986); Prabhakar *et al.*(1987); Kulvinder Singh and Sreevasthava (1988); Saji John (1989); Natarajan (1990) and Pandey *et al.* (1992). However, according to Shukla *et al.* (1987) the number of branches was not affected by nitrogen in chilli. Shirley (1996) noticed that number of branches produced per plant was maximum in chilli with drip irrigation @ 2 litres plant^{-1} day^{-1} and at higher level of nutrients.

In general an increase in number of branches plant-^{1} with increase in levels of nitrogen was observed.

2.1.1.3 Dry matter production

The significant influence of nitrogen on dry matter production was reported by several workers. Chougule and Mahajan (1979) observed that the dry matter content of leaves, branches and fruits were significantly influenced by nitrogen application in chilli. Subramonian (1980) observed that in bhindi crop DMP was increased with increasing levels of nitrogen up to 60 kg N ha^{-1} though the statistical significance was observed only up to 30 kg N ha^{-1}. Rajendran (1981) reported that the total DMP at 60 days after sowing and at harvest was increased with increasing levels of nitrogen in pumpkin. Joseph (1982) noticed an increase in total dry matter production in chilli due to application of nitrogen. A positive correlation between nitrogen application and total dry matter production in chilli was observed by Dod *et al.*(1983). Paraminder Singh *et al.*(1986) showed that higher dosage of nitrogen significantly increased the total dry matter production in chilli. Wankhade and Moreg (1986) reported that in chilli nitrogen produced significantly higher DMP up to 100 kg N ha^{-1}. Hedge (1987) observed that increase in nitrogen application increased the dry matter production in chilli through higher leaf area index and crop growth rate. Increased dry matter production with increase in nitrogen application in chilli was also noted by Manchanda and Bhopal Singh (1987). Hedge (1988) found that in water melon increase in DMP occurred with increase in nitrogen level up to 120 kg ha^{-1}. Saji John (1989) reported that in chilli there was a progressive increase in dry matter production due to increasing levels of nitrogen up to 125 kg ha^{-1}. Sajitharani (1993) observed that the dry matter content increased with increasing levels of nutrients, recording their maximum value 1.21g at 330:110:220 kg NPK ha^{-1} in bhindi crop. Shirley (1996) observed maximum dry matter production in chilli with drip irrigation @ 2 litres $plant^{-1}$ day^{-1} and at higher levels of nutrient.

In general dry matter production increased with increasing levels of nitrogen.

2.1.1.4. Canopy spread

The significant influence of nitrogen on canopy spread was reported by several workers. Sundstrom *et al.* (1984) noticed that canopy spread in chilli increased with nitrogen application from 0 to 112 kg ha^{-1}. Thomas and Leong (1984) observed that increase in nitrogen application increased the foliar growth and canopy spread in chilli. Increase in nitrogen application enhanced the cell division and elongation in chilli resulting in more spread of canopy as reported by Nazeer Ahamed and Tanki (1991). Shirley (1996) observed that higher dose of nutrients significantly increased the spread of canopy in chilli and it was highest with drip irrigation @ 2 litres $plant^{-1}$ day^{-1}.

In general canopy spread increased with increasing levels of nitrogen.

2.1.2. Effect on yield attributes and yield

2.1.2.1. Time of 50 percent flowering

Shrestha (1983) in a study to find out the effect of spacing and nitrogen fertilization in bhindi variety pusa sawani found that nitrogen fertilization advanced the first harvest by 4-6 days compared with controls receiving no nitrogen. Rao and Gulshanlal (1986) noted a significant increase in the number of days for 50 percent flowering with increased levels of nitrogen up to 150 kg ha^{-1}. Saji John (1989) pointed out that time taken for 50 percent flowering was significantly delayed with graded levels of nitrogen. Plants supplied with nitrogen @ 125 kg ha^{-1} took about 36 days for flowering while that with 75 kg ha^{-1} took only 32 days for 50 percent flowering. Subhani *et al.* (1990) reported that, 120 kg ha^{-1} nitrogen recorded minimum time for 50 percent flowering in chilli. Sajitharani (1993) showed that plants supplied with highest levels of nutrients (330:110:220 kg NPK ha^{-1}) took about 42 days for flowering while those supplied with lowest levels of nutrients (50:8:30 kg NPK ha^{-1}) took only 38 days in the case of bhindi. Shirley (1996) observed that with increase in levels of nutrients time taken for 50 percent flowering was increased and number of day taken for 50 percent flowering decreased with drip irrigation in chilli.

In general delayed flowering was observed due to nitrogen application.

2.1.2.2. Number of flowers plant^{-1}

Subramonian (1980) reported that application of nitrogen resulted in significantly higher number of flowers up to the highest level of 60 kg ha^{-1} in bhindi. Splittstoesser and Gerber (1986) found that number of flowers plant^{-1} increased with increased dose of nitrogen in chilli. Kulvinder singh and Srivasthava

(1988) reported that number of flowers plant^{-1} increased with increase in nitrogen application upto 120 kg ha^{-1} in chilli. According to Saji John (1989), maximum flower production was obtained with 100 kg N ha^{-1} in chilli. Sajitharani (1993) observed that the maximum flower production of 39.69 plant^{-1} was obtained with higher levels of nutrients (330:110:220 kg NPK ha^{-1}) in bhindi. Shirley (1996) noted that number of flowers plant^{-1} was highest in chilli plants drip irrigated @ 2 litres plant^{-1} day^{-1} and at higher levels of nutrients.

In general flower formation increased with increasing levels of nitrogen fertilization.

2.1.2.3. Setting percentage of fruits

Significant increase in setting percentage in chilli by the application of graded doses of nitrogen was reported by Joseph (1982). Splittstoesser and Gerber (1986) observed an increasing trend in setting percentage by the application of higher doses of nitrogen in chilli. According to Kulvinder Singh and Srivasthava (1988) increase in nitrogen application increased the setting percentage of fruit in chilli. Similar results were noted by Goyal *et al.* (1989) and Saji John (1989). Shirley (1996) observed that drip irrigation @ 2 litres plant^{-1} day^{-1} and higher level of nutrients contributed to the highest setting percentage of fruits in chilli. Subramonian (1980) studied the effect of nitrogen at different levels (0:30:60 kg N ha^{-1}) on the setting percentage in bhindi and observed that increasing levels of nitrogen tended to reduce the fruit set and 60 kg N ha^{-1} recorded the lowest compared to zero and 30 kg N ha^{-1} which were on par with each other.

In general setting percentage of fruits is significantly influenced by nitrogen fertilization.

2.1.2.4. Number of fruits $plant^{-1}$

Khan and Suryanarayana (1977) summerising the results of experiments on chilli reported that pod number was highest with 120 kg nitrogen ha^{-1}. Nitrogen application significantly increased the fruit yield in bhindi upto 100 kg N ha^{-1} as reported by Gupta and Rao (1979). Ramachandran and Subbiah (1981) showed that number of fruits $plant^{-1}$ increased with increase in nitrogen upto 120 kg ha^{-1} in chilli. Number of fruits $plant^{-1}$ was highest with 120 kg nitrogen ha^{-1} in chilli(Joseph, 1982). Shrestha (1983) found that in bhindi pod yield was highest from plots receiving 60 kg N ha^{-1}. Similar results have been reported by Majanbu *et al.* (1985), Mishra and Pandey (1987), Balasubramani (1988) and Lenka *et al.* (1989). Shukla *et al.* (1987) reported that number of fruits $plant^{-1}$ was significantly influenced by varying levels of nitrogen in chilli. Similar results were noted by Kulvinder Singh and Srivastava (1988); Saji John (1989), Natarajan (1990), Nazeer Ahamed and Tanki (1991), Ajay Kumar and Thakral (1993), Lata and Singh (1993), and Prabhakar and Naik (1993) in chilli. Sajitharani (1993) showed that maximum numbers of fruits per bhindi plant (20.93) was recorded at the highest dose of nutrient (330:110:220 kg NPK ha^{-1}). Shirley (1996) showed that drip irigation @ 2 litres $plant^{-1}$ day^{-1} and higher levels of nutrients recorded maximum number of fruits $plant^{-1}$ in chilli.

In general increased fruit production is recorded by nitrogen fertilization.

2.1.2.5. Length and girth of fruits

According to Chougule and Mahajan (1979), length of fruits was significantly increased due to higher and medium levels of nitrogen in chilli. According to Joseph (1982) application of graded doses of nitrogen upto 75 kg ha^{-1} increased the length and girth of pods in chilli. Dod *et al.* (1983) also observed an increase in length of fruits with increase in nitrogen dose in chilli. Majanbu *et al.* (1985) reported that nitrogen application significantly increased pod diameter in bhindi. Balasubramani (1988) observed that fruit girth was increased by the application of nitrogen at 30 kg ha^{-1} in bhindi. Balasubramani (1988) reported that in bhindi nitrogen application showed significant increase in fruit length with increasing levels. Lenka *et al.* (1989) in a study in bhindi with 4 levels of nitrogen (0,50,75 and 100 kg ha^{-1}) found that nitrogen at 50,75 and 100 kg ha^{-1} were on par with respect to length of bhindi fruits. Saji John (1989) observed that length and girth of chilli fruits were significantly influenced by varying levels of nitrogen. Singh (1979) reported that when nitrogen dose increased from 75 kg to 150 kg ha^{-1} there was adverse effect on pod length and diameter in bhindi.

In general length and girth of chilli fruits were increased with increasing levels of nitrogen fertilization.

2.1.2.6. Total yield of chilli

Subramonian (1980) reported that highest yield in bhindi is obtained with 60 kg N ha^{-1}. Ramachandran and Subbiah (1981) observed significant increase in the yield of fruits with the application of higher doses of nitrogen in chilli. According to Joseph (1982), the yield of dry pods was significantly increased by the application of graded doses of nitrogen upto 112.5 kg ha^{-1} in chilli. Srinivas and Prabhakar (1982) reported that mean fruit yield in chilli was 111.3 q ha^{-1} by the application of 150 kg nitrogen ha^{-1} while in conrol it was only 25.71 q ha^{-1}. According to Srinivas (1983), increase in nitrogen application increased the yield of chilli. Ahmed (1984) reported that, highest yield was obtained by the application of 80 kg nitrogen ha^{-1} in chilli. Narasappa *et al.* (1985) observed that application of 150 kg ha^{1} nitrogen recorded maximum yield of 17.07 q ha^{-1} in chilli. Application of nitrogen fertilizer five times from anthesis to harvest increased yield by 167 to 232 percentage over those of control plants in chilli (Song, 1987). Nitrogen fertilization upto 120 kg ha^{-1} increased the yield by 119 percent over control in chilli (Hegde, 1988). Tomar and Rathore (1988) found that yield of bhindi was highest in plants which received

75 kg N ha^{-1}. Shibhila Mary and Balakrishnana (1990) reported that increase in nitrogen application increased the yield of chilli. Similar results were reported by Thiagarajan (1990), Jayaraman and Balasubramanian (1991), Nazeer Ahamed and Tanki (1991). Pandey *et al.* (1992), Prabhakar and Naik (1993) and Subbiah (1993). Sajitharani (1993) showed that highest level of nutrients (330:110:220 kg NPK ha^{-1}) recorded the highest per plant yield of 2.7 kg in bhindi. Gulati *et al.* (1995) reported that increase in nitrogen application increased the yield of chilli. Shirley (1996) observed that maximum yield was obtained for chilli with drip irrigation @ 2 litre day^{-1} and at higher level of nutrients.

In general fruit yield increased with increasing levels of nitrogen.

2.1.3. Effect on quality of fruit

2.1.3.1. Effect on ascorbic acid content of fruits

Joseph (1982) observed that incremental doses of nitrogen significantly increased the ascorbic acid content of chilli fruits. Dod *et al.* (1983) reported profound effect of nitrogen fertilization on the ascorbic acid content of chilli fruits. Ascorbic acid content of chilli fruit was increased by nitrogen application (Thomas and Leong, 1984). Paraminder singh *et al.* (1986) showed that vitamin C content was increased with enhanced levels of nitrogen and the response was linear upto 90 kg ha^{1} in chilli. Manchandra and Bopal Singh (1987) noted that vitamin C content in bell pepper increased significantly with incremental rate of nitrogen and ranged from 55.42 mg per 100 g of fruit at O kg nitrogen to 97.12 mg per 100 g of fruit at 160 kg ha^{1}. Amritalingam (1988) observed that application of 87.5 kg nitrogen $h\bar{a}^{1}$ recorded maximum ascorbic acid content in chilli. Irene Vethamoni (1988) found that in bhindi, application of 55 kg N ha^{-1}, recorded the highest ascorbic acid content of fruits followed by the decreasing levels of nitrogen. Balasubramoni (1988) reported that application of 30 kg N ha^{-1} gave highest ascorbic acid content in bhindi fruits. Saji John (1989) found that in chilli, application of 100 and 125 kg N ha^{-1} significantly increased the fruit ascorbic acid content compared with nitrogen at 75 kg ha^{-1} and the effects due to 100 and 125 kg N ha^{-1} were on par. Shibhila Mary and Balakrishnan (1990) stated that, in chilli, increase in nitrogen application increased the ascorbic acid content due to the enhancement of enzymatic activities for amino acid synthesis. Similar results were reported by Demirovska *et al.* (1992) and Lata and Singh (1993). Sajitharani (1993) showed that the highest level of nutrient (330 : 110 : 220 kg NPK ha^{1}) recorded the highest ascorbic acid content of 24.48 mg per 100g of fresh weight of bhindi fruit which was on par with 220:73:146 kg NPK $h\bar{a}^{1}$. Shirley (1996) observed that plants with drip irrigation @ 2 litres day^{-1} and at higher levels of nutrients recorded maximum ascorbic acid content of fruits in chilli.

In general asscorbic acid content increased with increasing levels of nitrogen.

2.2. Effect of organic amendment on the growth,yield and quality of vegetables with special reference to chilli

Role of organic amendments on vegetable crops are reviewed here.

2.2.1. Effect on growth characters

A study on optimum level of poultry manure requirement for cauliflower by Singh *et al.* (1970) revealed progressive increase in growth and yield of cauliflower when the dose was increased from 0 to 169.6 q ha^{-1} . Zhang *et al.* (1988) found that in comparison with the application of nitrogen alone, the combined use of nitrogen with Soyabean meal resulted in better growth, higher yield and better fruit quality in tomato. Almazov and Kholuyako (1990) reported that application of optimum dose of NPK along with peat increased drymatter production and yield of tomato compared to the application of NPK alone. Zachariah (1995) reported that application of vermicompost inoculated with both Azospirillum and P solubilising organisms had the highest plant height (75 cm), more number of leaves (771.5)),highest shoot root ratio (3) and maximum per plant yield (302.9 g $plant^{-1}$) in chilli grown in pot. Pushpa (1996) observed that biometric observation viz. height of the plant, number of leaves, number of flowers and number of fruits were grately influenced by the application of vermicompost in tomato. Maximum height (77 cm), number of leaves (774), number of flowers (66) and the number of fruits (61) were obtained when vermicompost @ 25 t was applied along with full dose of inorganic fertilizers.

2.2.2. Effect on yield attributes and yield

Morelock and Hall (1980) compared the effects of broiler litter applied at different rates (0-8 t $acre^{-1}$) with a preplanting application of commercial fertilizer (N_{10} P_{20} K_{10}) at 280 - 840 Kg ha^{-1} on field grown tomato plants. Marketable fruit yield was found to increase with broiler application. Abusaleha (1981) reported early flowering and highest yield of 18.02 t ha^{-1} with application of half nitrogen through $(NH_4)_2SO_4$ and the remaining half through poultry manure in bhindi. The effect of composts prepared out of water hyacinth, paddy straw or mango leaves with or without basic slag either in sunlight or in dark, on yield and composition of chilli was studied by Maurya and Dhar (1983). They found that compost prepared from water hyacinth and basic slag had the highest nitrogen content and resulted in the highest plant yield (up to 612 g from 1 seedling per pot). The role of increasing levels of mushroom spent compost (MSC) as soil amendment was evaluated by Sherry Hsiao-Lei-Wang *et al.* (1984) and reported that yield of cucumber increased as the rate of mushroom spent compost increased. In lettuce, poultry manure applied at 0, 20 and 40 m^3 ha^1 either as entire basal dose or in splits increased the yield from 0.66 to 0.81 and 0.90 kg $pant^{-1}$ (Anez and Tarira , 1984). Increase in the yield of chilli, bhindi, tomato and brinjal by organic manure application was reported by Guar *et al.* (1984). Khawari and Nejad (1986) observed that fertilized compost treated tomato plants produced bigger sized fruits than those treated with Hewitt culture solution. Jose *et al.* (1988) observed that plants supplied with 50 kg N as poultry manure and 50 kg nitrogen as urea recorded the highest yield of brinjal fruits (51 t ha^1) followed by plants supplied with 50 kg N as pig manure and 50 kg as urea. Meena Nair and Peter (1990) reported highest yield in chilli with 15 t FYM + 175:40:25 to NPK ha^{-1} compared to FYM alone or inorganic fertilizer alone. Gianquinto and Borin (1990) reported that fertilizer / manure application stimulated plant growth and increased tomato yield. Studies conducted in KAU revealed that the organic and inorganic fertilizers and their combination had significant influence on vegetable productivity and higher rate of N alone with FYM induced earliness and enhanced the fruit yield in cultured chilli (Kerala Agricultural University, 1991). Subbiah and Sundararajan (1993) found that combined application of 12.5 t ha^{-1} FYM + recommended dose of macronutrients + 25 kg Zn SO_4 ha^{-1} in bhindi was better than FYM alone or combination of 25 t ha^{-1} FYM with the recommended dose of fertilizer with or without micronutrient. Ismail *et al.* (1993) conducted a comparative evaluation of vermicompost, farmyard manure and fertilizer on yield of bhindi, chilli and water melon and observed an increase in yield with vermiculture. Sheshadri *et al.* (1993) conducted an experiment to study the comparative effect of vermicompost, farmyard manure and fertiliser on yield of chilli. The results showed that the yield of dry chillies obtained from vermicompost was somewhat higher than the control and farm yard manure and somewhat lower than the fertiliser treated bed but the yield of fresh chilli was maximum in the vermicompost treated bed. Minhas and Sood (1994) reported that farm yard manure application significantly increased the crop yield.

Superimposition of inorganic fertilizers over farm yard manure had a spectacular effect on crop yields. The effect of farm yard manure was beneficial in enhancing the uptake of all the three major nutrients. Rajalekshmi (1996) observed that with regard to the yield and dry matter production of chilli crop, the treatment receiving vermicompost + NPK recorded highest yield. Pushpa (1996) observed that yield attributes like mean fruit weight, girth of fruits and yield were significantly influenced by vermicompost application in tomato. Mean fruit weight (63 gram), mean girth (18 cm) and yield (10.8 t ha^{-1}) were obtained with tomato plants receiving 25 t vermicompost along with full dose of inorganic fertilizers.

2.2.3. Effect on quality parameters

Kansal *et al.* (1981) opined that application of 20 t FYM ha^{-1} increased the ascorbic acid content in spinach leaves. Khamkar (1993) suggested that vermicompost could be well adopted for vegetable farming and vegetable keeping quality in vermiculture plots was higher than chemical fertiliser applied plots. Pushpa (1996) showed that highest protein (20 percent) was found in tomato plants receiving 100 t vermicompost whereas maximum carbohydrate content was found in tomato plants receiving 25 t vermicompost along with full dose of inorganic fertilizers.

2.3. Effect of biofertilizer on the growth, yield and quality of vegetables with special reference to Azospirillum .

2.3.1. Effect on growth characters

One of the striking responses of crop plants upon inoculation with Azospirillum is the increased root and shoot growth and biomass accumulation (Smith *et al.*, 1978). Azospirillum has the ability for better root induction in inoculated plants mainly due to the production of plant growth hormones like IAA and GA. As a result of this, such plants are capable of absorbing more and more available nutrients from the soil, which in turn results in better establishment of plant seedling and subsequent growth (Tien *et al.*, 1979; Govindan and Purushotaman, 1984). Wam and Konde (1986) reported that performance of Azospirillum was better at lower dose of nitrogen. Parvatham *et al.* (1989) observed that seed, soil and foliage application of *Azospirillum brasilience* not only increased the root biomass but also shoot biomass and plant height in bhindi.

2.3.2. Effect on yield attributes and yield

Significant increase in yield was recorded in rice, cabbage and brinjal and evidence of a positive increase in yield obtained in wheat, onion and tomato on Azotobacter inoculation of seed or seedling (Sundar Rao *et al.*, 1963; Lehri and Mehrotra, 1972; Mehrotra and Lehri, 1971 and Shinde *et al.* 1977).

Cohen *et al.* (1980) obtained increased yield for a wide range of tropical and temperate crops by Azospirillum inoculation. Plant responses to inoculations with Azotobacter and Azospirillum in cereals and noncereals are often reported in terms of increased grain yield, plant biomass yield, nutrient uptake, grain and tissue N content, nitrogenase activity, early flowering, tiller numbers, greater plant height, leaf size, increased enzyme levels in plant parts, increased number of spikes and grains per spikes, thousand grain weight, increased root length and volume, reduced insect and disease infection (Okon, 1985; Wani, 1990). Shukla and Kundu (1986) obtained increased yields in plants by bacterial inoculation. Azospirillum inoculation was known to increase the yield of crop by 5 to 20 percent with savings of 40 percent of the recommended dose of nitrogen (Dart , 1986).

The mechanism by which the plants inoculated with Azospirillum and Azotobacter derive positive benefits in terms of increased grain yield, plant biomass and N uptake are attributed to small increase in N input from BNF, development and branching of roots, production of plant growth hormones, enhancement on uptake of NO_3, NH_4^+, $H_2PO_4^-$, K^+, Pb^+ and Fe^{2+}, improved water status of plants, increased nitrate reductase activity in plants, production of antibacterial and antifungal compound (Okon, 1985; Pandey and Kumar, 1989; Wani, 1990).

Fertilizers Association of India (1994) reported that field trials conducted to study the influence of Azotobacter and Azospirillum inoculation on several nonleguminous crops experienced 5-15 per cent increase in yield and a nitrogen contribution of about 25 kg ha^{-1}.

2.3.3. Effect on quality parameters

Inoculation with Azospirillum increased capsicin and ascorbic acid contents in chilli (Balakrishnan, 1988). Subbiah (1990) observed that Azospirillum inoculation recorded the highest nitrogen use efficiency and saved 50 percent of the recommended dose of nitrogen in tomato. Subbiah (1991) reported that in bhindi, Azospirillum inoculation saved up to 50 percent of fertilizer nitrogen, besides increasing yield and nitrogen use efficiency.

2.4. Integrated nutrient management in vegetables

Role of integrated nutrient management on vegetables are reviewed here.

2.4.1. Effect on growth characters

Combined application of FYM and NPK as FYM alone proved less effective in increasing the dry matter content in tomato (Dolkova 1977). Field studies revealed that tomato species favourably respond to individual as well as combined inoculation of Azotobacter vinekndii and Glomus fasciculatum (Sukhada

1987). Senapati *et al.* (1987) noted increased plant height, number of leaves per plant, number of fruits per plant, pod length in mycorriza inoculated bhindi over the control. Subbaiah (1991) conducted field experiments to study the effect of Azospirillium and fertilizer nitrogen on bhindi and found that 60 percent of the recommended dose of nitrogen was saved by the application of Azospirillum and it had beneficial effect on bhindi. Combined application of 12.5 t ha^{-1}, FYM and recommended dose of macronutrients + 25 kg $ZnSO_4$ ha^{-1} in bhindi was better than FYM alone.

2.4.2. Effect on yield attributes and yield

Oblisami *et al.* (1977) obtained an yield of 7290 and 7135 kg ha^{-1} in Okra cv. pusa sawani by soil application of Azotobacter and 40 kg N ha^{-1} and Azotobacter and 30 kg N ha^{-1} in addition to basal P and K. Combination of stable manure at 15,30,45 t ha^{-1} and NPK (15:15:15) at 500, 1000, 1500 kg ha^{-1} were tried by Sutapradia (1979) in cv. Green Gondol in glass house.The highest yield was obtained by stable manure at 30 t + 1000 kg NPK fertilizer ha^{-1}. Morelock and Hall (1980) compared the effect of broiler litter appllied at different rates in December with pre-planting application of commercial fertilizer. Marketable fruit yield was found to increase as broiler litter application rose. In an experiment conducted to assess the effect of organic and inorganic manures on the quality and yield response of oriental pickling melon, it was observed that the treatment which received highest dose of NPK in the organic - inorganic combination (1.5 times standard dose of NPK and 75 percent N in inorganic nitrogen) recorded maximum yield (58.62 kg) (KAU, 1987). Increased fruit yield and final shoot fresh weight were observed in Capsicum inoculated with mycorhiza in P deficient soil and under water stress (Waterer and Caltman, 1989). Nair and Peter (1990) reported highest yield in chilly with 15 t FYM and 175:40:25 kg NPK ha^{-1} in the three season trial when compared to FYM alone or inorganic fertilizer alone. Studies conducted at KAU revealed that organic and inorganic fertlizers and their combination had significant influence on vegetable productivity and higher rate of N along with FYM induced earliness and increased fruit yield in clustered chilly (KAU, 1991). Paramaguru and Natarajan (1993) noted seed treatment with Azospirillum along with 56 kg N gave highest yield of chillies in both local cultivar and CA-42. Jagadeesh *et al.* (1996) noted that treatment comprising organic manure vikas (7:10:5)) @ 1.5t + 75:25:25 kg NPK ha^{-1} produced the maximum yield of green chillies followed by plots receiving neem cake @ 2t + 75:25:25 kg of NPK ha^{-1}. Usha Kumari *et al.* (1996) noted 694 and 51.3 percent more yield in bhindi when inorganic fertilizer was reduced to 3/4th recommended dose and supplemented with vermi compost. Jiji *et al.* (1996) found that requirement of chemical fertilizer in Cowpea var. Malika was reduced when recommended dose of FYM was substituted with equal quantity of vermicompost, and vermicompost with full dose of chemical fertilizer gave an yield increase of 19 percent. Jiji *et al.* (1996) found similar results with bitter gourd var preethi and found 21.1 percent yield increase when full dose of NPK was given with vermicompost.

2.4.3. Effect on quality parameters

Luchnik (1975) is of the opinion that both organic and inorganic fertilization resulted in high sugar and vitamin C content in cabbage. Yoshida *et al.* (1984) found that fertilization with bone and rape seed meals produced firm fruits with most cohesiveness, chewingness and uniform firmness at top and bottom of tomato fruits. Shanmugavelu (1989) pointed out that the application of a combination of FYM and inorganic mixture was the best for firmness, storage life and keeping quality of tomatoes for a long time. Almazov and Kholuyako (1990) found increased sugar content in tomato due to the application of NPK along with peat compared to the application of NPK alone. Pushpa (1996) showed that maximum carbohydrate cotent was found in tomato plants receiving 25 t vermicompost along with full dose of inorganic fertilizers.

It is evident from these studies that an integrated system caters to the improved yield and quality of vegetable crop.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment was conducted as pot culture at College of Agriculture, Vellayani to assess the effect of levels of nitrogen, organic amendment and Azospirillum inoculation on the growth and productivity of vegetable chilli grown in pots under modified drip system of irrigation. The materials used and methods adopted in this investigation are explained in this chapter.

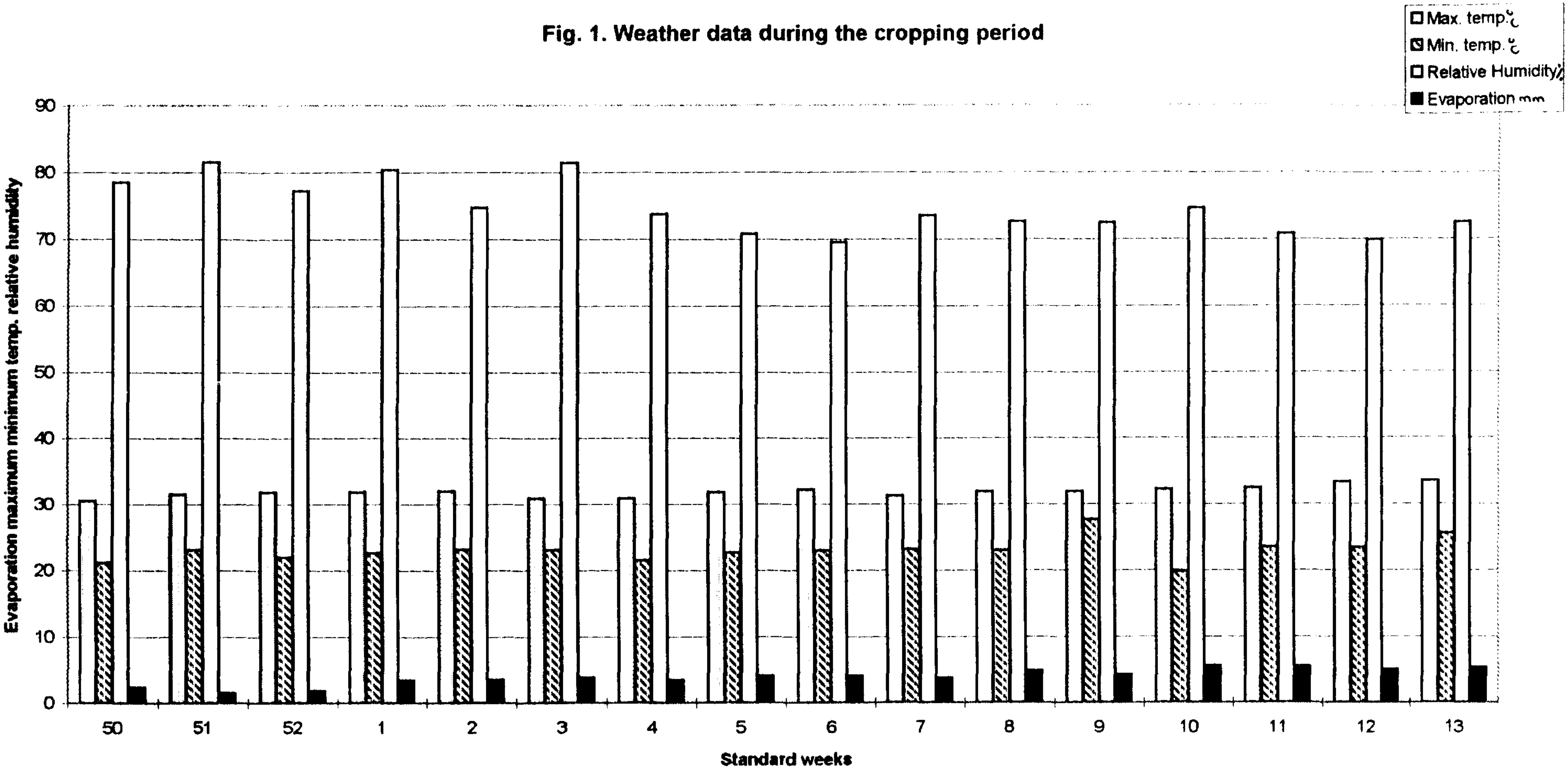
3.1. Location

The experiment was conducted in the net house attached to the Department of Agronomy, College of Agriculture, Vellayani. This location is situated 85° N latitude, 76.9° E longitude and at an altitude of 29 m above mean sea level.

3.2. Season

The experiment was conducted during the summer season of 1994-95. The details of weather parameters like rainfall, evaporation, relative humidity, maximum and minimum temperature during the cropping period collected from the meteorological observatory attached to the College of Agriculture, Vellayani are presented in Appendix I and Fig. I.

Fig. 1. Weather data during the cropping period



The rainfall ranged from 0.5 mm to 1.2 mm per day. Maximum temperature ranged between 33.5°C and 30.5°C and the minimum temperature between 27.7°C and 19.8°C. The relative humidity ranged from 69.5 to 81.5 percent. The evaporation values varied from 1.5 mm to 5.5 mm per day.

3.3. Materials

3.3.1. Potting Mixture

Potting mixture comprising of equal proportion of red loam soil, sand and cowdung was used as the media for crop growth. The chemical characteristics of the potting mixture is given in Table 3.1.

Table 3.1.

Chemical Properties of Potting Mixture

Constituent	Content %	Rating	Method Used
Organic carbon	0.189	Low	Walkley and Black rapid titration method (Jackson, 1973)
Available nitrogen	0.008	Low	Alkaline potassium permanganate method (Subbaiah and Asija, 1956)
Available P_2O_5	0.0019	Medium	Bray colorimetric method (Jackson, 1973)
Available K_2O	0.0046	Low	Ammonium acetate method (Jackson. 1973)
pH	5.9	Acidic	1:2 Soil solution ratio using P^H meter (Jackson, 1973)

3.3.2. Cultivar

Chilli variety Jwalamukhi, a newly released high yielding variety of vegetable chilli evolved by Kerala Agricultural University by crossing Pusa Jwala and Local variety Vellanotchi is the test crop for the study. It has got high yield potential, ideal for culinary purpose and suited for pot culture. The maximum yielding period is between 90 to 120 days. The seed material was obtained from the Instructional farm, College of Agriculture, Vellayani.

3.3.3. Planting Site

Earthern pots of 25 cm diameter and 30 cm height were used as containers. Pots were filled with potting mixture at the rate of 8 kg pot^{-1} for raising the crop.

3.3.4. Modified drip system

The holes of the garden pots were plugged with rubber corks provided with holes. Through the holes tubes of 0.5 m length and 0.6 cm diameter were inserted. Water was stored in these pots and the flow was regulated @ 10 ml $minute^{-1}$ for 2 1/2 hours (1.5 litres $plant^{-1}$ day^{-1}) with the screw type pinch cork attached to the tube. These garden pots which served as water source were placed at a level above plant height and plants were irrigated exploiting gravitational force. Garden pots were insulated from solar heating with thick coating of white paint on all exposed phases (Plate - 1).

3.3.5. Manures and Fertilizers

Cowdung (0.42% N, 0.25% P_2O_5, 0.43% K_2O) was used for the preparation of potting mixture. Other organic amendments used were vermicompost (1.1% N, 0.42 % P_2O_5 and 1.7% K_2O) and poultry manure (1.8% N, 1.15 % P_2O_5 and 0.5% K_2O). The fertilizers used were urea (45.7% N) super phosphate (16.1% P_2O_5) and muriate of potash (59.6% K_2O). Azospirillum obtained from the microbiology unit of College of Agriculture, Vellayani was the biofertiliser used in this experiment.

3.4. Methods

3.4.1. Design and treatments

The experiment was laid out in a factorial completely randomised design with 42 treatment combinations. Treatments consisted of 7 levels of nitrogen, 3 types of organic amendments and 2 types of microbial inoculation.

Modified drip system

PLATE - I

Treatments

A. Levels of nitrogen [N] (g N plant^{-1})

No	-	0.0
N_1	-	0.4
N_2	-	0.8
N_3	-	1.6
N_4	-	3.2
N_5	-	6.4
N_6	-	12.8

B. Organic amendments [O]

O_o	-	Control (no organic amendment)
O_1	-	Vermicompost @ 200g plant^{-1}
O_2	-	Poultry manure @ 100 g plant^{-1}

C. Microbial inoculation [M]

M_o	-	Control (no inoculation)
M_1	-	Azospirillum

(Phosphorus and potassium were given uniformly for all treatments as per package of practices recommendation)

Treatment Combinations

1. $N_oO_oM_o$
2. $N_oO_oM_1$
3. $N_oO_1M_0$
4. $N_oO_1M_1$
5 $N_oO_2M_0$
6. $N_oO_2M_1$
7. $N_1O_oM_0$
8. $N_1O_oM_1$
9. $N_1O_1M_0$
10. $N_1O_1M_1$
11. $N_1O_2M_0$
12. $N_1O_2M_1$
13. $N_2O_oM_0$
14. $N_2O_oM_1$
15. $N_2O_1M_0$
16. $N_2O_1M_1$
17. $N_2O_2M_0$
18. $N_2O_2M_1$
19. $N_3O_oM_0$
20. $N_3O_oM_1$
21. $N_3O_1M_0$
22. $N_3O_1M_1$
23. $N_3O_2M_0$
24. $N_3O_2M_1$
25. $N_4O_0M_0$
26. $N_4O_oM_1$
27. $N_4O_1M_0$
28. $N_4O_1M_1$
29. $N_4O_2M_0$
30. $N_4O_2M_1$
31. $N_5O_oM_0$
32. $N_5O_oM_1$
33. $N_5O_1M_0$
34. $N_5O_1M_1$
35. $N_5O_2M_0$
36. $N_5O_2M_1$
37. $N_6O_oM_0$
38. $N_6O_0M_1$
39. $N_6O_1M_0$
40. $N_6O_1M_1$
41. $N_6O_2M_0$
42. $N_6O_2M_1$

Replications - 3

3.4.2. Layout

The garden pots were arranged in such a way that one garden pot served as the water source for four earthern pots (Plate-2)

3.4.3. Nursery

Bavistin treated chilli seeds were sown (@ 4g seeds bed^{-1}) in well prepared raised nursery beds of size 1.2 m wide and 15 cm high with channels around to facilitate drainage of excess water. A basal dressing of powdered cattle manure at the rate or 1kg m^{-2} was applied in nursery beds. The seeds were sown on 13-11-1994. The seedlings were irrigated daily. Hand weeding was done at weekly intervals. The seedlings were transplanted on 12.12.1994.

3.4.4. Transplanting

The seedlings were transplanted in earthern pots filled with potting mixture. In the case of Azospirillum inoculated treatments, the roots of seedlings were dipped in Azospirillum slurry for 10 minutes and seedlings were transplanted in earthern pots filled with potting mixture. Immediately after planting shade was provided for the seedlings.

Experimental site - an overview

PLATE - II

3.4.5. Manures and Fertilizers

Cowdung was used for preparing the planting medium. Nitrogen, phosphorus and potash were applied to the pots in the form of urea, superphosphate and muriate of potash respectively. Nitrogen was applied in seven levels as per treatments. Uniform dose of phosphorus and potash at the rate of 40 and 25 kg ha^{-1} respectively were applied to all pots. 50 percent nitrogen, full phosphorus and 50 percent potash were applied as basal dose. The remaining 25 percent nitrogen and 50 percent potash were applied 30 days after transplanting and 25 percent nitrogen one month after the second application.

3.4.6. Scheduling of irrigation

The moisture content of potting mixture was brought to field capacity and later irrigation was scheduled @ 10 ml min^{-1} for 2 1/2 hours (1.5 litre $plant^{-1}day^{-1}$) for all treatments.

3.5. After cultivation

3.5.1. Gap filling

Gap filling was done on the sixth day after transplanting.

3.5.2. Weeding

The crop was hand weeded thrice at monthly intervals.

3.5.3. Plant protection

Monocrotophos (0.05%) was sprayed to control thrips.

3.5.4. Harvesting

The first harvest was done on 15-2-1995, about 2 months after transplanting and subsequent harvests were made at 8 days interval. Total number of harvests was six.

3.6. Observations

3.6.1. Growth Characters

Observations were recorded at three growth stages viz. 35 DAT, 70 DAT and harvest.

3.6.1.1. Height of the plant

The height of plants were measured from the base to the growing tips and expressed in cm.

3.6.1.2. Number of branches

The total number of branches per plant were counted, mean values were calculated and recorded.

3.6.1.3. Canopy spread of the plant

The canopy spread of the plants were measured from the centre to the boundary having maximum spread and calculated using the formula πr^2 and expressed in cm^2.

π - a constant

r - distance from the centre to the boundary having maximum canopy spread

3.6.1.4. Total dry matter production

Total dry matter production was worked out by recording the dry weight of shoot and pods after oven drying at 80°c. Drying and weighing were repeated till constant weights were obtained and expressed in g.

3.6.1.5. Relative growth rate (RGR)

The rate of increase in dry weight per unit dry weight per unit time expressed as mg g^{-1} day^{-1} was calculated by the following formula suggested by Blackmann (1919).

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

W_1- Dry weight of the plant at time t_1

W_2- Dry weight of the plant at time t_2

3.6.2. Yield and yield attributes

3.6.2.1. Time of 50 percent flowering

The number of days taken for 50 percent of the plant population to flower in each treatment was recorded.

3.6.2.2. Number of flowers per plant

Flower production on plants was recorded from the first flower opening till the last harvest.

3.6.2.3. Setting percentage

Setting percentage was computed from total number of fruits and flowers produced on the same plant.

3.6.2.4. Number of fruits per plant

The total number of fruits harvested from all the plants were counted and the averages were worked out for each treatment.

3.6.2.5. Length of fruits

Length of randomly selected 10 fruits were measured and averages worked out and expressed in cm.

3.6.2.6. Girth of fruits

Fruits used for measuring length were used for recording the girth. Girth was measured at the broadest part of fruits and expressed in cm.

3.6.2.7. Fruit yield

Fruit yield was computed by adding the weights of fruits of each harvest and is expressed in g $plant^{-1}$.

3.6.2.8. Harvest Index

From the yield data, HI was calculated using the formula suggested by Donald (1962)

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.6.3. Quality aspects

3.6.3.1. Ascorbic acid content of fruit

The ascorbic acid content of fruits was estimated by titrimetric method (Paul Gyorgy and Pearson, 1967)

3.6.3.2. Chlorophyll content

The leaf samples were homogenised in cold 80 percent acetone and centrifuged to get the clear extract. The absorbance of the extracts were measured at wavelengths of 645 and 663 nm for chlorophyll 'a' and 'b' in spectronic 20 spectrophotometer. The amounts of total chlorophyll 'a' and 'b' were calculated using the formula of Starnes and Hadley (1965)

3.6.4. Nutrient uptake

Plant samples were analysed for N,P and K at harvest by adopting standard procedures. The plants were chopped and dried in an air oven at 80± 5°C separately till constant weights were achieved. Samples were then passed through a 0.5mm mesh in a Wiley mill. Nitrogen content was estimated using microkjeldahl method (Jackson, 1973), phosphorus content using vanadomolybdophosphoric yellow colour method (Jackson, 1973) and potassium content using flame photometer (Piper, 1966).

The total uptake of N,P and K were calculated as the product of percent content of nutrients in the plant samples and dry weight and expressed as g $plant^{-1}$.

3.6.4.1. Fertilizer use efficiency

It is the proportion of the fertilizer nutrient that is absorbed by the plant from the soil.

$$FUE = \frac{\text{Fertilizer nutrient absorbed by the plant}}{\text{Fertilizer nutrient added to the soil}}$$

3.7. Economics of cultivation

Economics of cultivation of vegetable chilli in pot under modified drip irrigation system was worked out. Only the variable costs were considered in computing the economics. Labour charges were not included since family labour can be utilised for cultivation. Earthern pots costing Rs.15 pot^{-1} were used for planting the chilli. Garden pots costing Rs.20 pot^{-1} were used for drip irrigation. One garden pot was used as the source of water for 4 plants. Curtain tube of 0.5 m meter length (Rs. 4 m^{-1}) was used. One rubber cork (Rs. 3.5 $cork^{-1}$) was utilised by 2 plants. The durability of garden pots, earthern pots, is considered as 10 years. One screw type punch cork (Rs. 3 $cork^{-1}$) was used for each plant. The curtain tube, rubber cork and screw type pinch cork can be used for at least 2 years. The economics of cultivation of the experiment was worked out as per the formulae given below.

Net return (Rs/Plant) = Gross income - cost of cultivation

$$\text{Benefit cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.8. Statistical analysis

Data relating to each character was analysed by applying analysis of variance technique and significance tested by F test (Snedecor and Cochran, 1967). Significance was tested at 0.05 and 0.01 levels. When the effects were found to be significant, critical differences were calculated for effective comparison among the means.

3.9. Correlation studies

Simple correlations were worked out between biometric observations, yield attributes, quality aspects, nutrient uptake and yield.

RESULTS

4. RESULTS

An investigation was conducted to assess the effect of levels of nitrogen, organic amendments and Azospirillum inoculation on the growth and productivity of vegetable chilli grown in pots under modified drip system of irrigation. The data on various observations were statistically analysed and presented in this chapter.

4.1. Growth characters

The results on various growth characters recorded at 35 DAT, 70 DAT and harvest are presented below.

4.1.1. Plant height

The data on plant height recorded at 35 DAT, 70 DAT and harvest is presented in Table 4.1.

At all growth stages nitrogen has influenced plant height significantly. At 35 DAT the treatment N_6 recorded maximum plant height (24.74 cm). At 70 DAT height recorded by N_5 and N_6 were significantly superior to all other treatments. N_6 recorded a height of 43.76 cm which was on par with N_5 (43.59 cm). At harvest N_3 (53.28 cm), N_4 (53.33 cm), N_5 (53.38 cm) and N_6 (53.41 cm)recorded comparable plant heights which were significantly superior to the plant height recorded by the lower three levels of nitrogen.

Table 4.1. Effect of nitrogen, organic amendment and microbial inoculation on height of plant.

Treatments	Height (cm)		
Levels of nitrogen	35 DAT	70 DAT	Harvest
N_o	20.94	41.03	51.27
N_1	22.05	42.30	52.57
N_2	22.49	42.78	53.01
N_3	22.71	42.87	53.28
N_4	23.13	43.30	53.33
N_5	23.86	43.59	53.38
N_6	24.74	43.76	53.41
F Test	s	s	s
SE	0.21	0.13	0.11
CD (0.05)	0.60	0.37	0.31
Organic Amendments			
O_O (control)	21.96	41.94	52.18
O_1 (vermi compost)	23.08	43.00	52.92
O_2 (Poultry manure)	23.50	43.48	53.55
F Test	S	S	S
SE	0.14	0.09	0.007
CD (0.05)	0.39	0.25	0.20
Microbial Inoculation			
M_o (control)	22.44	42.32	52.42
M_1 (Azospirillum)	23.39	43.29	53.35
F Test	S	S	S
SE	0.11	0.07	0.06
CD (0.05)	0.32	0.20	0.17

S - Significant

Table 4.1a. Interaction effect of levels of nitrogen, organic amendments and microbial inoculation on height of the plant at 35 DAT

Treatments	Height(cm.)		
	35 DAT		
Levels of Nitrogen	Organic amendments		
	O_0	O_1	O_2
N_0	19.38	21.45	22.00
N_1	20.78	22.28	23.00
N_2	21.43	22.52	23.52
N_3	21.78	23.00	23.33
N_4	22.43	22.98	23.97
N_5	23.47	23.80	24.32
N_6	24.43	25.52	24.28
F Test	S	S	S
SE	0.37	0.37	0.37
CD (0.05)	1.04	1.04	1.04

S- Significant

Table 4.1b. Interaction effect of nitrogen, organic amendment and microbial inoculation on height of the plant at 70 DAT and at Harvest

Treatments	Height (cm) 70 DAT					Height (cm) Harvest				
	nitrogen X organic amendment (N X O)			nitrogen X microbial inoculation (N X M)		nitrogen X organic amendment (N X O)			nitrogen X microbial inoculation (N X M)	
Levels of nitrogen	organic amendment			microbial inoculation		organic amendment			microbial inoculation	
	O_0	O_1	O_2	M_0	M_1	O_0	O_1	O_2	M_0	M_0
N_0	39.52	41.73	41.83	40.26	41.80	40.26	51.77	52.17	50.88	51.67
N_1	41.27	4237	43.27	41.44	43.16	51.53	52.65	53.35	51.99	53.03
N_2	41.70	43.17	43.47	42.04	43.51	52.13	53.47	53.42	52.49	53.52
N_3	42.07	43.0	43.57	42.24	43.51	52.18	53.28	54.37	52.61	53.99
N_4	42.57	43.27	44.07	43.12	43.48	53.28	53.13	53.58	53.01	53.66
N_5	43.13	43.90	43.95	43.24	43.94	52.88	53.50	53.75	52.80	53.96
N_6	43.30	43.80	44.18	43.91	43.61	53.37	52.65	54.22	53.13	53.96
F Test	s	s	s	s	s	s	s	s	ns	ns
SE	0.23	0.23	0.23	0.19	0.19	0.19	0.19	0.19	-	-
CD (.05)	0.65	0.65	0.65	0.53	0.53	0.54	0.54	0.54	-	-

Treatments	Height (cm) 70 DAT organic amendment X microbial inoculation(O X M)		Height (cm) Harvest organic amendment X microbial inoculation(O X M)	
organic amendments	microbial inoculation		microbial inoculation	
	M_0	M_1	M_0	M_1
O_0	41.58	42.29	51.89	52.47
O_1	42.07	43.94	51.91	53.93
O_2	43.32	43.63	53.45	53.65
F Test	S	S	S	S
SE	0.12	0.12	0.10	0.10
CD (0.05)	0.35	0.35	0.29	0.29

S- Significant

Poultry manure recorded significantly higher plant height compared to vermicompost applied plants. Control plants recorded lowest plant height at all the stages of plant growth. The heights recorded by poultry manure at the respective three stages were 23.50 cm, 43.48 cm and 53.55 cm. Corresponding values for vermicompost were 23.08 cm , 43.00 cm and 52.92 cm and that for the control were 21.96 cm, 41.94 cm and 52.18 cm respectively.

Azospirillum inoculation significantly increased the plant height at all the growth stages. By Azospirillum inoculation the corresponding heights recorded at the 3 stages were 23.39 cm, 43.29 cm and 53.35 cm respectively. These heights were 3.61, 2.29 and 1.77 percent more than the respective heights recorded by control plants.

The interaction between nitrogen and organic amendment was significant at all growth stages. At 35 DAT N_6O_1 recorded the maximum plant height of 25.52 cm which was significantly superior to all other treatment combinations (Table 4.1a). At 70 DAT, N_6O_2 recorded a height of 44.18 cm which was on par with N_4O_2 (44.07 cm), N_5O_2(44.00 cm), N_6O_1 (43.80cm), N_5O_1 (43.90) and N_3O_2 (43.57). N_3O_2 recorded maximum and significant height of 54.37 cm at harvest (Table 4.1 b).

Interaction between nitrogen levels and microbial inoculation had a significant influence on plant height at 70 DAT. N_5M_1 recorded a height of

43.94 cm which was significantly superior to N_0M_1 (41.80 cm) and N_1M_1 (43.16) and was on par with all other treatment combinations. During the initial and harvest stage the influence was not significant (Table 4.1b).

Interaction between organic amendment and microbial inoculation influenced plant height significantly at 70 DAT and at harvest. O_1M_1 recorded maximum plant height of 43.94 cm at 70 DAT. The height recorded by the corresponding treatment at harvest was 53.93 cm which was on par with O_2M_1 (53.65 cm). Both these treatments recorded significantly higher plant height than other treatment combinations (Table 4.1b).

4.1.2. Number of branches per plant

The data on number of branches per plant is presented in Table 4.2. At all stages nitrogen had a significant effect on number of branches per plant. Number of branches recorded at N_5 and N_6 levels were significantly higher than all other levels of nitrogen at all growth stages. The number of branches recorded at N_6 level at the respective three stages were 17.39, 37.22 and 53.00, which were on par with N_5 level.

Table 4.2 Effect of nitrogen, organic amendment and microbial inoculation on branches plant^{-1}

Treatments	Number of branches plant^{-1}		
	35 DAT	70 DAT	Harvest
Levels of Nitrogen			
N_0	13.67	33.72	49.06
N_1	14.17	34.22	52.39
N_2	14.61	35.28	49.89
N_3	16.50	36.11	51.44
N_4	16.39	36.33	51.72
N_5	17.00	37.06	52.67
N_6	17.39	37.22	53.00
F Test	s	s	s
SE	0.23	0.20	0.17
CD (0.05)	0.65	0.57	0.47
Organic Amendment			
O_0 (Control)	14.55	34.79	50.02
O_1 (Vermicompost)	15.98	36.12	51.60
O_2 (Poultrymanure)	16.50	36.21	52.74
F Test	S	S	S
SE	0.15	0.13	0.11
CD (0.05)	0.43	0.37	0.31
Microbial Inoculation			
M_0 (Control)	15.32	35.32	50.78
M_1 (Azospirillum)	16.03	36.10	52.13
F Test	S	S	S
SE	0.12	0.11	0.09
CD (0.05)	0.35	0.30	0.25

S- Significant

Table 4.2a. Interaction effect of levels of nitrogen,organic amendments and microbial inoculation on number of branches plant^{-1} at 70 DAT and at harvest

Treatments	Number of branches per plant 70 DAT					Number of branches per plant Harvest				
	nitrogen X organic amendment (N x O)			nitrogen x microbial inoculation (N x M)		nitrogen X organic amendment (N x O)			nitrogen x microbial inoculation (N x M)	
Levels of Nitrogen	Organic amendment			Microbial inoculation		Organic amendment			Microbial inoculation	
	O_0	O_1	O_2	M_0	M_1	O_0	O_1	O_2	M_0	M_1
N_0	33.00	33.50	33.67	33.67	33.78	48.00	49.33	49.83	48.67	49.44
N_1	33.50	34.83	34.33	33.67	34.78	48.67	49.83	50.67	51.78	53.00
N_2	34.33	35.00	36.50	35.33	35.22	49.33	50.00	50.33	49.22	50.56
N_3	35.17	36.83	36.33	35.00	37.22	50.50	50.33	51.50	49.78	53.11
N_4	36.33	37.33	36.33	35.33	37.33	50.33	53.00	51.83	50.78	52.67
N_5	36.00	37.67	37.50	36.89	37.22	51.83	52.83	53.33	52.33	53.00
N_6	36.17	37.67	37.83	37.33	37.11	51.50	53.83	53.67	52.89	53.71
F Test	S	S	S	S	S	S	S	S	S	S
SE	0.35	0.35	0.35	0.28	0.28	0.29	0.29	0.29	0.24	0.24
CD (0.05)	0.98	0.98	0.98	0.80	0.80	0.82	0.82	0.82	0.67	0.67

Organic amendments also influenced the number of branches significantly at all stages. Poultry manure recorded significantly higher number of branches at 35 DAT (16.50) and at harvest (52.74). At 70 DAT both organic amendments behaved similarly.

Azospirillum inoculation registered significantly higher number of branches at all growth stages. The corresponding values recorded were 16.03, 36.10 and 52.13 at 30 DAT, 70 DAT and at harvest respectively.

Interaction between levels of nitrogen and organic amendment influenced branching significantly at 70 DAT and at harvest. Application of vermicompost along with N_4, N_5 and N_6 levels of N recorded comparable number of branches with poultry manure applied in conjunction with N_5 and N_6 levels of nitrogen. All these treatment combinations recorded significantly higher number of branches compared to other treatment combinations. At harvest N_6O_1 recorded 53.83 branches which was on par with N_5O_2 (53.33)and N_6O_2 (53.67) and significantly superior to other treatment combinations.(Table 4.2a).

Interaction between organic amendment and microbial inoculation failed to give any significant influence on number of branches whereas interaction between nitrogen and microbial inoculation differed significantly at 70 DAT and at harvest. Microbial inoculation at N_3, N_4, N_5 and N_6 levels gave comparable number of branches which were significantly superior to all the treatment combinations except N_5M_o (36.89) and N_6M_0 (37.33). At harvest N_6 level recorded a significantly higher number of branches compared to all other levels of nitrogen in the absence of Azospirillum inoculation. No of branches registered at this level of nitrogen was on par with the corresponding number of branches produced by microbial inoculation at N_3, N_4, N_5 and N_6 levels.(Table 4.2a)

4.1.3. Canopy spread

The influence of various treatments on canopy spread presented in Table 4.3 revealed that levels of nitrogen, organic amendment and microbial inoculation influenced canopy spread significantly. At all stages maximum level of nitrogen gave maximum canopy spread. At 35 DAT maximum spread obtained was 504.67 cm^2 and at 70 DAT the spread was 632.87 cm^2 and the spread at corresponding level of nitrogen at harvest was 803.64 cm^2.

Vermicompost applied plants registered maximum canopy spread of 454.50 cm^2 at 35 DAT which was significantly superior to poultry manure applied and control plants. But at later two stages both organic amendments had a similar effect on canopy spread.

Azospirillum inoculation gave significantly higher canopy spread at all stages of study. The spread recorded at 35 DAT was 455.16 cm^2 and respective canopy spreads at 70 DAT and at harvest were 572.87 cm^2 and 738.97 cm^2.

4.3. Effect of nitrogen, organic amendment and microbial inoculation on canopy spread (cm^2) at 35 DAT, 70 DAT and at harvest

Treatments	canopy spread (cm^2)		
	35 DAT	70 DAT	Harvest
Levels of Nitrogen			
N_0	343.97	446.4	601.82
N_1	354.52	464.71	628.93
N_2	375.61	496.42	654.32
N_3	450.84	567.59	740.02
N_4	454.91	585.77	751.80
N_5	496.18	611.12	793.99
N_6	504.67	632.87	803.64
F Test	S	S	S
CD (0.05)	2.71	3.85	2.77
Organic Amendment			
O_0 (Control)	375.23	485.76	645.56
O_1 (Vermicompost)	454.50	573.14	744.70
O_2 (Poultrymanure)	447.72	571.77	741.68
F Test	S	S	S
SE	1.77	2.52	1.81
CD (0.05)	5.02	7.13	5.12
Microbial Inoculation			
M_0 (Control)	396.47	514 24	682.32
M_1 (Azospirillum)	455.16	572.87	738.97
F Test	S	S	S
SE	1.45	2.06	1.48
CD (0.05)	4.10	5.82	4.18

S - Significant

Table 4.3a. Interaction effect of nitrogen, organic amendment and microbial inoculation on canopy spread at 35 DAT

Treatments	Canopy spread cm^2 nitrogen x organic amendment (N x O)			Canopy spread nitrogen x microbial inoculation (N x M)	
	organic amendments			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1
N_0	281.18	362.83	387.90	314.23	373.71
N_1	324.08	378.17	361.32	323.38	385.67
N_2	315.23	404.70	406.90	330.31	420.91
N_3	399.90	496.27	456.35	397.43	504.24
N_4	405.37	483.63	475.73	416.03	493.79
N_5	422.27	527.97	518.32	492.41	499.41
N_6	458.57	527.93	527.50	501.47	507.87
F Test	S	S	S	S	S
SE	4.69	4.69	4.69	3.83	3.83
CD (0.05)	13.28	13.28	13.26	10.84	10.84
Treatments	organic amendment x microbial inoculation (O x M)				
Organic amendments	M_0	M_1			
O_0	339.41	411.04			
O_1	429.29	479.71			
O_2	420.70	474.73			
F TEst	S	S			
SE	2.51	2.51			
CD (0.05)	7.10	7.10			

S - Significant

Table 4.3b. Interaction effect of levels of nitrogen organic amendments and microbial inoculation on canopy spread plant-1 at 70 DAT and at Harvest.

Treatments	Canopy spread (cm^2) 70 DAT					Canopy spread (cm^2) Harvest				
	nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)		nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)	
N level	O_o	O_1	O_2	M_o	M_1	O_o	O_1	O_2	M_o	M_1
N_o	346.96	481.52	510.73	436.03	456.77	513.03	640.57	651.87	590.00	613.64
N_1	431.03	481.35	481.75	422.44	506.98	593.77	658.37	634.67	587.60	670.27
N_2	434.62	526.83	527.82	447.11	545.73	587.33	692.18	683.47	609.86	698.78
N_3	520.33	604.42	578.03	518.67	616.52	667.30	772.33	780.42	695.41	784.62
N_4	536.10	614.23	606.93	536.11	635.42	694.63	780.97	779.80	703.07	800.53
N_5	551.40	644.65	637.30	607.59	614.64	728.90	829.77	823.25	791.43	796.56
N_6	579.83	658.97	659.77	631.73	634.00	733.87	738.87	838.32	798.89	808.39
F Test	s	s	s	s	s	s	s	s	s	s
SE	6.67	6.67	6.67	5.45	5.45	4.79	4.79	4.79	3.91	3.91
CD	18.87	18.87	18.87	15.41	15.41	13.55	13.55	13.55	11.06	11.06

S-Significant

Treatments	Canopy spread (cm^2) Harvest organic amendment x microbial inoculation (O x M) microbial inoculation	
Organic amendments	M_0	M_1
O_0	612.07	679.05
O_1	719.12	770.28
O_2	715.78	767.58
f test	s	s
SE	2.56	2.56
CD (0.05))	7.24	7.24

S - Significant

Nitrogen and organic amendment interaction recorded significantly higher canopy spread at all growth stages (Table 4.3a). N_5O_1 recorded a canopy spread of 527.97cm^2 which was on par with N_5O_2 (518.32cm^2), N_6O_1 (527.93cm^2) and N_6O_2 (527.50cm^2) at 35 DAT. At 70 DAT N_6O_2 recorded a canopy spread of 659.77cm^2 which was on par with N_5O_1 (644.65cm^2) and N_6O_1 (658.97cm^2) and significantly superior to all other treatment combinations. At harvest N_6O_2 and N_5O_1 registered comparable but significant canopy spread (Table 4.3b).

Interaction between nitrogen and microbial inoculation was significant at all the growth stages. N_6M_1 recorded a canopy spread of 507.87 cm^2, which was on par with N_3M_1 (504.24 cm^2), N_5M_1 (499.41 cm^2) and N_6M_o (501.47 cm^2) and was significantly superior to all other treatment combinations at 35 DAT (Table 4.3a). At 70 DAT N_4M_1 recorded a canopy spread of 635.42 cm^2 which was on par with N_6M_o (631.73 cm^2) and N_6M_1 (634.00 cm^2) and significantly superior to all others. At harvest N_6M_1 recorded superior canopy spread of 808.39 cm^2 which was significantly superior to all treatment combinations except N_4M_1 (800.53 cm^2) N_6M_o (798.89 cm^2),N_5M_1 (796.56 cm^2) and N_5M_0 (791.43 cm^2)(Table 4.3b).

Interaction between organic amendment and microbial inoculation was significant at initial and harvest stages. O_1M_1 recorded the highest canopy spread of 479.71 cm^2, which was on par with O_2M_1 (474.73 cm^2) and was significantly superior to the other treatment combinations (Table 4.3a). At harvest

O_1M_1 (770.28 cm^2) and O_2M_1 (767.58 cm^2) recorded significantly superior canopy spread than other treatments. But they themselves were on par.(Table4.3b).

4.1.4. Dry matter production (DMP)

DMP recorded at all growth stages were subjected to statistical analysis and the result is presented in Table 4.4. Dry matter production was significantly influenced by levels of nitrogen, organic amendment and Azospirillum inoculation. The data showed that N_6 recorded 3.07g of dry matter at 35 DAT, 58.88g at 70 DAT and 338.44g at harvest. DMP recorded at this level of N was significantly superior to those recorded at all other levels.

Organic amendment registered significantly higher DMP. Poultry manure applied plants produced maximum and significant dry matter compared to vermicompost applied plants. At 35 DAT the DMP by poultry manure addition was 2.58g while at 70 DAT it was 48.41g and at harvest the DMP was 262.33g. The corresponding DMP by vermicompost were 2.47g, 45.69g and 238.05g.

Azospirillum inoculation registered significantly higher DMP. At 35 DAT Azospirillum inoculation recorded a DMP of 2.50g and at 70 DAT the corresponding DMP was 47.50g and at harvest it was 259.83g.

4.4. Effect of nitrogen, organic amendments and microbial inoculation on dry matter production

Treatments	DMP (g plant^{-1})		
	35 DAT	70 DAT	Harvest
Levels of Nitrogen			
N_0	2.09	22.47	129.19
N_1	2.23	33.49	155.87
N_2	2.26	38.64	182.51
N_3	2.33	44.46	229.70
N_4	2.61	50.08	265.10
N_5	2.80	53.84	307.28
N_6	3.07	58.88	338.44
F Test	S	S	S
SE	-	0.21	0.28
CD (0.05)	0.01	0.63	0.81
Organic Amendment			
O_0 (Control)	2.40	39.21	188.80
O_1(Vermicompost)	2.47	45.69	238.05
O_2 (Poultrymanure)	2.58	48.41	262.33
F Test	S	S	S
SE	-	0.19	0.35
CD (0.05)	0.01	0.57	0.98
Microbial Inoculation			
M_0 (Control)	2.47	40.45	199.60
M_1 (Azospirillum)	2.50	47.50	259.83
F Test	S	S	S
SE	-	0.20	0.36
CD (0.05)	0.01	0.59	0.99

S - Significant

Table 4.4a. Interaction effect of nitrogen, organic amendments and microbial inoculation on dry matter production at 35 DAT

	DMP(g $plant^{-1}$)				
Treatments	nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)	
N levels	organic amendment			microbial inoculation	
	O_o	O_1	O_2	M_o	M_1
N_0	2.02	2.03	2.24	2.09	2.10
N_1	2.20	2.21	2.26	2.21	2.25
N_2	2.19	2.25	2.34	2.23	2.29
N_3	2.31	2.32	2.34	2.32	2.33
N4	2.51	2.59	2.73	2.59	2.63
N_5	2.66	2.82	2.92	2.79	2.81
N_6	2.95	3.03	3.23	3.06	3.08
F Test	S	S	S	S	S
SE	0.001	0.001	0.001	0.001	0.001
CD(0.05)	0.01	0.01	0.01	0.01	0.01
Organic amendments	Organic amendment x microbial inoculation (O x M)				
	Microbial inoculation				
	M_0	M_1			
O_0	2.39	2.42			
O_1	2.46	2.48			
O_2	2.56	2.60			
F Test	S	S			
SE	0.001	0.001			
CD (0.05)	0.01	0.01			

S - Significant

4.4b. Interaction effect of levels of nitrogen,organic amendments microbial inoculation on dry matter production at 70 DAT and harvest

	DMP (g plant^{-1})									
Treatment	70 DAT					Harvest				
	nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)		nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)	
N levels	Organic amendment			microbial inoculation		Organic amendment			microbial inoculation	
	O_o	O_1	O_2	M_o	M_1	O_o	O_1	O_2	M_o	M_1
N_o	25.03	29.25	31.12	26.36	30.58	110.67	134.79	142.18	114.08	144.30
N_1	28.53	34.50	37.35	30.38	36.60	130.86	161.82	174.98	135.76	175.98
N_2	32.38	40.10	43.45	34.53	42.75	151.03	189.47	207.04	157.40	207.62
N_3	36.25	46.60	50.53	39.35	49.57	192.78	235.70	260.64	199.59	259.81
N_4	40.84	53.44	55.95	45.06	55.09	214.10	274.80	306.40	230.00	300.21
N_5	54.23	57.36	59.57	50.73	56.95	251.56	317.16	353.12	267.11	347.39
N_6	57.22	58.50	60.94	56.77	60.99	270.70	352.76	391.97	293.33	383.55
F Test	s	s	s	s	s	s	s	s	s	s
SE	0.38	0.38	0.38	0.41	0.41	0.52	0.52	0.52	0.49	0.49
CD (0.05)	1.04	1.04	1.04	1.21	1.21	1.53	1.53	1.53	1.37	1.37

Treatments	organic amendment x microbial inoculation (O x M)		organic amendment x microbial inoculation (O x M)	
Organic amendment	microbial inocualtion		microbial inoculation	
	M_o	M_1	M_o	M_1
O_o	35.1	43.32	153.70	223.90
O_1	42.5	48.80	208.01	268.04
O_2	44.6	52.22	237.30	287.36
F Test	S	S	S	S
SE	0.23	0.23	0.46	0.46
CD (0.05)	0.64	0.64	1.27	1.27

S - Significant

Interaction between nitrogen and organic amendment was significant at all growth stages. N_6O_2 recorded maximum and significant dry matter at 35 DAT (3.23g),at 70 DAT (60.94g) and at harvest (391.97g). This treatment has registered maximum dry matter at all growth stages (Table 4.4a & b).

Interaction between nitrogen and microbial inoculation was significant. N_6M_1 recorded maximum DMP at all growth stages. DMP realised in this treatment were 3.08g at 35 DAT, 60.99g at 70 DAT and 383.55g at harvest. Interaction between organic amendment and microbial inoculation was significant at all stages of growth. O_2M_1 recorded maximum, 2.60g at 35 DAT, 52.22g at 70 DAT and 287.36 g at harvest (Table 4.4a & b).

4.1.5. Relative Growth Rate (RGR)

Effect of nitrogen, Organic amendment and microbial inoculation on RGR is presented on Table 4.5. RGR was significantly influenced by nitrogen, Organic amendment and Azospirillum inoculation. At initial stage N_5 level recorded maximum RGR of 84.47 mg g^{-1} day^{-1} and it was significantly superior to all other levels. At final stage N_6 level recorded the maximum RGR of 49.97 mg g^{-1} day^{-1}.

Organic amendment also influenced the RGR significantly. Poultry manure recorded maximum RGR at both stages. At initial stage RGR recorded was 83.77 mg g^{-1} day^{-1} and at final stage it was 48.28 mg g^{-1} day^{-1}.

Table 4.5. Effect of nitrogen,organic amendments and microbial inoculation on RGR (mg g^{-1} day^{-1})

Treatments	RGR (mg g^{-1} day^{-1})	
Level of nitrogen	Initial stage	Final stage
N_0	74.65	43.21
N_1	77.40	43.94
N_2	81.11	44.36
N_3	84.25	46.92
N_4	84.41	47.61
N_5	84.47	49.76
N_6	84.40	49.97
F Test	S	S
SE	0.09	0.02
CD (0.05)	0.27	0.06
Organic amendment		
O_o (Control)	79.81	44.91
O_1 (Vermicompost)	83.36	47.16
O_2 (Poultrymanure)	83.77	48.28
F Test	S	S
SE	0.07	0.02
CD (0.05)	0.21	0.05
Microbial inoculation		
M_0 (Control)	79.88	45.61
M_1 (Azospirillum)	84.13	48.55
F Test	S	S
SE	0.08	0.02
CD (0.05)	0.22	0.04

S - Significant

Table 4.5a. Interaction effect of levels of nitrogen, organic amendments and microbial inoculation on RGR at initial stage and final stage

	RGR mg g^{-1} day^{-1}									
Treatments	Initial stage					Final stage				
	nitrogen x organic amendments (N x O)			nitrogen x microbial inoculation (N x M)		nitrogen x organic amendments (N x O)			nitrogen x microbial inoculation (N x M)	
	Organic amendment			microbial inoculation		Organic amendment			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1	O_0	O_1	O_2	M_0	M_1
N_0	71.91	76.22	75.18	72.42	76.53	42.46	43.65	43.40	41.86	44.33
N_1	73.21	78.51	80.14	74.88	79.69	43.52	44.08	44.12	42.77	44.87
N_2	76.96	82.29	83.47	78.28	83.62	43.99	44.37	44.61	43.34	45.15
N_3	78.66	85.72	87.78	80.88	87.36	47.75	46.31	46.85	46.39	47.33
N_4	79.69	86.48	86.29	81.61	86.91	47.34	46.79	48.58	46.57	48.44
N_5	84.14	85.07	85.16	82.76	85.97	43.84	48.86	50.85	47.46	51.66
N_6	84.72	84.58	83.93	83.45	85.31	44.40	51.34	53.18	46.92	52.36
F Test	s	s	s	s	s	s	s	s	s	s
SE	0.15	0.15	0.15	0.12	0.12	0.04	0.04	0.04	0.03	0.03
CD (0.05)	0.39	0.39	0.39	0.32	0.32	0.09	0.09	0.09	0.07	0.07

Treatments	Initial stage		Final stage	
	Organic amendment x microbial inoculation (O x M)		Organic amendment x microbial inoculation (O x M)	
Organic amendments	microbial inoculation		microbial inoculation	
	M_0	M_1	M_0	M_1
O_0	76.77	82.42	42.19	46.93
O_1	81.41	85.13	45.37	48.67
O_2	81.65	85.71	47.76	48.72
F Test	S	S	S	S
SE	0.08	0.08	0.01	0.01
CD (0.05)	0.22	0.22	0.02	0.02

S - Significant

Azospirillum inoculation also registered higher RGR than non inoculated plants. At initial stage Azospirillum inoculation recorded 84.13 mg g^{-1} day^{-1} and at final stage it was 48.55 mg g^{-1} day^{-1}.

Interaction between nitrogen and organic amendment was significant at both stages. N_3O_2 recorded maximum RGR (87.78 mg g^{-1} day^{-1}.) at initial stage and at final stage N_6O_2 recorded maximum RGR (53.18 mg g^{-1} day^{-1}) (Table 4.5a).

Interaction between nitrogen and microbial inoculation was also significant. N_3M_1 recorded an RGR of 83.36 mg g^{-1} day^{-1} at initial stage and significantly superior to all other treatment combinations. At final stage N_6M_1 registered maximum and significant RGR of 52.36 mg g^{-1} day^{-1}.

Interaction between organic amendment and microbial inoculation was significant at both stages. M_1O_2 recorded 85.71 mg g^{-1} day^{-1} at initial stage and 48.72 mg g^{-1} day^{-1} at final stage. At both stages RGR recorded at M_1O_2 was significantly superior to all other combinations(Table 4.5a).

4.2. Yield and yield attributes

4.2.1. Time of 50 percent flowering

The data on the influence of various treatments on 50 percent flowering are presented on Table 4.6.

The levels of nitrogen, organic amendments and microbial inoculation had profound influence on 50 percent flowering. N_3 recorded minimum number of days for 50 percent flowering (37.83 days) and was significantly superior to all other levels of nitrogen.

Organic amendments also influenced this character significantly. Significant variations were noticed among O_o ,O_1 and O_2. Poultry manure was the most superior (40.57 days) followed by Vermicompost (41.14 days) and control (41.48 days).

Influence of Azosprillum on flowering was significant. Azospirillum inoculation decreased the days to flower significanly. Inoculated plants flowered in 40.73 days. Interaction between nitrogen and organic amendments and interaction between nitrogen and microbial inoculation were significant. N_3O_2 was the superior most (35.17 days) followed by N_4O_1 (37.17days).Interaction between nitrogen and microbial inoculation, N_3M_1 recorded the early flowering compared to all other treatments(37.22 days).

The interaction effect between organic amendment and Azospirillum inoculation was not significant (Table 4.6a) .

Table 4.6. Effect of nitrogen, organic amendment and microbial inoculation on time of 50 percent flowering and number of flowers plant^{-1}

Treatment	Time of 50 percent flowering	Number of flowers plant^{-1}
Levels of Nitrogen		
N_0	42.17	81.28
N_1	41.33	90.94
N_2	40.22	100.11
N_3	37.83	106.67
N_4	38.50	110.78
N_5	42.11	115.11
N_6	45.28	117.06
F Test	s	s
SE	0.17	0.22
CD (0.05)	0.47	0.62
Organic Amendment		
O_0 (control)	41.48	92.40
O_1 (vermicompost)	41.14	100.76
O_2 (poultry manure)	40.57	116.24
F Test	S	S
SE	0.11	0.14
CD (0.05)	0.31	0.14
Microbial Inoculation		
M_0 (control)	41.40	99.98
M_1 (Azospirillum)	40.73	106.29
F Test	S	S
SE	0.09	0.12
CD (0.05)	0.25	0.33

S - Significant

Table 4.6a. Interaction of nitrogen,organic amendment and microbial inoculation on time of 50 percent flowering

Time of 50 percent flowering					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation(N x M)	
N levels	organic amendment			microbial inoculation	
	O_0	O_1	O_2	M_0	M_1
N_0	43.50	42.33	40.67	42.56	41.78
N_1	42.67	41.83	39.50	41.89	40.78
N_2	41.33	40.67	38.67	41.00	39.44
N_3	39.83	38.50	35.17	38.44	37.22
N_4	38.17	37.17	40.17	38.67	38.33
N_5	41.10	42.17	43.17	42.00	42.22
N_6	43.83	45.33	46.67	45.20	45.33
F Test	S	S	S	S	S
SE	0.29	0.29	0.29	0.23	0.23
CD (0.05)	0.81	0.29	0.29	0.66	0.66

S - Significant

Table 4.6b. Interaction effect of nitrogen,organic amendment and microbial inoculation on number of flowers plant^{-1}

Number of flowers plant^{-1}					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
N levels	organic amendment			microbial inoculation	
	O_0	O_1	O_2	M_0	M_1
N_0	75.33	79.50	89.00	80.00	82.56
N_1	81.50	88.83	102.50	88.00	93.89
N_2	88.17	99.00	113.17	96.11	104.11
N_3	95.67	102.67	121.67	103.33	110.00
N_4	99.17	107.17	126.00	107.33	114.22
N_5	102.0	113.00	130.00	111.78	118.44
N_6	104.67	115.17	131.33	113.33	120.78
F Test	S	S	S	S	S
SE	0.38	0.38	0.38	0.31	0.31
CD (0.05)	1.07	1.07	1.07	0.88	0.88
Treatments	organic amendment X microbial inoculation(O X M)				
organic amendment	microbial inoculation				
	M_0	M_1			
O_0	90.29	94.52			
O_1	95.90	105.62			
O_2	113.76	118.71			
F Test	S	S			
SE	0.20	0.20			
CD (0.05)	0.57	0.57			

S - Significant

4.2.2. Number of flowers per plant

The mean number of flowers recorded per plant are shown in Table 4.6.

The total number of flowers produced per plant was significantly influenced by the different levels of nitrogen. The maximum flower production of 117.06 per plant was obtained with N_6. N_o recorded(81.28) the lowest number of flowers which was significantly inferior to all the other levels of nitrogen.

Application of poultry manure recorded significantly higher number of flowers(116.24) than vermicompost(100.76) treated plants. Control plants recorded the lowest number of flowers per plant(92.4).

Azospirillum inoculation significantly increased the flower production(106.29). Control plants registered 99.98 number of flowers.

The interaction between nitrogen and organic amendment had significant effect on number of flowers plant^{-1}. N_6O_2 recorded the highest number of flowers plant^{-1} (131.33) followed by N_5O_2 (130.00). N_oO_o recorded the lowest number of flowers(75.33).

Interaction effect of nitrogen and microbial inoculation on number of flowers was significant. N_6M_1 recorded the maximum number of flowers per plant(120.78).

The interaction between organic amendment and microbial inoculation also had significant influence on number of flowers plant^{-1}. O_2M_1 recorded the maximum number of flowers per plant (118.71) (Table 4.6b).

4.2.3. Setting percentage of fruits

The influence of various treatments on setting percent are given in Table 4.7.

Levels of nitrogen, application of organic amendments and microbial inoculation had significant influence on setting percentage. Setting percentage was significantly higher in N_6 (52.72). N_o recorded the lowest setting percentage (25.40).

Poultry manure applied plants recorded significantly higher setting percentage (43.75)compared to vermicompost treated plants (37.90).

Azospirillum inoculated plants recorded higher setting percentage (39.87) than control (37.07).

The interaction between nitrogen and organic amendment was significant. N_6O_2 recorded the highest(55.99) and N_oO_o recorded the lowest setting percentage (22.25).

Table 4.7. Effect of nitrogen,organic amendment and microbial inoculation on number of fruits plant^{-1} and setting percent

Treatments	Number of fruits plant^{-1}	setting percent
Levels of Nitrogen		
N_0	20.89	25.40
N_1	25.89	27.96
N_2	30.55	30.95
N_3	38.64	37.47
N_4	47.31	45.47
N_5	53.79	49.34
N_6	58.13	52.72
F Test	S	S
SE	0.21	0.11
CD (0.05)	0.58	0.30
Organic Amendment		
O_o(control)	32.02	33.76
O_1(vermicompost)	39.21	37.90
O_2(poultry manure)	50.31	43.75
F Test	S	S
SE	0.13	0.07
CD (0.05)	0.38	0.20
Microbial Inoculation		
M_0(control)	38.54	37.07
M_1(Azospirillum)	43.38	39.87
F Test	S	S
SE	0.11	0.06
CD (0.05)	0.31	0.16

S - Significant

Table 4.7a. Interaction effect of nitrogen,organic amendement and microbial inoculation on setting percent

Setting percent					
Treatment	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
N levels	organic amendment			microbial inoculation	
	O_0	O_1	O_2	M_0	M_1
N_0	22.25	25.18	28.77	24.80	25.99
N_1	22.55	27.65	33.67	26.30	29.61
N_2	26.59	28.59	37.67	29.91	31.99
N_3	30.18	35.23	47.00	35.45	39.49
N_4	39.51	46.68	50.21	43.20	47.74
N_5	46.24	48.81	52.96	78.21	50.46
N_6	49.00	53.17	55.99	51.59	53.84
F Test	s	s	s	s	s
SE	0.18	0.18	0.18	0.15	0.15
CD (0.05)	0.52	0.52	0.52	0.42	0.42
organic amendment	organic amendment X microbial inoculation(O X M)				
	microbial inoculation				
	M_0	M_1			
O_0	31.84	35.68			
O_1	36.70	39.10			
O_2	42.66	44.84			
F Test	s	s			
SE	0.10	0.10			
CD (0.05)	0.28	0.28			

S - Significant

Table 4.7b. Interaction effect of nitrogen,organic amendment and microbial inoculation on number of fruits plant^{-1}

Number of fruits plant^{-1}					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1
N_0	17.00	20.17	25.50	20.44	21.33
N_1	18.67	24.33	34.67	23.67	25.11
N_2	23.50	28.33	42.50	29.11	33.78
N_3	29.50	28.33	42.50	29.11	33.78
N_4	38.50	49.67	63.50	46.67	54.40
N_5	46.00	55.17	69.33	54.44	59.20
N_6	51.00	60.33	73.17	58.11	64.89
F Test	S	S	S	S	S
SE	0.36	0.36	0.36	0.29	0.29
CD (0.05)	1.01	1.01	1.01	0.82	0.82
organic amendment	organic amendment X microbial inoculation(O X M)				
	microbial inoculation				
	M_0	M_1			
O_0	29.57	34.48			
O_1	35.95	42.48			
O_2	50.10	54.24			
F Test	S	S			
SE	0.19	0.19			
CD (0.05)	0.54	0.54			

S - Significant

Interaction between nitrogen and microbial inoculation was significant and N_6M_1 recorded maximum setting percentage (53.84). The combination N_oM_o recorded the minimum setting percentage (24.80).

Interaction between organic amendment and microbial inoculation had significant influence on setting percentage. O_2M_1 was superior most(44.84) followed by O_1M_1 (39.10).

4.2.4. Fruits Per Plant

The mean number of fruits recorded per plant is shown in Table 4.7.

There was significant increase in the total number of fruits produced per plant due to different levels of nitrogen. Maximum number of fruits per plant (58.13) was recorded at the highest dose of nitrogen (N_6) and this was significantly superior to the other six levels. Minimum number of fruits per plant (20.89) was recorded by N_o.

Effect due to organic amendment was also significant. O_o, O_1 and O_2 showed significant variations.Poultry manure applied plants recorded the highest number of fruits per plant (50.31) and control recorded the lowest (32.02).

Fruit production was significantly influenced by Azospirillum inoculation (43.38) than control(38.54).

Interactions between nitrogen and organic amendment (N x O), nitrogen and microbial inoculation (N x M) and organic amendment and microbial inoculation (O x M) were significant. N_6O_2 was the superior (73.17) and N_oO_o was the most inferior (17.00).

In nitrogen and microbial inoculation interaction, N_6M_1 recorded the highest number of fruits per plant (64.89) and N_oM_o recorded the lowest (20.44).

In organic amendment and microbial inoculation interaction, O_2M_1 recorded the maximum number of fruits per plant (54.24) and O_oM_o recorded the minimum number of fruits per plant (29.57) (Table 4.7b).

4.2.5. Length of fruit

The data on mean length of fruits are presented in Table 4.8.

The influence of various treatments on length of fruit presented in Table 4.8 revealed that levels of nitrogen, organic amendments and microbial inoculation influenced the length of fruit significantly. N_6(8.15cm) was superior to all other levels of nitrogen. N_o recorded the lowest fruit length(7.16cm).

Poultry manure treated plants recorded the highest fruit length (8.31cm). Vermicompost treated plants recorded 7.67cm fruit length and fruit length recorded by control was 7.23cm. Azospirilum inoculation registered significantly higher fruit length (7.88cm). Non inoculated plants registered 7.60cm fruit length.

Interaction between nitrogen and organic amendment recorded significantly higher fruit length. N_6O_2 recorded the highest fruit length (8.90cm) and N_oO_o recorded the lowest length of fruit(6.88cm).

The interaction effect between nitrogen and microbial inoculation, N_6M_1 registered maximum length of fruit (8.36cm) and N_oM_o recorded the minimum(7.09cm).

Interaction between organic amendment and microbial inoculation was significant and O_2M_1 recorded the maximum fruit length (8.39cm)(Table 4.8a).

Table 4.8. Effect of nitrogen,organic amendment and microbial inoculation on girth of fruit and length of fruits

Treatments	Girth of fruit (cm)	Length of fruit (cm)
Levels of Nitrogen		
N_0	4.77	7.16
N_1	5.03	7.43
N_2	5.21	7.83
N_3	5.40	7.54
N_4	5.62	8.02
N_5	5.81	8.01
N_6	5.87	8.15
F Test	s	s
SE	0.01	0.01
CD (0.05)	0.04	0.04
Organic Amendment		
O_o(control)	4.95	7.23
O_1(vermicompost)	5.34	7.67
O_2(poultry manure)	5.87	8.31
F Test	S	S
SE	0.001	0.001
CD (0.05)	0.02	0.02
Microbial Inoculation		
M_0(control)	5.27	7.60
M_1(Azospiri)	5.51	7.88
F Test	s	s
SE	0.01	0.01
CD (0.05)	0.02	0.02

S - Significant

Table 4.8a. Interaction effect of nitrogen,organic amendment and microbial inoculation on length of fruits

Length of fruits(cm)					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_o	O_1	O_2	M_o	M_1
N_o	6.88	7.00	7.60	7.09	7.23
N_1	6.97	7.33	8.00	7.28	7.59
N_2	7.30	7.95	8.25	7.69	7.98
N_3	7.18	7.47	7.97	7.47	7.61
N_4	7.50	7.97	8.60	7.88	8.17
N_5	7.33	7.88	8.83	7.83	8.19
N_6	7.43	8.12	8.90	7.94	8.36
F Test	S	S	S	s	S
SE	0.02	0.02	0.02	0.002	0.02
CD (0.05)	0.06	0.06	0.06	0.05	0.05
organic amendment	organic amendment X microbial inoculation(O X M)				
	microbial inoculation				
	M_o	M_1			
O_o	7.10	7.36			
O_1	7.47	7.88			
O_2	8.23	8.39			
F Test	S	S			
SE	0.01	0.01			
CD (0.05)	0.03	0.03			

S - Significant

Table 4.8b. Interaction effect of nitrogen, organic amendment and microbial inoculation on girth of fruit

Girth of fruit(cm)					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1
N_0	4.50	4.78	5.03	4.70	4.84
N_1	4.63	4.87	5.60	4.92	5.14
N_2	4.75	5.12	5.77	5.09	5.33
N_3	4.90	5.35	5.95	5.26	5.54
N_4	5.32	5.85	6.27	5.69	5.93
N_5	5.32	5.85	6.27	5.69	5.93
N_6	5.42	5.83	6.35	5.73	6.00
F Test	S	S	S	S	S
SE	0.02	0.02	0.02	0.02	0.02
CD (0.05)	0.06	0.06	0.06	0.05	0.05
organic amendment	organic amendment X microbial inoculation (O X M)				
	microbial inoculation				
	M_0	M_1			
O_0	4.88	5.03			
O_1	5.13	5.55			
O_2	5.79	5.95			
F Test	S	S			
SE	0.01	0.01			
CD (0.05)	0.03	0.03			

S - Significant

4.2.6. Girth of fruit

The influence of various treatment on girth of fruit is presented in Table 4.8.

N_6 recorded highest girth of fruit (5.87cm) followed by N_5 (5.81cm), N_4 5.62cm), N_3(5.40cm), N_2(5.21cm), N_1(5.03cm) and control recorded lowest girth of 4.77cm.

Poultry manure applied plants (O_2) showed highest girth of fruit (5.87cm) than vermicompost treated plants (5.34cm) and control (4.95cm).

Azospirillum inoculation (5.51cm) was superior over control (5.27cm).

Interaction between nitrogen and organic amendment had significant influence on girth of fruit. N_6O_2 recorded the highest value (6.35cm) and N_oO_o showed the lowest fruit girth (4.50cm).

Among the interaction between nitrogen and microbial inoculation, N_6M_1 recorded the maximum value (6.00cm) and N_oM_o the minimum value (4.70cm) for fruit girth.

O_2M_1 recorded significantly higher girth of fruit (5.95cm) than O_1M_1 (5.55cm) in the interaction between organic amendment and microbial inoculation.

4.2.7. Fruit yield per plant

The data presented in Table 4.9. revealed that yield per plant is significantly influenced by levels of nitrogen, organic amendments and Azospirillum inoculation. N_6 recorded the highest yield per plant (249.96g). N_5(230.22g), $N_4$201.08g), N_3(162.68g),N_2(126.82g),N_1(1O4.84) and N_o recorded the lowest yield per plant (83.42g).

Poultry manure applied plants recorded higher yield (207.77g) than vermicompost treated plants (159.21g). Yield recorded by control plants was 129.74g.

Azospirillum inoculation showed higher yield (175.67g) than control(155.47g)

Table 4.9. Effect of nitrogen, organic amendments and microbial inoculation on yield $plant^{-1}$

Treatments	Yield $plant^{-1}$ (g)
Levels of nitrogen	
N_0	83.42
N_1	104.84
N_2	126.82
N_3	162.68
N_4	201.08
N_5	230.22
N_6	249.96
F Test	S
SE	0.80
CD (0.05)	2.26
organic amendment	
O_0(control)	129.74
O_1(vermicompost)	159.21
O_2(poultry manure)	207.77
F Test	s
SE	0.52
CD (0.05)	1.48
M_0(control)	155.47
M_1(Azospirillum)	175.67
F Test	S
SE	0.43
CD (0.05)	1.21

S - Significant

Table 4.9a. Interaction effect of nitrogen, organic amendments and microbial inoculation on yield $plant^{-1}$

Yield $plant^{-1}$ (g)					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1
N_0	68.32	79.65	102.28	79.47	87.37
N_1	74.05	100.47	140.00	95.94	113.73
N_2	96.45	112.87	171.13	117.61	136.02
N_3	117.23	145.80	225.00	149.31	176.04
N_4	155.53	196.80	250.90	185.24	216.91
N_5	186.62	227.18	276.85	221.57	238.87
N_6	209.97	251.70	288.20	239.14	260.77
F test	S	S	S	S	S
SE	1.39	1.39	1.39	1.13	1.13
CD(0.05)	3.92	3.92	3.92	3.20	3.20
organic amendment	organic amendment X microbial inoculation (O X M)				
	microbial inoculation				
	M_0	M_1			
O_0	118.71	140.76			
O_1	148.83	169.59			
O_2	198.86	216.67			
F Test	S	S			
SE	0.74	0.74			
CD(0.05)	2.09	2.09			

S - Significant

All interactions had significant influence on yield per plant. In the interaction between nitrogen and organic amendment N_6O_2 recorded the maximum yield (288.20g), N_5O_2 (276.85g), N_6O_1(251.70g), N_4O_2 (250.90g), N_5O_1 (227.18g), N_3O_2(225.00g), N_6O_o(209.97g), N_4O_1 (196.80g), N_5O_o (186.62g), N_2O_2 (171.13g), N_4O_o (155.53g), N_3O_1(145.80g), N_1O_2 (140.00g), N_3O_o (117.23g), N_2O_1 (112.87g), N_oO_2 (102.28g), N_1O_1 (100.47g), N_2O_o (96.45g), N_oO_1 (79.65g), N_1O_o (74.05g) and N_oO_o recorded the minimum yield (68.32g). In the interaction between nitrogen and microbial inoculation N_6M_1 recorded the highest yield (260.77g), N_6M_o (239.14g), N_5M_1 (238.87g), N_5M_o (221.57g), N_4M_1 (216.91g), N_4M_o (185.24g), N_3M_1 (176.04g), N_3M_o (149.31g), N_2M_1 (136.02g), N_2M_o (117.61g), N_1M_1 (113.73g), N_1M_o (95.94g), N_oM_1 (87.37g) and N_oM_o recorded the lowest yield (79.47g). In the interaction between organic amendment and microbial inoculation O_2M_1 recorded the highest yield (216.67g), O_2M_o (198.86g), O_1M_1 (169.59g), O_1M_o (148.83g), O_oM_1 (140.76g) and O_oM_o recorded the lowest yield per plant (118.71g)(Table 4.9a).

4.2.8. Harvest Index (HI)

The data on the influence of various treatments on H.I are presented in Table 4.10.

Levels of nitrogen had profound influence on HI. N_6 and N_5 recorded the highest HI (0.57) which was on par with N_4(0.56). N_o recorded the lowest HI (0.30).

Application of poultry manure recorded significantly higher harvest index(0.60) compared to vermicompost applied plants (0.47) and control(0.42).

Azospirillum inoculation significantly influenced the HI (0.52) over no inoculation (0.48).

N xO, N x M and O x M interactions were highly significant (Table 4.10a). Among the interaction between nitrogen and organic amendment the highest value was obtained at N_5O_2 (0.68) which was on a par with N_4O_2 (0.67), N_oO_o recorded the lowest HI (0.23).

Among the interaction between nitrogen and microbial inoculation the maximum value was obtained at N_6M_1 (0.59)and N_5M_1 (0.59) which was on par with N_4M_1 (0.58).

In the interaction between organic amendment and microbial inoculation O_2M_1 recorded the highest HI (0.63) over control (0.40).

Table 4.10. Effect of nitrogen, organic amendments and microbial inoculation on harvest index

Treatments	harvest index
Levels of nitrogen	
N_0	0.30
N_1	0.44
N_2	0.50
N_3	0.55
N_4	0.56
N_5	0.57
N_6	0.57
F Test	S
SE	-
CD (0.05)	0.01
Organic amendments	
O_0(control)	0.42
O_1(vermicompost)	0.47
O_2(poultry manure)	0.60
F Test	S
SE	-
CD (0.05)	0.01
Microbial inoculation	
M_0(control)	0.48
M_1(Azospirillum)	0.52
F Test	s
SE	-
CD (0.05)	0.01

S - Significant

Table 4.10a. Interaction effect of nitogen, organic amendments and microbial inoculation on harvest index

Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1
N_0	0.23	0.27	0.39	0.28	0.31
N_1	0.33	0.40	0.58	0.41	0.46
N_2	0.43	0.46	0.60	0.48	0.51
N_3	0.48	0.51	0.66	0.53	0.57
N_4	0.49	0.53	0.67	0.54	0.58
N_5	0.49	0.54	0.68	0.55	0.59
N_6	0.50	0.55	0.65	0.54	0.59
F test	S	S	S	S	S
SE	-	-	-	-	-
CD(0.05)	0.01	0.01	0.01	0.01	0.01
	organic amendment X microbial inoculation (O X M)				
organic amendment	microbial inoculation				
	M_0	M_1			
O_0	0.40	0.44			
O_1	0.44	0.49			
O_2	0.58	0.63			
F Test	S	S			
SE	-	-			
CD(0.05)	0.01	0.01			

S - Significant

4.3. Quality aspects

4.3.1. Ascorbic acid content of fruits

Table 4.11 gives the mean value of ascorbic acid content of fruits.

The different levels of nitrogen showed significant influence on the ascorbic acid content in fresh fruits. N_6, the highest level of nitrogen recorded the highest ascorbic acid content of 99.71 mg $100g^{-1}$ of fresh weight of fruit. N_o recorded the lowest ascorbic acid content of 93.60 mg $100g^{-1}$ of $fruits^{-1}$ and was significantly inferior to all other levels.

Poultry manure treated plants recorded significantly higher ascorbic acid content (96.99 mg $100g^{-1}$ fruit) than vermicompost treated plants (95.54mg $100g^{-1}$ fruit). Ascorbic acid of control plant was 94.67mg $100g^{-1}$ fruit.

Azospirillum inoculation registered significantly higher ascorbic acid content (95.99 mg 100 g^{-1} fruit) than the control(95.49mg $100g^{-1}$ fruit).

Interaction between nitrogen and organic amendment recorded significantly higher ascorbic acid content of fruits. N_6O_2 recorded the maximum value (101.66mg $100g^{-1}$ fruit) and N_0M_o registered the minimum value (93.10 mg $100g^{-1}$ fruit).

Among the interaction between nitrogen and microbial inoculation N_6M_1 recorded the highest value (99.88 mg $100g^{-1}$ fruit) and N_oM_o recorded the lowest value (93.45mg $100g^{-1}$ fruit). Interaction between organic amendment and microbial inoculation was not significant.

Table 4.11. Effect of nitrogen, organic amendments and mircrobial inoculation on ascorbic acid content of fruit

Treatments	Ascorbic acid (mg $100g^{-1}$ fruit)
Levels of nitrogen	
N_0	93.60
N_1	93.74
N_2	94.46
N_3	95.18
N_4	95.90
N_5	97.57
N_6	99.71
F Test	S
SE	0.04
CD (0.05)	0.12
Organic amendments	
O_0(control)	94.67
O_1(vermicompost)	95.54
O_2(poultry manure)	96.99
F Test	S
SE	0.03
CD (0.05)	0.08
Microbial inoculation	
M_0(control)	95.49
M_1(Azospirillum)	95.99
F Test	S
SE	0.02
CD (0.05)	0.06

S - Significant

Table 4.11a. Interaction effect of nitrogen, organic amendments and mircrobial inoculation on ascorbic acid content of fruit(mg 100 g^{-1} fruit)

Ascorbic acid content of fruit(mg 100 g^{-1} fruit)					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_o	O_1	O_2	M_o	M_1
N_0	93.10	93.50	94.11	93.45	93.74
N_1	93.29	93.62	93.30	93.55	93.92
N_2	93.71	94.20	95.46	94.24	94.67
N_3	94.19	94.91	96.45	94.83	95.53
N_4	94.51	95.86	97.33	95.63	96.17
N_5	95.98	97.08	99.65	97.16	97.90
N_6	97.86	99.62	101.66	99.54	99.88
F test	S	S	S	S	S
SE	0.07	0.07	0.07	0.06	0.06
CD(0.05)	0.20	0.20	0.20	0.16	0.16

S - Significant

4.3.2. Chlorophyll content

The influence of various treatments on chlorophyll content is presented in Table 4.12.

At all growth stages nitrogen has influenced chlorophyll content significantly. At 70 DAT, N_6 recorded maximum chlorophyll content (0.79 mg g^{-1} of fresh leaf). At harvest chlorophyll content recorded by N_5 and N_6 were significantly superior to all other treatments (0.34 mg g^{-1} of fresh leaf). At 70 DAT and at harvest poultry manure treated plants recorded significantly higher chlorophyll content (0.67 and 0.31mg g^{-1} of fresh leaf respectively) than vermicompost treated plants (0.57 and 0.24mg g^{-1} of fresh leaf respectively) and control (0.47 and 0.19 mg g^{-1} of fresh leaf at 70 DAT and at harvest respectively) .

Azospirillum inoculation significantly increased the chlorophyll content at 70 DAT (0.59 mg g^{-1} of fresh leaf) and at harvest(0.26 mg g^{-1} of fresh leaf) than the control which registered 0.54 and 0.23 mg g^{-1} of fresh leaf at 70 DAT and harvest respectively.

Interaction between nitrogen and organic amendment was significant at 70 DAT and at harvest. At 70 DAT, N_6O_2 recorded the maximum value of 0.89 mg g^{-1} of fresh leaf which was on par with N_5O_2 (0.88 mg g^{-1} of fresh leaf) At harvest N_5O_2 recorded the highest value of 0.43 mg g^{-1} of fresh leaf.

Table 4.12. Effect of nitrogen, organic amendments and mi crobial inoculation on chlorophyll contents of leaves at harvest 70 DAT and harvest

Treatments	Chlorophyll (mg g^{-1} fresh leaf)	
N levels	70 DAT	Harvest
N_0	0.36	0.15
N_1	0.42	0.17
N_2	0.49	0.21
N_3	0.54	0.23
N_4	0.60	0.26
N_5	0.75	0.34
N_6	0.79	0.34
F Test	S	S
SE	-	-
CD(0.05)	0.01	0.01
Organic amendments		
O_0(control)	0.47	0.19
O_1(vermicompost)	0.57	0.24
O_2(poultry manure)	0.67	0.31
F Test	S	S
SE	-	-
CD(0.05)	0.01	0.01
Microbial inoculation		
M_0(control)	0.54	0.23
M_1(Azospirillum)	0.59	0.26
F Test	S	S
SE	-	-
CD(0.05)	0.01	0.01

S - Significant

Table 4.12a. Interaction effect of nitrogen, organic amendments and mircrobial inoculation on chlorophyll contents of leaves at 70 DAT

Chlorophyll(mg g^{-1} fresh leaf) at 70 DAT					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_0	O_1	O_2	M_0	M_1
N_0	0.32	0.36	0.41	0.35	0.38
N_1	0.35	0.41	0.50	0.40	0.44
N_2	0.39	0.49	0.61	0.46	0.53
N_3	0.43	0.53	0.66	0.51	0.58
N_4	0.50	0.61	0.71	0.57	0.64
N_5	0.60	0.79	0.88	0.74	0.77
N_6	0.69	0.78	0.89	0.78	0.79
F test	S	S	S	S	S
SE	-	-	-	-	-
CD(0.05)	0.01	0.01	0.01	0.01	0.01
organic amendment	organic amendment X microbial inoculation (O X M)				
	microbial inoculation				
	M_0	M_1			
O_0	0.45	0.48			
O_1	0.53	0.60			
O_2	0.65	0.68			
F Test	S	S			
SE	-	-			
CD(0.05)	0.01	0.01			

S - Significant

Table 4.12b. Interaction effect of nitrogen, organic amendments and microbial inoculation on chlorophyll contents of leaves at harvest

Chlorophyll(mg g^{-1} fresh leaf) at harvest					
Treatments	nitrogen X organic amendment (N x O)			nitrogen X microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
N levels	O_o	O_1	O_2	M_o	M_1
N_0	0.11	0.14	0.18	0.14	0.15
N_1	0.14	0.18	0.21	0.16	0.18
N_2	0.16	0.20	0.26	0.19	0.22
N_3	0.17	0.21	0.30	0.21	0.25
N_4	0.20	0.25	0.35	0.24	0.28
N_5	0.24	0.36	0.43	0.32	0.36
N_6	0.29	0.34	0.41	0.33	0.36
F test	S	S	S	S	S
SE	-	-	-	-	-
CD(0.05)	0.01	0.01	0.01	0.01	0.01
organic amendment	organic amendment X microbial inoculation (O X M)				
	microbial inoculation				
	M_o	M_1			
O_0	0.17	0.20			
O_1	0.22	0.26			
O_2	0.29	0.32			
F Test	S	S			
SE	-	-			
CD(0.05)	0.01	0.01			

S - Significant

Interaction between nitrogen and microbial inoculation was significant at both stages. At 70 DAT, N_6M_1 recorded the highest value (0.79 mg g^{-1} of fresh leaf) which was on par with N_6M_o . (0.78mg g^{-1} of fresh leaf). At harvest N_6M_1 (0.36mg g^{-1} of fresh leaf) and N_5M_1 (0.36 mg g^{-1} of fresh leaf) recorded the highest value of chlorophyll .

Among the interaction between organic amendment and microbial inoculation, O_2M_1 recorded the highest value at 70 DAT (0.68 mg g^{-1} of fresh leaf) and O_2M_1 registered the maximum value at harvest (0.32 mg g^{-1} of fresh leaf) (Table 4.12 a&b).

4.4. Nutrient uptake

4.4.1. Nitrogen uptake

The data on uptake of nitrogen by plants are presented in Table 4.13.

There was a progressive increase in the uptake of nitrogen by plants due to different nitrogen levels and the difference was significant. N_6 recorded maximum nitrogen uptake of 6.65 g $plant^{-1}$ and N_o recorded the minimum uptake of 0.27 g $plant^{-1}$.

Application of poultry manure recorded significantly higher nitrogen uptake (2.93 g $plant^{-1}$) compared to vermicompost applied plants (2.43 g $plant^{-1}$) and control (1.39 g $plant^{-1}$).

Table 4.13. Effect of nitrogen, organic amendments and microbial inoculation on N,P,K uptake

Treatments	N uptake (g $plant^{-1}$)	P_2O_5 uptake (g $plant^{-1}$)	K_2O uptake (g $plant^{-1}$)
Levels of Nitrogen			
N_0	0.27	0.21	1.24
N_1	0.37	0.22	1.27
N_2	0.70	0.23	1.33
N_3	1.31	0.25	1.40
N_4	2.36	0.27	1.49
N_5	4.09	0.28	1.57
N_6	6.65	0.29	1.67
F Test	S	S	S
SE	0.01	-	-
CD (0.05)	0.02	0.01	0.01
Organic amendments			
O_0 (Control)	1.39	0.22	0.75
O_1(Vermicompost)	2.43	0.25	2.22
O_2 (Poultrymanure)	2.93	0.29	1.31
F Test	S	S	S
SE	-	-	-
CD (0.05)	0.01	0.01	0.01
Microbial inoculation			
M_0(Control)	1.87	0.24	1.41
M_1 (Azospirillum)	2.63	0.26	1.44
F Test	s	s	s
SE	-	-	-
CD (0.05)	0.01	0.01	0.01

S - Significant

Table 4.13a. Interaction effect of nitrogen, organic amendments and microbial inoculation on nitrogen uptake

Nitrogen uptake (g plant^{-1})					
Treatments	nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)	
	organic amendment			microbial inoculation	
Levels of nitrogen	O_0	O_1	O_2	M_0	M_1
N_0	0.25	0.27	0.30	0.26	0.28
N_1	0.29	0.35	0.47	0.35	0.39
N_2	0.42	0.72	0.95	0.62	0.78
N_3	0.91	1.23	1.79	1.15	1.47
N_4	1.51	2.51	3.07	1.85	2.87
N_5	2.29	4.29	5.69	3.75	4.42
N_6	4.05	7.65	8.25	5.11	8.20
F test	S	S	S	S	S
SE	0.01	0.01	0.01	0.01	0.01
CD (0.05)	0.02	0.02	0.02	0.02	0.02
	organic amendment x microbial inoculation (O x M)				
Organic amendment	microbial inoculation				
	M_0	M_1			
O_0	1.30	1.48			
O_1	1.80	3.06			
O_2	2.47	3.35			
F Test	S	S			
SE	-	-			
CD (0.05)	0.01	0.01			

S - Significant

Table 4.13b. Interaction effect of nitrogen, organic amendments and microbial inoculation on P_2O_5 uptake

P_2O_5 uptake g plant^{-1}					
Treatments	nitrogen x organic amendment (N x O)			nitrogen x microbial inoculation (N x M)	
Levels of Nitrogen	organic amendment			microbial inoculation	
	O_0	O_1	O_2	M_0	M_1
N_0	0.17	0.21	0.25	0.20	0.22
N_1	0.18	0.22	0.26	0.21	0.23
N_2	0.19	0.23	0.27	0.22	0.24
N_3	0.22	0.25	0.29	0.24	0.26
N_4	0.24	0.27	0.31	026	0.28
N_5	0.25	0.28	0.32	0.27	0.29
N_6	0.26	0.29	0.33	0.28	0.30
F test	S	S	S	S	S
SE	-	-	-	-	-
CD (0.05)	0.01	0.01	0.01	0.01	0.01
	organic amendment x microbial inoculation (O x M)				
Organic amendment	microbial inoculation				
	M_0	M_1			
O_0	0.21	0.23			
O_1	0.24	0.25			
O_2	0.28	0.31			
F Test	S	S			
SE	-	-			
CD (0.05)	0.01	0.01			

S - Significant

Table 4.13c. Interaction effect of nitrogen,organic amendments and microbial inoculation on K_2O uptake

K_2O uptake g plant^{-1}			
Treatments	nitrogen x organic amendment (N x O)		
	organic amendment		
Levels of nitrogen	O_0	O_1	O_2
N_0	0.59	1.94	1.19
N_1	0.63	1.98	1.22
N_2	0.66	2.07	1.23
N_3	0.70	2.22	1.21
N_4	0.80	2.40	1.35
N_5	0.89	2.47	1.43
N_6	0.99	2.49	1.46
F test	S	S	S
SE	-	-	-
CD (0.05)	0.01	0.01	0.01

S - Significant

Azospirillum inoculation significantly increased the nitrogen uptake (2.63 g $plant^{-1}$) over the control (1.87 g $plant^{-1}$).

The Interaction between nitrogen and organic amendment was significant and the treatment combination N_6O_2 recorded the highest uptake of nitrogen (8.25 g $plant^{-1}$). Lowest uptake was recorded by N_oO_o (0.25 g $plant^{-1}$).

Interaction between nitrogen and microbial inoculation was significant and N_6M_1 recorded the highest nitrogen uptake of 8.20 g $plant^{-1}$ and N_0M_0 (0.26 g $plant^{-1}$) recorded the lowest nitrogen uptake.

Interaction between organic amendment and microbial inoculation was significant and O_2M_1 recorded the maximum nitrogen uptake of 3.35 g $plant^{-1}$. Lowest uptake was recorded by O_0M_0 (1.30 g $plant^{-1}$).

4.4.2. Phosphorus uptake

The data on uptake of phosphorus by plants are presented in Table 4.13

Nitrogen application significantly influenced the phosphorus uptake by plants, which increased significantly with successive increase in nitrogen levels. Maximum uptake was observed in N_6 (0.29 g $plant^{-1}$) and least by N_o (0.21 g $plant^{-1}$).

Application of poultry manure recorded significantly higher phosphorus uptake(0.29 g plant^{-1}) compared to vermicompost applied plants(0.25 g plant^{-1}) and control (0.22 g plant^{-1}).

Azospirillum inoculation significantly increased the phosphorus uptake by plants(0.26 g plant^{-1}) compared to control (0.24 g plant^{-1}).

Interaction between nitrogen and organic amendment was significant and N_6O_2 recorded the maximum uptake (0.33 g plant^{-1}) and lowest uptake by N_0O_0 (0.17 g plant^{-1}).

Interaction between nitrogen and microbial inoculation was significant and N_6M_1 registered the maximum uptake of 0.30 g plant^{-1}, which was on par with N_5M_1. Lowest value was registered by N_0M_0 (0.20 g plant^{-1}).

Interaction between organic amendment and microbial inoculation was significant and O_2M_1 showed the highest uptake of 0.31 g plant^{-1}. Lowest uptake was registered by O_0M_0 (0.21 g plant^{-1}).

4.4.3. Potassium uptake

The data on uptake of potassium by plants are presented in Table 4.13.

Nitrogen application significantly influenced the potassium uptake by plants. N_6 recorded the maximum uptake (1.61 g plant^{-1}) and minimum uptake by N_0 (1.24 g plant^{-1}).

Vermicompost treated plants recorded significantly higher potassium uptake of 2.22 g plant^{-1}. Poultry manure treated plants registered an uptake of 1.31 g plant^{-1}. Control recorded the minimum potassium uptake (0.75 g plant^{-1}).

Azospirillum inoculation significantly increased the potassium uptake by plants (1.44 g plant^{-1}) over control (1.41 g plant^{-1}).

Interaction between nitrogen and organic amendment was significant. N_6O_1 recorded the highest potassium uptake (2.49 g plant^{-1}) and N_0O_0 recorded the minimum uptake value (0.59 g plant^{-1}).

The interaction between nitrogen and microbial inoculation and organic amendment and microbial inoculation were not significant.

4.4.4. Correlation studies

Correlations were worked out between yield and all growth, yield and quality parameters and is presented in Table 4.14.

Simple correlation studies were undertaken with a view to elucidate the relationship of each of the various growth and yield attributing characters, quality aspects and nutrient uptake. The correlation coefficients of yield with growth characters

Table 4.14. Values of simple correlation coefficients

Sl No	Character correlated	Correlation coefficient
1	Yield x height of plant at 35 DAT	0.76**
2	Yield x height of plant at 70 DAT	0.71**
3	Yield x height of plant at Harvest	0.63**
4.	Yield x number of branches plant^{-1} at 35 DAT	0.80**
5	Yield x number of branches plant^{-1} at 70 DAT	0.76**
6	Yield x number of brancches plant^{-1} at Harvest	0.55**
7	Yield x canopy spread at 35 DAT	0.83**
8	Yield x canopy spread at 70 DAT	0.84**
9	Yield x canopy spread at Harvest	0.87**
10	Yield x DMP at 35 DAT	0.89**
11	Yield x DMP at 70 DAT	0.91**
12	Yield x DMP at Harvest	0.90**
13	Yield x RGR at 70 DAT	0.87**
14	Yield x RGR at Harvest	0.83**
15	Yield x 50 percent flowering	0.13
16	Yield x flowers plant^{-1}	0.95**
17	Yield x fruit plant^{-1}	0.99**
18	Yield x setting percentage	0.98**
19	Yield x girth of fruit	0.93**
20	Yield x length of fruit	0.81**
21	Yield x yield plant^{-1}	1.00**
22	Yield x H.I	0.86**
23	Yield x ascorbic acid content	0.94**
24	Yield x chlorophyll at 70 DAT	0.98**
25	Yield x chlorophyll at Harvest	0.97**
26	Yield x N uptake	0.97**
27	Yield x P_2O_5 uptake	0.82**
28	Yield x K_2O uptake	0.21

** Significant at 1% level

viz plant height, number of branches, canopy spread, dry matter production each at 35 DAT, 70 DAT and at harvest, RGR at initial and final stage, yield attributing characters like time of 50 percent flowering, number of flowers plant^{-1}, number of fruits plant^{-1}, setting percentage, girth of fruit, length of fruit, yield plant^{-1}, harvest index, quality aspects like ascorbic acid content of fruit, chlorophyll content of leaves at 70 DAT and harvest and N,P,K uptake were calculated. The results showed that all the parameters were positively correlated with yield and all the correlation coefficients were statistically significant except in the case of time of 50 percent flowering and potassium uptake.(Characters 11,16,17,18,19,23,24,25 & 26)

Number of fruit plant^{-1} showed the highest degree of correlation with yield (r = 0.99). There was also a significant correlation between yield and number of flowers (r=0.95). Yield was significantly and positively correlated with setting percentage (r = 0.98), girth of fruit (r = 0.81), dry matter production at 70 DAT (r=0.91), ascorbic acid content (r = 0.94), chlorophyll content at 70 DAT (r = 0.98), chlorophyll content at harvest (r=0.97) and nitrogen uptake (r=0.97).

4.4.5. Economic appraisal of various nutrient sources

The data on cost of treatments, gross income (returns) pot^{-1},net income (profit) pot^{-1} and benefit cost ratio are shown in table 4.15.

Increase in the profit was noticed due to increase in nitrogen levels. Maximum profit was registered by N_6 levels (Rs. 1.94) and lowest profit was recorded by N_0 (Rs.0.40). Application of poultry manure registered maximum profit (Rs. 1.18) over vermicompost treated plants (Rs. 1.05) and control (Rs.1.04). Azospirillum inoculation showed a low profit (Rs. 1.12) than control (Rs.1.29).

In the case of benefit cost ratio highest value was registered by N_5 level (4.67) and it was followed by N_6 level (4.50). Lowest benefit cost ratio was showed by N_0 (1.97). Application of vermicompost recorded minimum benefit cost ratio (2.94) and poultry manure showed a value of 3.15. Maximum value was recorded by control (5.33). Azospirillum inoculation registered minimum benefit cost ratio (2.81) and control recorded a maximum value (5.96).

Table 4.15. Effect of nitrogen, organic amendment and microbial inoculation on economics of cultivation.

	Levels of nitrogen							Organic amendment			Microbial inoculation	
Treatments	N_0	N_1	N_2	N_3	N_4	N_5	N_6	Control (O_0)	Vermicompost (O_1)	Poultry manure(O_2)	Control (M_0)	Azospirillum inoculation(M_1)
Cost of treatment Pot^{-1} (Rs.)	0.42	0.43	0.44	0.45	0.46	0.49	0.55	0.24	0.54	0.55	0.26	0.62
Returns Pot^{-1} (Rs.)	0.83	1.03	1.25	1.67	2.02	2.29	2.48	1.28	1.59	1.73	1.55	1.74
Profit Pot^{-1} (Rs.)	0.40	0.60	0.81	1.16	1.56	1.80	1.94	1.04	1.05	1.18	1.29	1.12
Benefit cost ratio	1.97	2.39	2.84	3.57	4.39	4.67	4.50	5.33	2.94	3.15	5.96	2.81

DISCUSSION

5.DISCUSSION

Response of chilli grown in pots under modified drip irrigation to varying levels of nitrogen was studied in this investigation and the results is discussed below.

5.1. Effect of nitrogen on growth, yield and quality of vegetable chilli

The test doses were 0.0, 0.4, 0.8, 1.6, 3.2, 6.4 and 12.8 g nitrogen plant^{-1}. The recommended dose of chilli under field condition is 75 kg N ha^{-1}. The per plant requirement of nitrogen under field condition is around 1.5 g plant^{-1}. Since the performance of the same crop differ in pot and field condition levels of nitrogen were tried below and above the per plant recommendation under field condition. A control treatment with no nitrogen was also included for comparison.

The results of the experiment showed that yield of chilli increased with increasing levels of nitrogen. Lowest yield was recorded in the control plant. This showed the essentiality of the nutrient nitrogen for chilli. The role of N in plant growth is well known.

Nitrogen is essential for the synthesis of both structural and functional protein, which play an important role in plant metabolism. Besides its role in the formation of protein, nitrogen is an integral part of chlorophyll, which is the primary absorber of the light energy needed for photosynthesis. An adequate supply of nitrogen is associated with better vegetative growth. The result of the experiment showed that the growth parameters like plant height, number of branches, canopy spread and dry matter production increased with increasing levels of nitrogen. Compared to control the highest level of nitrogen increased plant height by 18.14 percent, 6.70 percent and 4.71 percent at 35 DAT, 70 DAT and harvest respectively. Similar findings were reported by Prabhakar *et al.* (1987), Belichki (1988), Saji John (1989) and Sajitharani (1993). Branching also increased from 13.67 to 17.39 at 35 DAT, from 33.72 to 37.22 at 70 DAT and from 49.06 to 53 at harvest with the highest level of nitrogen. Similar observations of increased branching at higher level of nutrients have been reported by Joseph (1982), Zayed *et al.* (1985) Saji John (1989), Natarajan (1990) and Pandey *et al.* (1992).

This increase in plant height and branching has resulted in a better canopy spread. which increased by 46.71 percent, 41.77 percent and 33.53 percent at 35 DAT, 70 DAT and at harvest by increase in the nitrogen level from 0 to 12.8 g $plant^{-1}$ respectively. This better canopy spread has helped the plant to tap more solar radiation and to form more photosynthates. Increase in nutrient supply enhanced cell division and elongation in chilli resulting in more spread of canopy as reported by Nazar Ahamed and Tanki (1991).

This better assimilation has helped to increase the DMP from 2.09 g to 3.07 g at 35 DAT, from 28.47 g to 58.88 g at 70 DAT and from 129.19 g to

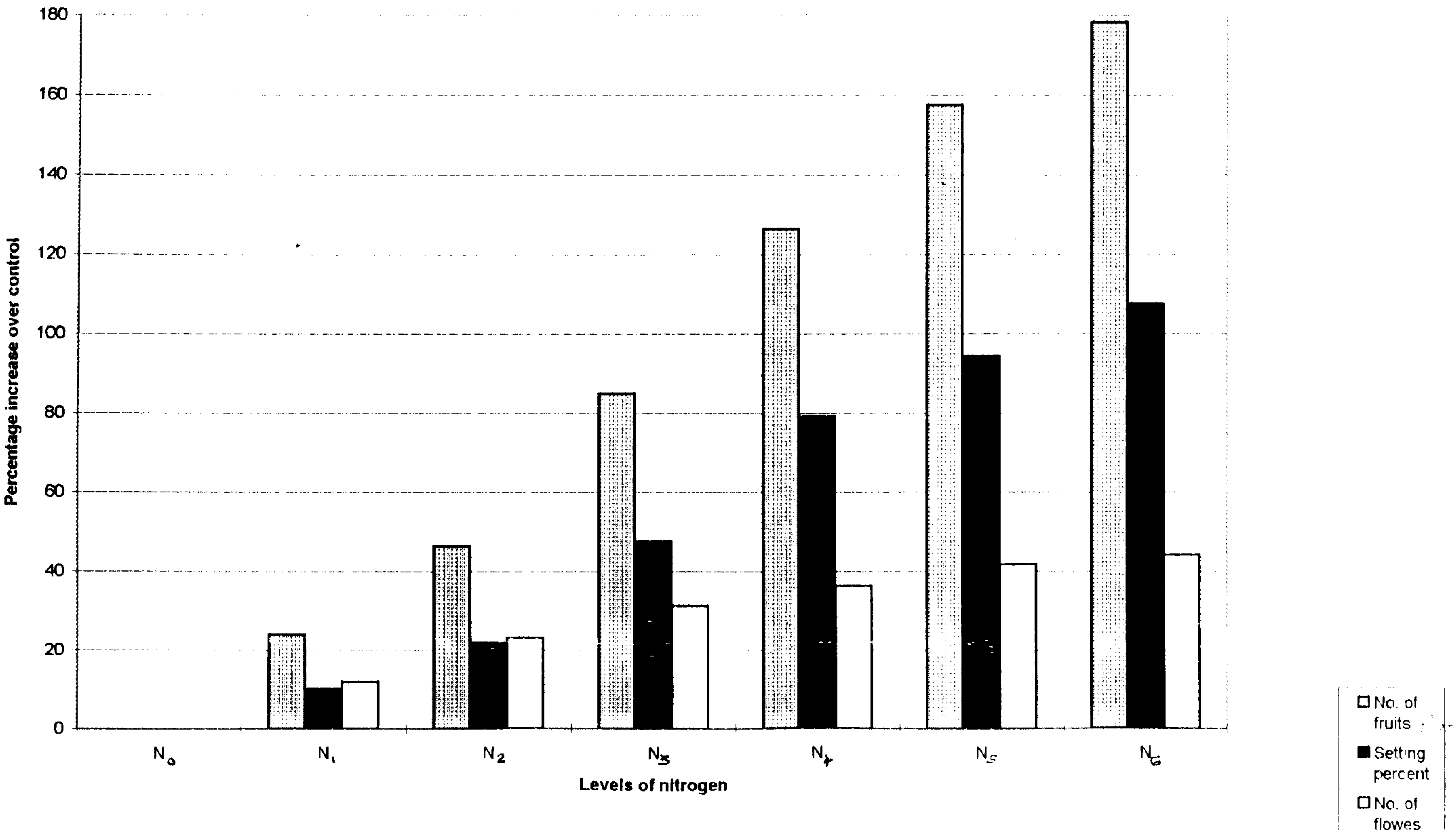
338.44 g at harvest by the application of N_6 level of nitrogen. Similar results were earlier reported by Pandey *et al.* (1980), Parmindar Singh *et al.* (1986), Nazeer Ahmed and Tanki . . . (1991) and Pandey *et al* (1992).

It can be observed that the chlorophyll content also increased with increase in levels of nitrogen. This better development of chlorophyll by the increased supply of nitrogen shows the importance of this nutrient in the synthesis of chlorophyll. The basic unit of chlorophyll structure is the porphyrin ring system composed of 4 pyrrole rings each containing one nitrogen and four carbon atoms. This higher percent of chlorophyll coupled with higher development of photosynthetic surface might have helped in better development of the growth and yield contributing parameters.

The number of flowers has increased by 44.02 percent by the application of N_6 level of nitrogen. Number of fruits also increased by 178.27 percent by the application of N_6 level of nitrogen (Fig. 2). Increase in nitrogen levels inturn increased the production, translocation and assimilation of photosynthates to growing points thereby stimulating plants to produce more number of flowers plant^{-1} and subsequently more fruits plant^{-1}. Similar results were reported by Dolkova *et al.* (1984) and Kaminwar and Rajagopal (1993).

Higher levels of nitrogen significantly increased the setting percentage of fruit from 25.40 to 52.72 percent. This better setting percent has

Fig.2. Effect of nitrogen on number of flowers, number of fruit plant^{-1} and setting percentage

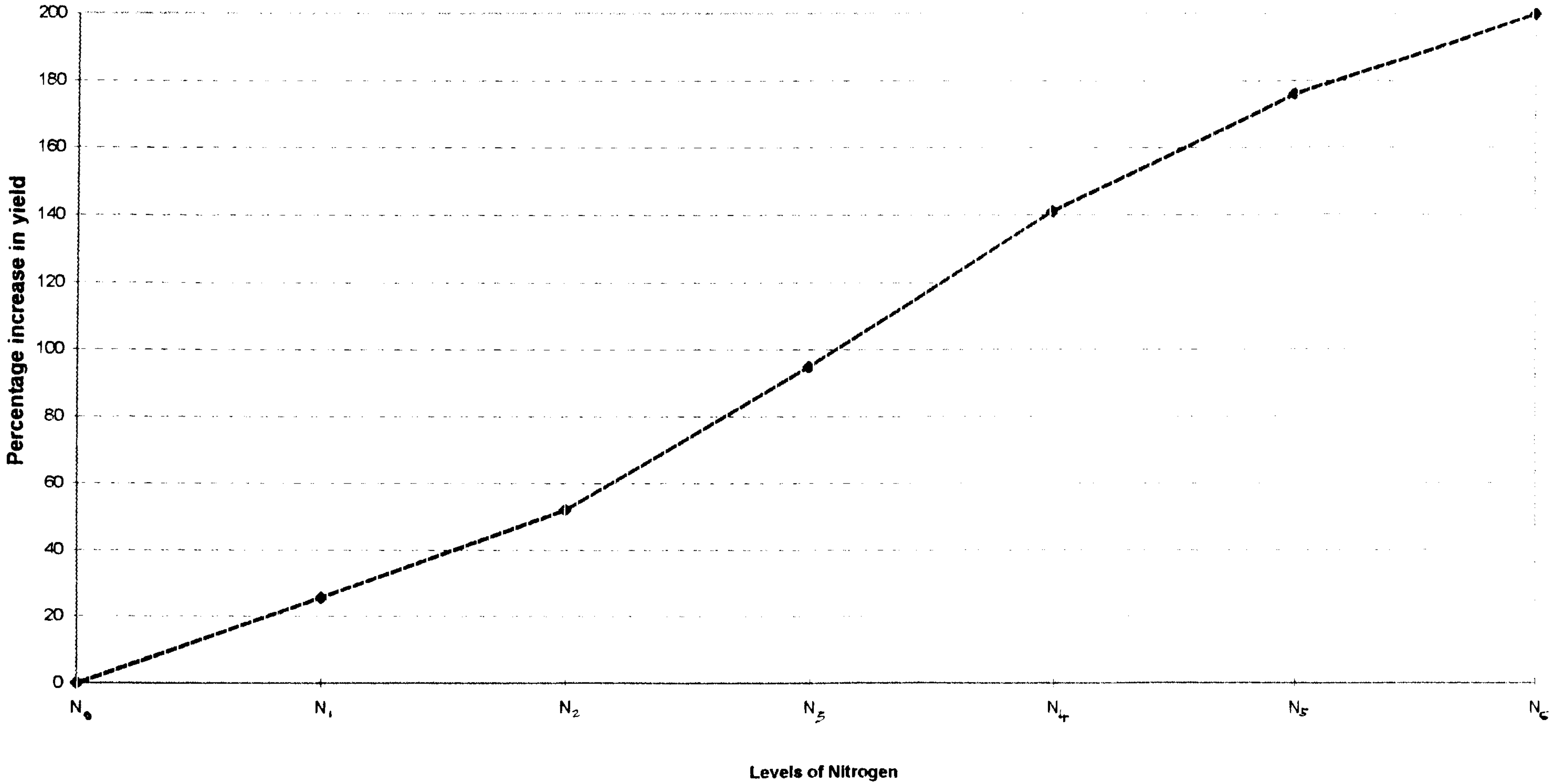


resulted in the better production of fruits . Similar findings were reported by Joseph (1982) and Jayaraman and Balasubramanian (1991).

Not only the number of fruits but the girth and length were also positively increased by nitrogen application. Girth increased from 4.77 cm to 5.87 cm and length increased from 7.16 to 8.15 cm. Subramonian (1980) found significant influence of nitrogen on fruit length.

The fruit yield also increased significantly with increase in levels of nitrogen (Fig. 3). Yield at N_1 level registered 25.7 percent over N_0 level and yield at N_2 level registered 20.9 percent over the N_1 level and 52.02 percent over the control. The N_3 level showed 28.27, 55.17, 95 percent increase respectively over the preceeding levels. Application of nitrogen at N_4 level has produced 201.8g $plant^{-1}$ which was 23.6, 58.56, 91.79 and 141.0 percent over N_3, N_2, N_1 and N_0 levels. The N_5 level has recorded 14.49, 41.76, 81.5, 199.59 and 175.9 percent increase in yield compared to the respective preceding levels. Maximum yield was realised at N_6 level which has out yielded N_5 level by 8.57 percent, N_4 by 24.3 percent, N_3 by 53.65 percent, N_2 by 97.09 percent, N_1 by 138.4 percent and N_0 by 199.6 percent. Thus the result of this study showed the response of chilli upto a dose of 12.8g $plant^{-1}$. Similar findings on increased yield with higher levels of nutrients had been reported by Singh and Srivasthava (1988), Jayaraman and Balasubramonian (1991), Kaminwar and Rajagopal (1993) and Subbiah (1993).

Fig. 3. EFFECT OF NITROGEN ON YIELD OF CHILLI

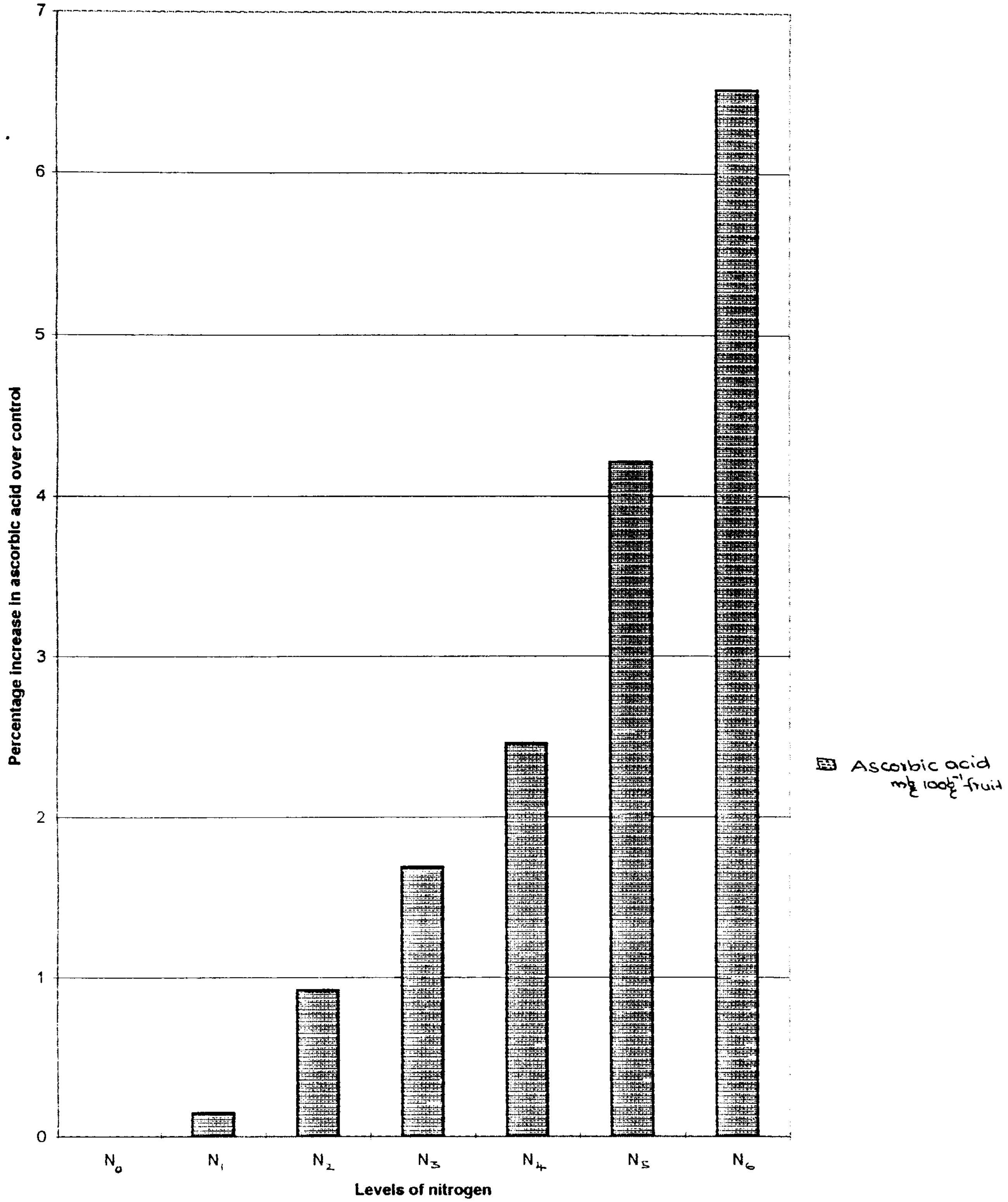


Ascorbic acid content of fruits showed significant increase with increase in nitrogen level. Maximum ascorbic acid content 99.71 mg 100 g fruit^{-1} was noted at N_6. Ascorbic acid content increased by 6.52 percent over the control (Fig. 4). Increased ascorbic acid content noticed in the present study might be due to increase in protein synthesis and enhancement of enzymatic activities for amino acid synthesis at higher level of nutrients which is instrumental in improving the quality (Shihbila Mary and Balakrishnan, 1990 and Kaminwar and Rajagopal, 1993).

5.2. Effect of nitrogen on nutrient uptake

Increased supply of nitrogen might have lead to the development of better root system due to better uptake of nutrient phosphorus (Fig.5.). An efficient uptake of phosphorus has been associated historically with increased root growth. The greatly increased root proliferation should encourage extensive exploitation of the treated soil area for nutrients. At N_o level, plants recorded the lowest uptake of nutrients, 0.27, 0.21, 1.24g NPK plant^{-1} and it has increased significantly at all other levels of nitrogen. So this showed that in the absence of nitrogen addition, phosphorus and potassium could register the lowest uptake of nitrogen. This increase in levels of nitrogen along with phosphorus and potassium helped to increase the uptake of all the three primary nutrients. This showed the importance of balanced application of nitrogen, phosphorus and potassium. The beneficial effect of higher levels of nutrients in increasing the uptake of nitrogen has been reported by Dolkova *et al.* (1986); Hedge (1988), Saji John

Fig. 4. Nitrogen on ascorbic acid content of chilli



(1989) and Sajitharani (1993). Relationship between nitrogen and phosphorus is synergetic in nature. Potassium is required for nitrogen uptake and potassium uptake increased with increasing levels of nitrogen. Nitrogen at higher level recorded maximum potassium uptake. The beneficial effect of higher levels of nutrients in increasing the potassium uptake were reported by Tapia and Dabed (1984) and Subbiah (1994).

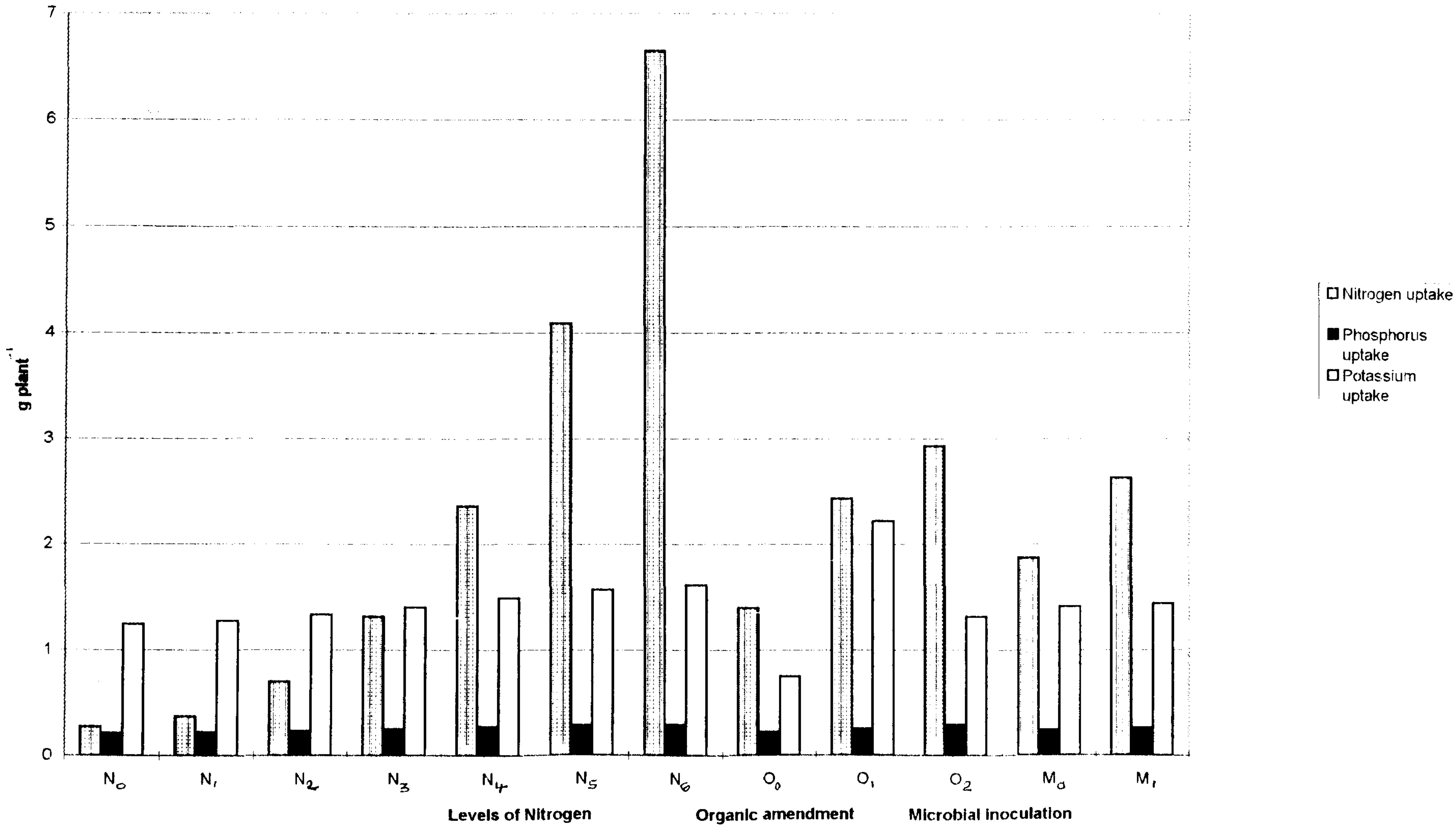
The result of this study also showed that uptake of all the primary nutrients increased by the application of nitrogen, which might have played a role in developing a better expression of growth and yield parameters.

5.3. Effect of organic amendment on growth, yield and quality of vegetable chilli

Effect of organic amendments namely vermicompost and poultry manure in potted vegetable chilli was studied in this experiment.

Proper soil management without impairing soil health is the prerequisite for achieving higher productivity in agricultural land. Our soils are poor in organic matter due to high temperature. The chemical inputs in crop production are becoming increasingly in short supply and prohibitively costly. This situation has created a renewed interest in the biological transformation of organic residue or waste into valuable manures. Composting is the microbiological conversion of

Fig. 5. Effect of levels of nitrogen, organic amendment and microbial inoculation on nitrogen, phosphorus and potassium uptake



biodegradable organic waste to a stable humus. Technology has been developed for producing compost by using earth worms.

Control Vs organic amendments

The results of this experiment showed that vermicompost and poultry manure applied plants were superior to control plants in all the aspects.

Height of the plants were found to be superior in the case of organic amendment treated plants 23.29 at 35 DAT, 43.24 at 70 DAT and 53.24 cm at harvest but the control recorded 21.96 cm at 35 DAT, 41.94 cm at 70 DAT and 52.18 cm at harvest. Maximum number of branches plant^{-1} (16.24, 36.1, 52.17 at 35 DAT, 70 DAT and at harvest respectively) was produced by organic amendment application. Number of branches plant^{-1} at O_o was only 14.55, 34.79, 50.02 at 35 DAT, 70 DAT and at harvest respectively. In the case of canopy spread and DMP also organic amendment treated plants showed higher values than the untreated plants. The beneficial effect of organic amendments in increasing the growth parameters were reported by Zhang *et al.* (1988), Almasov and Kholuyako (1990) and Pushpa (1996).

Not only the growth parameters, the yield and yield attributes were significantly increased by the application of organic amendments over the control. Maximum number of flowers plant^{-1} (108.5) were produced in organic amendment treated plants. In the case of control it was only 92.4. Number of fruits plant^{-1} was 44.76 for treated plants and 32.02 for untreated plant. Yield plant^{-1} was significantly higher for organic amendment treated plants (183.49) than the control plants (129.74).

Similar results of increased plant growth and yield by the application of organic amendment was reported by Gianguinto and Borin (1990), Meena Nair and Peter (1990). Various experiments conducted in Kerala Agricultural University revealed that higher rates of nitrogen along with FYM induced earliness and increased fruit production and yield in clustered chilli (KAU, 1991). Rajalekshmi (1996) observed that with regard to the yield and dry matter production of chilli crop the treatment receiving organic amendment and NPK recorded highest yield. Pushpa (1996) also observed the same effect in tomato.

This better expression of growth and yield parameters noticed in the study may be due to the multidynamic role played by organic amendments. Addition of organic amendments is a must for augmenting soil physical, chemical and biological properties. Application of organic manure reduced the bulk density and increased the infiltration rate (Boparai *et al* , 1992). More (1994) reported that addition of farm wastes and organic manures increased the status of available nitrogen of the soil.

In the quality aspect (Vitamic C content) also organic amendment application showed significant increase (96.27 mg 100 g $fruit^{-1}$). In control plants it was only 94.67 mg 100 g $fruit^{-1}$. Increased ascorbic acid content might be due to increase in protein synthesis and enhancement of enzymatic activities for amino acid synthesis. Increased ascorbic acid content by the application of organic amendment was reported by Kansal *et al* (1981). Organic amendment application showed significant increase in the chlorophyll (0.62 mg g $leaf^{-1}$ at 70 DAT and 0.27 mg g $leaf^{-1}$ at harvest) content of leaf than the control. Increased chlorophyll content resulted in better expression of growth and yield parameters and there by yield.

Application of organic amendment showed significant increase in the uptake of NPK than the control 2.68, 0.27 and 1.77 NPK g $plant^{-1}$. In control plants it was only 1.39, 0.22 and 0.75 NPK g $plant^{-1}$. The effect of farmyard manure was beneficial in enhancing the uptake of all the three major nutrients (Minhas and Sood, 1994). Increased nutrient uptake resulted in better expression of growth, yield parameters and there by yield.

Vemicompost Vs Control

Growth parameters like height of the plant (52.92cm at harvest), number of branches (51.60), canopy spread (744.70cm^2) and DMP(95.40g) were significantly higher for vermicompost treated plants than the control. The excreta or castings of earth worms are rich in nutrients like nitrogen, phosphorus, potassium, calcium and magnesium and also in bacterial and actinomycetes population. Vermicompost contain many growth promoting hormones, vitamins enzymes etc in addition to plant nutrients. Worm cast when used in organic manure significantly influenced vegetative characters (Kala and Krishnamoorthy ,1981). Biometric observationss viz.height of the plant, number of leaves were greatly influenced by the application of vermicompost (Pushpa 1996).

Vermicompost can act not only as a growth determinant but also as an yield determinant. Application of vermicompost induced early flowering (41.14 days). For control it was 41.48 days. The presence of phytohormone, enzymes, antibiotics, vitamins etc in vermicompost might have positively influenced the early flowering of plants. Number of flowers plant^{-1} was also significantly higher for vermicompost treated plants (100.76) than the control (92.40). Pushpa (1996) obtained increase in number of flowers by the application of vermicompost compared to farm yard manure. Number of fruits plant^{-1} was significantly higher for vemicompost treated plants (39.21) than the control (32.02). Increased number of fruits plant^{-1} in vermicompost treated plants may be due to higher level of nitrogen present in vermicompost. Vermicompost is reported to contain about three times more nutrients than FYM (Prabhakumari *et al.* 1995). Length and girth of fruits were significantly superior for vermicompost treated plants (7.67 cm and 5.34 cm respectively) than the control (7.23 cm and 4.95cm respectively). Yield attributes like mean fruit length and girth were found to be significantly influenced by vermicompost application (Pushpa, 1996). Yield was 159.21g for vermicompost treated plants while for control it was only 129.74g. The positive response of vermicompost on growth and yield attributes cumulatively resulted in higher yield of chilli. Sheshadri *et al.* (1993) showed that the yield of dry chillies obtained from vermicompost was higher than the control and farm yard manure and lower than the fertiliser treated bed but the yield of fresh chilli was maximum in the vermicompost treated bed.

The results indicated that plants treated with vermicompost registered higher ascorbic acid content (95.54 mg 100 g^{-1} fruit) than the control (94.67 mg 100 g^{-1} fruit). The results showed that plants treated with vermicompost registered higher chlorophyll content (0.57 mg g^{-1} leaf at 70 DAT and 0.24 mg g^{-1} leaf at harvest) than the control (0.47 and 0.19mg g^{-1} leaf at 70 DAT and harvest respectively).

In the case of nutrient uptake also vermicompost treated plants showed significantly higher values than the control. The higher rate of metabolic activity with rapid cell division brought by vermicompost application might have resulted in high uptake of nutrients.

Poultry Manure Vs Control

Growth parameters like height of the plant, number of branches, canopy spread and DMP were significantly higher for poultry manure treated plants than the control at all growth stages. Yield attributing parameters like earliness in flowering (40.57 days), number of flowers $plant^{-1}$ (116.24), number of fruits $plant^{-1}$(50.31), setting percentage (43.75) fruit girth (5.87 cm), length (8.31 cm), yield $plant^{-1}$ (207.77 g), ascorbic acid content(96.99 mg 100 g $fruit^{-1}$) and N,P,K uptake were significantly higher than the control plants.

Poultry manure is a good source of nutrient particularly for vegetable production. In poultry manure 60 percent of nitrogen is present as uric acid, which readily changes into ammoniacal form of nitrogen which become available to the plant immediately and there,by increase growth and yield of the plant(Smith, 1950). Brown (1958) observed that poultry manure contained growth promoting hormones which produced better root growth. Another important factor contributing to the higher yield with poultry manure might be its higher P_2O_5 content. (Singh and Srivastava, 1970). Singh *et al* (1973) attributed higher efficiency of poultry manure to its narrow C:N ratio and comparatively higher content of readily mineralisable nitrogen.

Vermicompost Vs Poultry Manure

The result of this experiment showed that the chilli crop responded very well to addition of poultry manure. Poultry manure was found to be better than vermicompost on equivalent nitrogen basis.

Poultry manure exhibited better response than vermicompost on growth, yield, its quality aspects and NPK uptake. It may be attributed to the release of nitrogen, the first limiting essential nutrient, which is readily made available to the plants through poultry manure. Smith (1950) reported that uric acid, which constituted 60 percent of the nitrogen in poultry manure, changes rapidly to ammoniacal form which is utilised by the plants. Brown (1958) observed that poultry manure contained growth promoting hormones which produced better root growth. Another important factor contributing to the higher yield with poultry manure might be its higher P content or increased availability of native soil phosphorus through increased biological activity (Singh and Srivastava, 1970). Higher nutrient supplying efficiency of poultry manure was reported by Singh *et al.*(1973).

5.4. Effect of Azospirillum inoculation on growth, yield and quality of vegetable chilli.

Effect of Azospirillum inoculation on growth, yield and quality of chilli was studied in this experiment.

Biofertilisers are most effective as well as safe to environment. The management of soil fertility through biofertilisers is a vital component of sustainable agriculture. Growth parameters like height of the plant, number of branches per plant, canopy spread and DMP were significantly higher for Azospirillum treated plants over the untreated plants. Yield attributing parameters like earliness in flowering (40.73 days), number of flowers $plant^{-1}$ (106.29), number of fruits $plant^{-1}$ (43.38), setting percent (39.87) girth of fruit (5.51 cm), length of fruit (7.88 cm) and harvest index (0.52) were significantly higher than the control. Yield was significantly higher for plants inoculated with Azospirillum(175.67 g $plant^{-1}$). The yield of the control plant was only 155.47 g $plant^{-1}$. Increase in yield by Azospirillum inoculation is a cumulative effect of various positive roles played by Azospirillum. Azosporillum inoculation helps not only in promoting nitrogen fixation but also in the release of various growth promoting agents, which led to higher plant growth and yield. Azospirillum inoculation was known to increase yield of crop by 5 to 20 percent (Dart, 1986).

The ascorbic acid conent of fruit was higher for Azospirillum inoculated plants (95.99mg $100g^{-1}$ fruit) than the control (95.49 mg 100 g^{-1} fruit). Inoculation with Azospirillum increased ascorbic acid content in chilli (Balakrishnan, 1988). The chlorophyll content also increased by Azospirillum inoculation (0.59 mg g^{-1} of leafat 70 DAT and 0.26 mg $g^{-1}$of leaf at harvest). The enhancement in chlorophyll content indicated greater availability of nitrogen which is an integral part of chlorophyll molecule (Tisdale *et al.* 1985)

The nutrient uptake was also favourably influenced by Azospirillum inoculation. Azospirillum has the ability for better root induction in inoculated plants mainly due to the production of plant growth hormones like IAA and GA. As a result of this, such plants are capable of absorbing more and more available nutrients from the soil, which in turn results in better establishment of plant seedling and subsequent growth (Tien *et al* 1979; Govindan and Purushotaman, 1984).

5.5. Interaction effect of nitrogen and organic amendments on yield of chilli

Interaction between nitrogen and organic amendments revealed that by adding vermicompost alone (79.65g) the yield realised is better than the yield obtained by the addition of N_1 level (74.05g) of nitrogen (Table 4.9a.). By adding poultry manure alone chilli crop (102.28g) registered a yield higher than the yield realised at N_1(74.05g) and N_1O_1 (100.47g). N_1O_1 registered a yield higher than N_2O_0 (96.45g) while N_1O_2 (140.00g) registered a yield higher than N_2O_0 (96.45g) and N_2O_1 (112.87g). Similarly N_2O_2 (171.13g) registered a yield higher than N_3O_0 (117.23g) and N_3O_1 (145.80g). N_3O_2 (225.00g) recorded a yield higher than N_4O_0(155.53g) and N_4O_1(196.80g). Similarly N_4O_2 (250.90 g) showed a higher yield than N_5O_0 (186.62 g) and N_5O_1 (227.18g). N_5O_2 (276.85g) registered a yield higher than N_6O_0 (209.97g) and N_6O_1 (251.70g).

Application of nitrogen along with poultry manure at each level recorded significantly higher yield than the yield realised by the addition of nitrogen alone at the preceeding level and the combined application of that level of nitrogen along with vermicompost. So this shows the superiority of organic manures compared to chemical fertiliser and poultry manure is found better than vermicompost at all levels of nitrogen. By adding poultry manure it is possible to save fertilizer nitrogen. Addition of poultry manure along with N_5 level of nitrogen recorded a yield of about 276.85 g which was significantly higher than the yield realised by the addition of the maximum level of nitrogen alone and the yield realised by the combined application of maximum level of nitrogen along with vermicompost. So this shows that efficiency of chemical fertilizer can be enhanced with the addition of organic manures and chilli respond better to poultry manure than vermicompost. Poultry manure exhibited better response than vermicompost on yield and its different attributes at every level and combination. It may be attributed to the release of nitrogen, the first limiting essential nutrient which is readily made available to the plants through poultry manure. Smith (1950) reported that uric acid, which constituted 60 percent of the nitrogen in poultry manure, changes rapidly to ammoniacal form which is utilised by the plants.

Singh *et al.* (1973) reported that a combination of poultry manure and fertilizer gave the maximum yield in patoto and poultry manure exhibited better response than FYM on yield and different attributes.

Rajalekshmi (1996) showed that with regard to the yield and dry matter production of chilli crop, the treatment receiving vermicompost and NPK recorded highest yield in chilli.

5.6. Interaction effect of nitrogen and microbial inoculation on yield of chilli

Interaction between levels of nitrogen and Azospirillum inoculation showed that (Fig. 6)yield increase of about 18 percent was observed by Azospirillum inoculation at N_1, N_2 ,N_3,and N_4 levels. But at higher levels of nitrogen (N_5 and N_6) the percentage increase in yield was only about 8.9. This shows that efficiency of Azospirillum inoculation is less at higher levels of nitrogen. Wani and Konde (1986) reported that performance of Azospirillum was better at lower doses of nitrogen.

5.7. Interaction effect of organic amendments and microbial inoculation on yield of chilli

The interaction between organic amendments and microbial inoculation showed that yield of chilli increased significantly by the combined application of organic manure along with Azospirillum inoculation (Fig. 7.). Azospirillum along with vermicompost registered 21 percent increase in yield over the yield realised by Azospirillum inoculation alone. While Azospirillum along with poultry manure registered 54 percent increase in yield compared to Azospirillum inoculation alone. This very well showed that organic manure is a must to reap maximum benefit from Azospirillum inoculation. Zachariah (1995) showed that application of Eudrillus compost enriched with both Azospirillum and P solubilising organisms to plants gave maximum per plant yield in chilli (302.89 g $plant^{-1}$)

Fig. 6. Interaction effect of levels of nitrogen and microbial inoculation on yield plant^{-1}

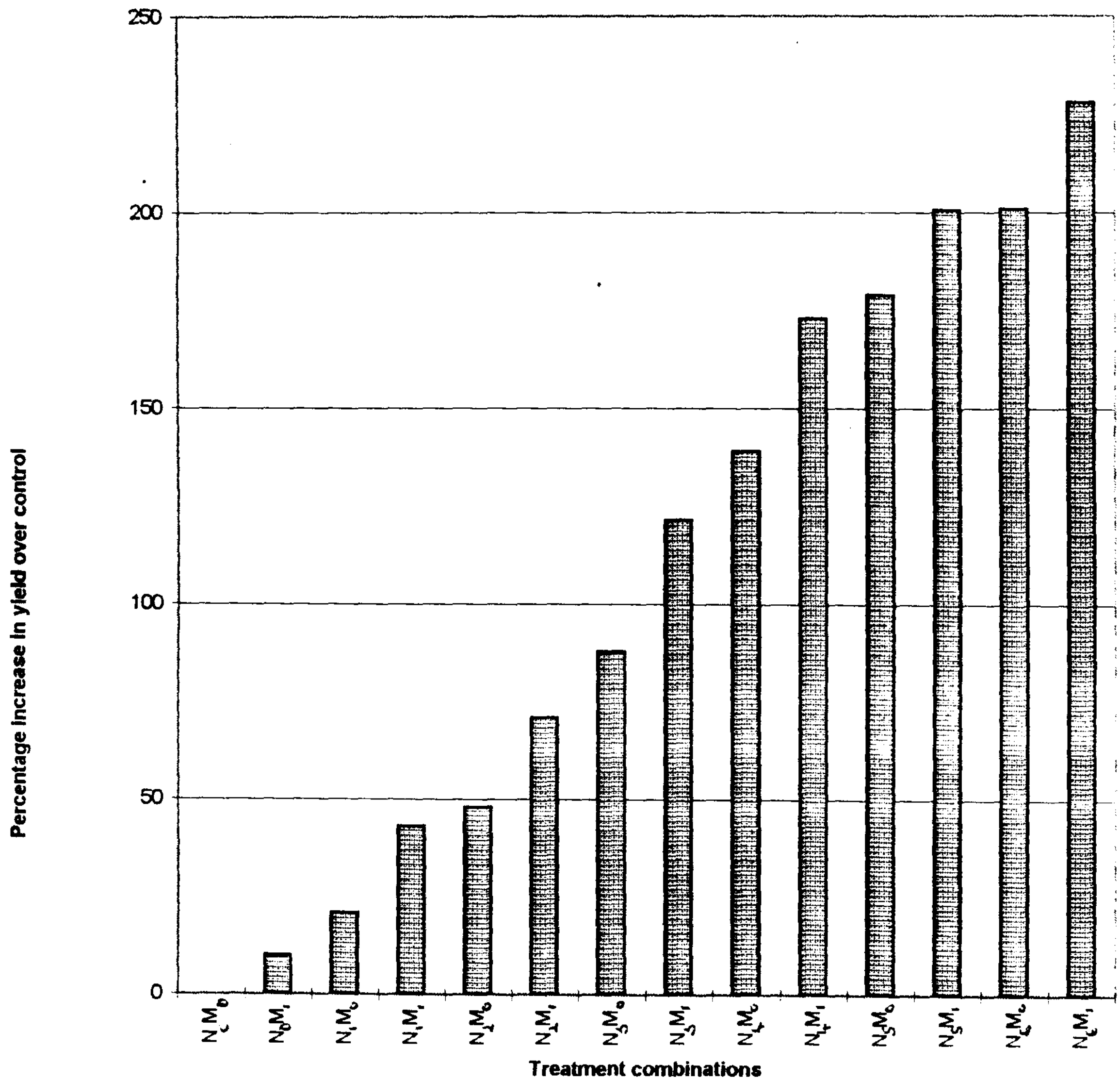
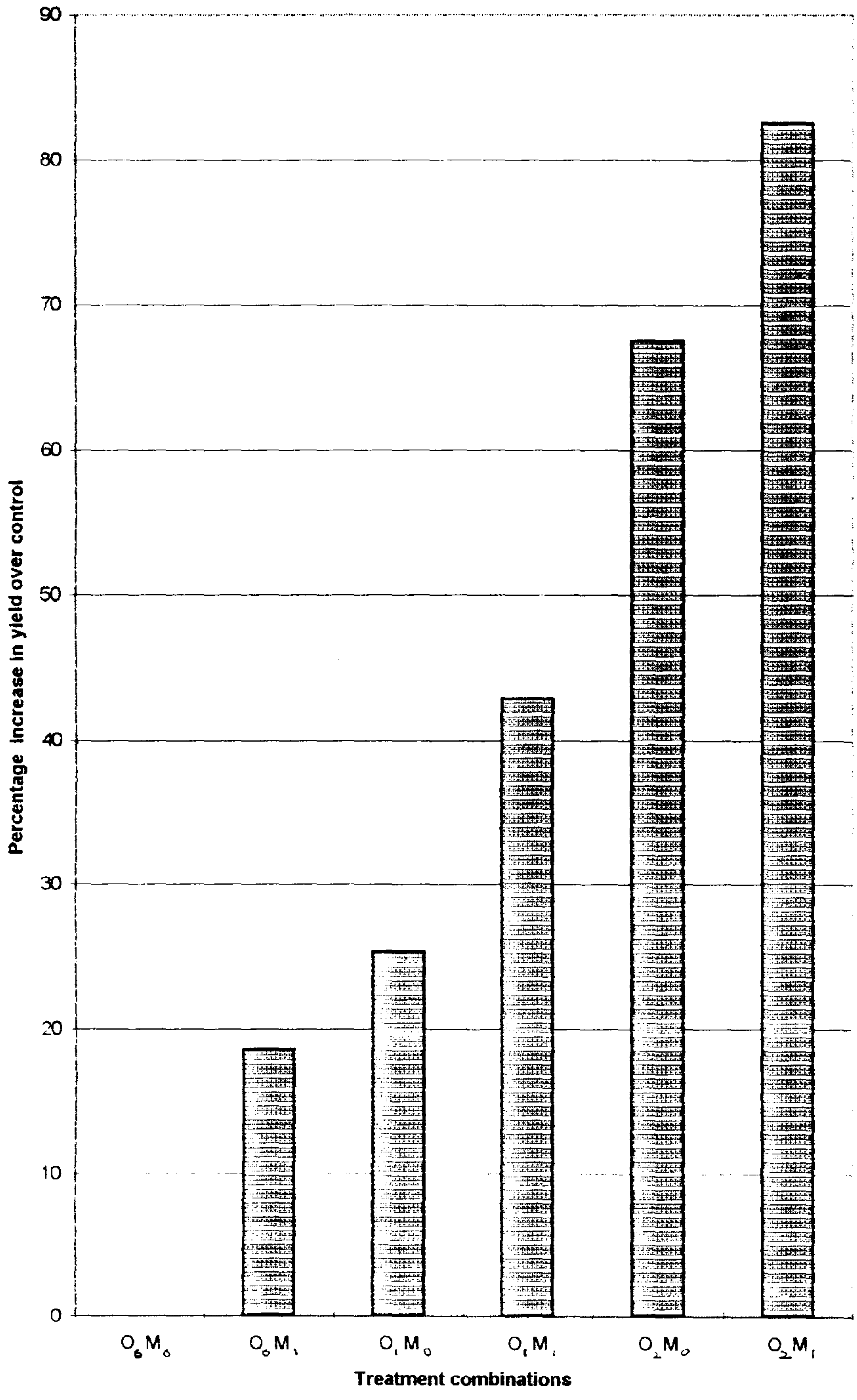


Fig. 7. Interaction effect of organic amendment and microbial inoculation on yield plant^{-1}



5.8. Comparative response of chilli to biological and chemical nitrogen sources

Among the nutrient sources, if we analyse the single effect, we can see that the least responsive one is Azospirillum, which has registered an yield of 175.67 g $plant^{-1}$. While organic amendment alone recorded a yield of 183.49 g $plant^{-1}$ and nitrogen at highest level (N_6) registered the maximum yield of 249.96g $plant^{-1}$. This clearly demonstrates the advantage of chemical fertilizer. Nitrogen being in the easily available form might have enabled for this better performance. Combined application of organic manure along with N_6 level of nirogen recorded 8 percent increase in yield over the application of N_6 alone. Azospirillum along with N_6 recorded 4.3 percent increase in yield over N_6. Maximum productivity is obtained by integrating chemical, organic and microbial nutrient sources which was 11.42 percent higher than the yield realised at N_6 level, 58.5 percent higher than the yield realised by Azospirillum inoculation alone and 51.8 percent higher than yield obtained by organic amendment alone. It is very clear that productivity has been enhanced by an integrated approach. Not only the productivity but the quality was also better by integrating the nutrient sources. Considering the economic feasibility also integrated approach is better than any other treatments. (Fig. 8.). Enhanced crop yield has also been reported through the use of neem cake, neem seed extracts, mahuacake and castor cake when blended with urea in tomato (Shanmugavelu 1989). Zachariah (1995) showed that application of Eudrillus compost enriched with both Azospirillum and P solubilising organisms to plants gave maximum per plant yield in chilli (302.89 g $plant^{-1}$).

5.9. Efficiency of chemical fertilizer as influenced by organic amendments

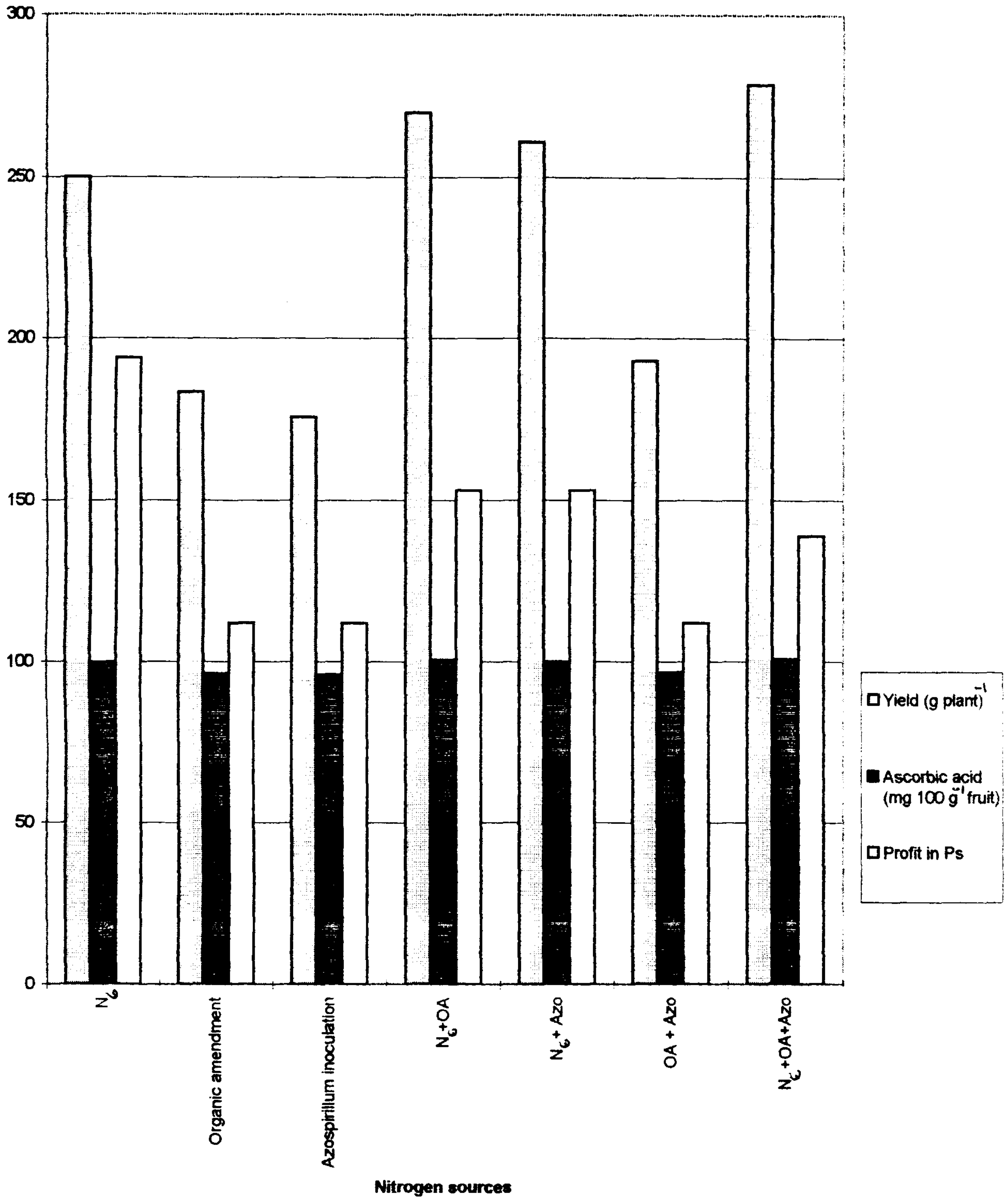
The fertilizer use efficiency recorded for N_1,N_2,N_3,N_4,N_5 and N_6 levels of nitrogen without organic amendment application were 0.92, 0.89, 0.82, 0.74, 0.64 and 0.52 respectively. While the fertilizer use efficiency recorded for N_1,N_2,N_3,N_4,N_5 and N_6 levels of nitrogen with organic amendment application were 1.0, 1.0, 0.94, 0.87, 0.78 and 0.62 respectively. The results showed that as the level of nitrogen increases the fertilizer use efficiency decreases. The fertilizer use efficiency of chemical fertilisers increased with the combined application of chemical fertilizer and organic amendment.

5.10. Economics of nutrient sources

Economics of inorganic nitrogen, organic amendments and microbial inoculation was studied in this experiment (Fig. 8).

Profit pot^{-1} was found to be maximum in the case of N_6 levels of nitrogen (Rs. 1.94)followed by organic amendment application (Rs. 1.12), and Azospirillum inoculation (Rs. 1.12). This is due to the low price of fertilizer nitrogen than the organic amendment and biofertilizers.

Fig. 8. Comparative response of chilli to biological and chemical nitrogen sources



SUMMARY

6. SUMMARY

The study entitled "Nitrogen management in vegetable chilli grown in pots with modified drip irrigation system" has been carried out in a net house under the Department of Agronomy, College of Agriculture, Vellayani during 1994 - 95. The main objectives of the study was to assess the effect of levels of nitrogen, organic amendments and Azospirillum inoculation on the growth and productivity of a vegetable chilli variety Jwalamukhi, recommended for cultivation in Kerala. The treatments consisted of seven levels of nitrogen (0.0, 0.4, 0.8, 1.6, 3.2, 6.4, 12.8 g N plant^{-1}), three levels of organic amendments (control, vermicompost @ 200 g plant^{-1}, poultry manure @ 100 g plant^{-1}), and two levels of microbial inoculation (control and Azospirillum). The experiment was laid out in a factorial completely randomised design.

The results of investigation are summarised below.

1. Plant height differed significantly with levels of nitrogen, organic amendment and Azospirillum inoculation at all stages of growth. Plant height was maximum with N_6 level of nitrogen, application of poultry manure and with Azospirillum inoculation.

2. Number of branches produced per plant increased significantly with increased levels of nitrogen, organic amendment and Azospirillum inoculation.

Plants treated with 12.8g N plant^{-1}, poultry manure and Azospirillum inoculation recorded maximum number of branches plant^{-1}.

3. Increased levels of nitrogen, organic amendment and Azospirillum had profound influence on DMP of plant. Maximum DMP was observed with 12.8 g N plant^{-1} , poultry manure treated plants and Azospirillum inoculated plants.

4. High doses of nitrogen, organic amendment and Azospirillum increased the spread of canopy and it was highest with 12.8 g N plant^{-1}, vermicompost treated plants and azospirilum inoculated plants.

5. Number of days taken for 50 percent flowering decreased with the application of poultry manure and Azospirillum inoculation. With increase in level of nitrogen time taken for 50 percent flowering was increased. 1.6 g N plant^{-1} recorded minimum days for 50 percent flowering.

6. Number of flowers plant^{-1} increased with higher levels of nitrogen, organic amendment and Azospirillum inoculation. Plants treated with 12.8 g N plant^{-1}, poultry manure and Azospirillum inoculation recorded highest number of flowers plant^{-1}.

7. Number of fruits plant^{-1} significantly increased with higher levels of nitrogen, organic amendment application and Azospirillum inoculation. Nitrogen @

12.8 g N $plant^{-1}$ along with poultry manure application and Azospirillum inoculation recorded maximum number of fruits $plants^{-1}$.

8. Significant influence was observed on setting percentage of fruit with treatments. Application of 12.8 g N $plant^{-1}$ with poultry manure application and Azospirillum inoculation contributed to the highest setting percentage of fruit.

9. Maximum yield was obtained for plants treated with 12.8 g N $plant^{-1}$, with poultry manure application and Azospirillum inoculation.

10. Plant treated with higher levels of nitrogen 12.8 g N $plant^{-1}$, poultry manure application and Azospirillum inoculation recorded maximum ascorbic acid content of fruit.

11. Plants treated with 12.8 g of nitrogen with poultry manure application and Azospirillum inoculation gave maximum chlorophyll content.

12. The total uptake of nitrogen by plant was significantly increased by 12.8 g N $plant^{-1}$, poultry manure application and with Azospirillum inoculation.

13. Potassium uptake was maximum for N_6 level (12.8 g N $plant^{-1}$) of nitrogen: Vermicompost treated plants showed highest level of potassium uptake.

Azospirillum treated plants also showed significant increase in the uptake of potassium.

14. Profit was maximum for N_6 level (12.8 g N plant^{-1}) of nitrogen. Poultry manure treated plant showed maximum profit than vermicompost treated plants. Azospirillum treated plants showed a low profit than the control.

15. In the case of interaction between nitrogen, organic amendment and microbial inoculation $N_6O_2M_1$ (12.8 g N plant^{-1} + poultry manure + azospirillum) showed maximum plant height, number of branches, DMP, RGR (final stage), canopy spread, number of flowers plant^{-1}, number of fruits plant^{-1}, girth of fruit, length of fruit, yield plant^{-1}, ascorbic acid content of fruit, chlorophyll content of leaf, nitrogen uptake and P_2O_5 uptake. In the case of 50 percent flowering $N_3O_2M_1$ (1.6 g N plant^{-1} + poultry manure + azospirillum) egisterd the minimum number of days. $N_6O_1M_1$ (12.8 g N plant^{-1} + vermicompost + azospirillum) recorded the maximum value for K_2O uptake. From the economic point of view $N_6O_2M_0$ (12.8 g N plant^{-1} + poultry manure + without azospirillum) registered maximum profit pot^{-1}.

16. Practical utility of this investigation is, where little land available and scarcity of water, vegetables can be profitably grown in pots with modified drip irrigation and under integrated nutrient management system.

REFERENCES

REFERENCE

Abusaleha. 1981 .Studies on the effect of organic vs inorganic form of nitrogen on bhindi. *M.Sc.(Horticulture), Thesis, Tamilnadu Agricultural University, Coimbatore*

Ahmed, M.K. 1984. Optimum plant spacing and nitrogen fertilization of sweet pepper in Sudan Gezina. *Acta Hortic.*, 143: 305 - 310.

Ajaykumar and Thekral, K.K. 1993. Effect of herbicides and nitrogen fertilization on growth and yield of chilli (*Capsicum frutescens L.*). Proc. *Indian Soc. Weed. Sci., Weed Sci.* 3: 206-208.

Almazov, B.N. and Kholuyako, L.T. 1990 Change in productivity of a vegetable crop rotation and fertility of leached chernozem soil in relation to application of organic manures and mineral fertilizers on yield and quality of vegetable crops. *Agrokhimiya* : 53-60.

Amritalingam, S. 1988 Studies on the effect of Azospirillum, nitrogen and NAA on growth and yield of chilli (*Capscicum annum L.*) Cv. K-1 S. *Indian Hort*,36 (4) : 218.

Anez,B and Tavira, E.M. 1984. Application of nitrogen and manure to lettuce (*Lactus sativa L.*) *Turrialba* 34(4):527 - 530.

Anonymous, 1985 *Annual Report* . NARP Vellayani: 180.

Balakrishnan, R.1988.Effect of Azospirillum, nitrogen and NAA on growth and yield of chilli. *South Indian Hort.* 36(4): 218.

Balasubramoni, P. 1988. Studies on the effect of Azospirillum and nitrogen on growth and yield of bhindi. (*Ablemoschus esculentus L).*Moench var Pusa Sawani *South Indian Hort.*36(4): 216.

Belichki, J. 1988. Mineral fertilization of *Capsicum annum* for early field production. *Rasteniev "dni Nauki"* 25(6): 56-61.

Blackman, C.A. 1919. Comparitive physiological studies on the growth of field crops. *Ann. Bot.* 11:41-76.

Boparai, B.S., Yadvinder Singh and Sharma B.D. 1992. Effect of green manuring with *Sesbania aculeata* on physical properties of soil and on growth of wheat in rice-wheat and maize - wheat cropping systems in a semi arid region of India. *Arid Soil Res. Rehabilitation* 6(2) : 135-143.

Brown, T.T.1958.Poultry manure, a practical balanced fertilizer.*Poultry digest*,17:108.

Chougule, A. B. and Mahajan, P.R. 1979. Effect of varying levels of plant population, nitrogen, phosphorus and potash on growth and yield of chilli *Veg. Sci.* 6(2):73-80.

Cohen, E.Y.,Okon,J.K.,Nair,I. and Henis, Y. 1980. Increase in dry weight and total N content in *Zea, mays* and *Setaria italica* associated with nitrogen fixing *Azospirillum* spp *Plant physiol*. 66: 746-749.

Dart,P.J, 1986. Nitrogen fixation associated with non-legumes in Agriculture.*Plant and soil*.90:303-304.

*Demirovska, V, Trepeuski, V. Ognenorski, V, Sojnova, M, Agric, R and Simonor D. 1992. The effect of different nitrogen rates on yield and seed quality of Capsicum cultivars *Savremene Poljoprivreda,* 40 (1-2): 45-50.

Dod, V.N. Joshi., Kale, P.B. and Kulwal, L.V. 1983. Effect of different levels of nitrogen in split doses on yield and quality of red ripe chilli (*Capsicum annum L.*) CV G-3. *Proc. Nat. Sem. Prod. Tech. Chillies and Tomato, Tamilnadu Agric.Univ.Coimbatore:* 152-153.

*Dolkova, M.1977.Blgarski plaove Zelenchuts J Koncervi 1. 20-23.

*Dolkova, M, Petronv, K.H. and Rankov, V. 1984. Nutrient uptake from fertilized soil by Capsicum crop. *Gradinarska I Lozarsks Nauka*, 21 (8): 51-57.

*Dolkova,M.,Ralkova,L.and Rankov,V. 1986. Effect of fertilization on the productivity and total nitrogen and nitrate content of capsicum. *Rasteniev "dni Nauki,* 23(6) :70-74.

Donald, C.M. 1962 In search of yield. *J. Aust. Inst. Agr. Sci.* 28:171-178.

Ferriere,M.E.and Cruz,M.C.P.1992.Effect of a compost from municipal wastes digested by earthworms on the dry matter production of maize and on soil properties.*Cientifica.(Jabaticabal)* 20(1) :217-226.

Fertilizer Association of India, 1994. Harnessing biofertilizer potential, *Fert. News.* 39 (4): 9-10.

Gaur,A.C. 1994. Bulky organic manures and crop residues.In *fertnilizers, organic manures, recyclable wastes and biofertilizers.* H.L.S. Tandon (ed). Fert.development and consultation organization.Pomposh enclave,New Delhi:25-31.

*Gianquinto, G. and Borin, M. 1990. Effect of organic and mineral fertilizer application and soil type on the growth and yield of processing tomatoes. *(Lycopersicum esculentum* Mill). *Rivista di Agronomia,* 24(4) :339-348.

Govindan,M. and Purushothaman,D. 1984. Production of phyto hormones by the nitrogen fixing bacteria,Azospirillum.*Agric.Res.J.Kerala*.22: 133.

Goyal, M. R., Guadalupe-Luna, R., Hernandez, E. ,R.DE., Cha Ude. and Baez,C. 1989. Post harvest evaluation of nitrogen fertigated sweet pepper under drip irrigation and plastic mulch. *J.Agric. Univ Puerto Rico.* 73(2) :109-114.

Guar, A. C., Neelakandan, S. and Dargan, K. S.1984. *Organic manures*, ICAR, New Delhi.

Gulati, J.M.L., Mishra, M.M. , Paul, J.C. and Sahu, G.S. 1995. Production potential of chilli *(Capsicum annum* L) under levels of irrigation and nitrogen. *Indian J Agron.* 40(1): 145-146.

Gupta, A. and Rao, G.G. 1979. Studies on the response of Okra *Ablemoschus esulentus* (L) Moench) to nitrogen fertilization and irrigation.*Indian J Hort.* 36(2) : 177.

Hedge, D.M. 1986. Fruit development in sweet pepper (*Capsicum annum L*) in relation to soil moisture and nitrogen fertilization. *Singapore J. Prim. Ind.* 14(1)) : 64-75.

Hedge, D.M. 1987. Growth analysis of bell pepper *(Capsicum annum* L) in relation to soil moisture and nitrogen fertilization. *Scientia Hastic.* 33: 179-187.

Hedge, D.M. 1988. Irrigation and nitrogen requirement of bell pepper. *Indian J Agric. Sci.* 58(9): 669-672.

Irene Vethamoni, P. 1988. Studies on the effect of herbicide, nitrogen and mulching on growth and yield of bhindi *(Abelsmoscus esculentus* (L) Moench) Cv.MDV - 1. S. *Indian Hort.* 36(4): 219.

Ismail, S.A., Seshadri, C.V., Jeeji Bai, N. and Suriyakumar, C.R. 1993 Comparative evaluation of vermicompost, farm yard manure and fertiliser on the yield of chillies (*Capsicum annum*)). Monograph series on the engineering of photosynthetic systems. 35:101-127.

Jackson, M.L. 1973. *Soil Chemical Analysis* (2nd ed) Prentice Hall of India (Pvt) Ltd. New Delhi;1-498.

Jagdeesh,K.S., Geeta,G.S. and Suvarna,C.V. 1994. The effect of biogas spent slurry in combination with chemical nitrogen on rhizosphere micro organism and pod yield of chilli. *South Indian Hort.*42(2):96-101.

Jayaraman, S. and Balasubramanian, R. 1991. Effect of different levels of potassium and nitrogen on yield of irrigated chilli. *Madras Agric. J.* 78(9-12):519-520.

Jiji, T., Dale, D. and Padmaja, P. 1996. Vermicompost reduce the requirement for chemical fertilizers in cowpea and bitterguard. *Abstract National seminar on organic farming and sustainable agriculture*, Oct. 9-11, Banglore.

Joseph, P.A. 1982. Effect of nitrogen, phosphorus and potassium on the growth and yield of chilli, var. Pant C-I. *MSc (Ag) Thesis,Kerala Agricultural University.*

Joseph, P.A.and Pillai, P.B. 1985. Effect of nitrogen,phosphorus and potassium on the growth and yield of chilli, Var.Pant C-1. *Agric. Res.J. Kerala. 23(1): 75-82.*

Jose, D., Shanmughavelu. K.G. and Thamburaj. 1988. Studies on the efficacy of inorganic Vs organic form of nitrogen in brinjal. *Indian J. Hort.* 45(1-2): 100-103.

Kala,R.D. and Krishnamoorthy,R.V. 1981.Enrichment of soil fertility by earthworm activity.*Progress in soil biology and ecology in India.* G.K.Veeresh (Ed.).*USA Tech.Series*,37:64-68.

Kale, R.D., Bano, K., Sreenivasa, M.N., Vinayaka, K. and Bagyaraj, D.J. 1991. Incidence of cellulolytic and lignolytic organisms in the earthworm worked soil, Ibid. 599-604.

Kaminawar, S.P. and Rajagopal, V. 1993. Fertilizer response and nutrient requirements of rainfed chillies in Andhra Pradesh. *Fer. News,* 38(7) 21, 23-26.

Kansal, B. D., Singh, B., Bajaj,K. L. and Kaur, G. 1981. Qualitas Plantarum, 31:163-170

K.A.U. 1987.*Research Report.* 1984-1985. Directorate of Research, Vellanikkara, 89.

K.A.U., 1991. *Research Report.* 1987-1990. Directorate of Research, Vellanikkara. 312-313.

K.A.U. 1991. *Tips on vegetable seed production.* Directorate of Research, Vellanikkara 1-7.

Khamkar, M.G. 1993. Vegetable farming using vermiculture. *Paper presented at congress on traditional sciences and technologies of India. IIT. Bombay.*

Khan, M.A.R. and Suryanarayana, V. 1977. Effect of nitrogen,phosphorus and potassium on flowering, fruit size and yield of chilli var N.P. 46. A. *Veg. Sci* 4(1) : 53-60.

Khawari and Nejad, R. A. 1986. Growth analysis in Hewitt culture solution and fertilised compost under controlled condition. *Acta Horticulture 178:73-78.*

Kulvinder Singh. and Srivastava, B.K. 1988. Effect of various levels of nitrogen and phosphorus on growth and yield of Chilli (*Capsicum annum L.*). *Indian J. Hort.* 45(3-4): 319-324.

Lata, S. and Singh, R.P. 1993. Effect of nitrogen levels and growth regulators on growth, yield and quality of chilli (*Capsicum annum L.*) var Pant C-1. *Veg. Sci.* 20(1): 40-43.

Lehri, L.K. and Mehrotra, C.L. 1972. Effect of Azotobacter inoculation on the yield of vegetable crops. *Indian J.Agric.Res* .9(3)) : 201-204.

Lenka, P.C., Das D.K. and Mishra, H.N. 1989. Effect of nitrogen and phosphorus on seed yield of bhindi C.V. *Prabhanikranti. Orissa Agric. Res.* 2(2): 125-126.

Luchnik, N.A. 1975. Sborrik Nauchnykh Statez Karagand, Gos, S.Kn Opydnor Stantrii.

Majanbu, J.S., Ogunlela, V.B. Ahmed, M.K. and Olarewaju, J.D. 1985 Response of two okra *(Abelmoesculentus (L) Moench)* varieties to fertilizers, yield and yield component as influenced by N and P application. *Fert. Res.* 6(3): 257-267.

Manchandra, A.K. and Bhopal Singh 1987. Effect of plant density and nitrogen on yield and quality of bell pepper (*Capsicum annum L.) Indian J. Hort.* 44(3-4) : 250-252.

*Maurya, K.R. and Dhar N.R. 1983. Effect of different composts on yield and composition of chilli (*Capsicum annum L*) *Annales de Edafologia of Agrobiologia* 42(1/2)) : 183-191.

Mehrotra, C.L. and Lehri, L.K. 1971. Effect of Azotobacter inoculum on crop yields. *J. Indian .Soc .Soil.Sci.*19(3):243-248.

Minhas, R.S. and Sood, A. 1994. Effect of inorganics and organics on the yield and nutrient uptake by three crops in rotation on an acid Alfisol. *J. Indian. Soc. Soil. Sci.* 42(2):257-261.

Mishra, H.P. and Pandey, R.G. 1987. Effect of N and K on the seed production of Okra (*Abelmoschus esulentus mill*) in calcareous soil. *Indian J. Agron.* 32(4): 425-427.

More, S.D. 1994. Effect of farm waste and organic manures on soil properties, nutrient availability and yield of rice-wheat grown sodic vertisol. *J.Ind.Soc.Soil.Sci.* 42(2) :253-256.

Morelock,T.E and Hall, M.R (1980). *Arkane Farm Research* 29:10.

Nair Meena. and Peter, K.V. 1990. Organic, inorganic fertilizers and their combination on yield and storage life of hot chilli. *Veg.Sci.* 17(1) :7-10.

Narasappa, K., Reddy, E.N. and Reddy, V.P. 1985. Effect of nitrogen fertilization on chilli (*Capsicum annum* L) cv.Sindhur .*S.Indian.Hort.*, 33(3) :158-162.

Natarajan, S. 1990 .Standardization of nitrogen application for chilli (*Capsicum annum L.*) grown under semi dry condition *S. Indian. Hort*, 38(6):315-318.

Nazeer Ahmed and Tanki, M.I. 1991 Response of chilli (*Capsicum annum L.*) to nitrogen and phosphorus. *Haryana J. Hort. Sci.*, 20(1-2): 114-118.

Oblisami, G., Natarajan, T., Arumugam, R.and Muthukrishnan,C.R .1977. *South Indian Hort.*. 25:83-84.

Okon ,Y .1985. The physiology of Azospirillum in relation to its utilization as inoculum for promoting growth of plants. In *Nitrogen fixation and CO_2 metabolism*. P.W Ludden and J.E Burris (ed). Elsevier NewYork, U.S.A: 165-174.

Pandey,A. and Kumar, S.1989. Potential of Azospirillum as biofertilizers for up land agriculture. *J. Sci.Ind.Res.*, 48:134-144.

Pandey, D.P., Singh, S.B. and Shashank Singh. 1992. Effect of nitrogen levels and row spacings on growth and yield of autumn - winter chilli (*Capsicum annum L.*) *Narendra Deva J. Agric. Res.*, 7(1): 58-61.

Paramaguru, P. and Natarajan, S.1993. Effect of Azospirillum on the growth and yield of chilli grown under semi dry condition. *South Indian Hort* .41(2) :80-83

Parvatham, A., Vijayan, K.P. and Nazar,A. 1989. Effect of Azospirillum on growth and nutrient uptake of Pusa sawani bhindi. *(Abelmoschus esculentus L Moench) South Indian Hort.*37(4) :227-229.

Paul Gyorgy. and Pearson,W.N. 1967. *The vitamins - Chemistry, philosophy-method.* Academic Press, New York, 2nd ed. vol. VII. 235-238.

Piper, C.S. 1966. *Soil and Plant Analysis.* University of Adelaide, Australia. P.368.

Prabhakar, B.S. Srinivas, K. and Vishnu Shukla. 1987. Growth and yield response of green chilli to nitrogen and phosphorus fertilization. *Indian Cocoa Arecanut Spices J.*, 10(1) : 12-14.

Prabhakar, M. and Naik, L.B. 1993. Effect of irrigation and nitrogen fertilization on growth, yield, nitrogen uptake and water use of chilli (*Capsicum annum L.*) grown for green fruits. *Golden Jubilee Sym. Hort. Res. - Changing Scenario, Bangalore* May 24-28:185.

Prabhakumari,P., Jiji,T. and Padmaja,P.1995. Comparative efficiencies of identified earthworm species for biodegradation of organic wastes. *Proc. 7th Kerala Sci. Congress.* Palakkad, Jan.

Paraminder Singh, Sharma, P.P. and Arya, P.S. 1986. Studies on the effect of nitrogen and potassium on growth, fruit yield and quality of chilli. *Indian Cocoa Arecanut Spices. J.*, 9(3) : 67-79.

Pushpa ,S.1996. Effect of vermicompost on the yield and quality of tomato (*Lycopersicon esculentum Mill*). *M.Sc.(Ag.)thesis. Kerala Agricultural University, Thrissur.*

Rajagopal,A., Muthukrishnan, C.R., and Mohideen, M.K. 1977. Studies on varietal response to nitrogen in chilli. *Madras Agric. J.* 64(10): 659-662.

Rajalekshmi, K. 1996. Effect of vermicompost/vermiculture on physico chemical properties of soil and yield of chilli. *M.Sc. (Ag .) thesis. Kerala Agric. Univ., Thrissur.*

Rajendran, P.C. 1981. Studies on the effect of graded dose of nitrogen, phosphorus and potassium on growth, yield and quality of pumpkin var. CM-14, *M.Sc. (Hort.) thesis. Kerala Agric. Univ., Thrissur.*

Ramachandran ,S. and Subbaiah, K.K. 1981. Studies on the effect of plant density and graded levels of nitrogen on yield and yield components of chillies *(Capsicum annum* L) *S. Indian Hort.*, 29(4): 178-181.

Ramachandran ,S. and Subbiah ,K.K. 1982. Effect of plant density and graded levels of nitrogen on growth attributes of chillies *(Capsicum annum* L) CV.MDV-1. *S. Indian Hort.*, 30; 266-267.

Rao, E.H. and Gulshanlal. 1986. Response of chilli (*Capsicum annum L.*) var. Pant C-1 to varying levels of nitrogen and spacing. *Veg. Sci.*,13(1): 17-21.

Roshni,G.C. 1993. Evaluation of low cost techniques in potted vegetables grown in roof gardens. *M.Sc. (Ag.) thesis, Kerala Agric. Univ., Thrissur.*

Saji John. 1989.Nutrient management in vegetable chilli (*Capsicum annum L.)* var. Jwalasakhi *M.Sc. (Ag.) thesis. Kerala Agric. Univ., Thrissur.*

Sajitharani, T. 1993. Standardization of fertilizer schedule for export oriented production of bhindi [*Abelmoschus esculentus (L.) Moench] M.Sc. (Ag.) thesis, Kerala Agric. Univ., Thrissur.*

Senapati, H.K., Pal, A.K. , Swain, S.K. 1987. Effect of mycorrhiza on the growth characteristics of okra in lateritic soils. *Indian J.Hort. Sci.*, 44:(1-2):93-95.

Shirley,C.M. 1996. Response of vegetable chilli to graded levels of nitrogen and potassium under varying soil moisture levels. *M.Sc. (Ag.) thesis. Kerala Agric. Univ.,Thrissur.*

Sherry Hsiao-Lei Wang, I., Viriginia, Lohr and Coffey L. David 1984. A spent mushroom compost as a soil amendment for vegetables. *J.Am.Soc.Hort. Sci.*, 195(5): 698-702.

Shanmugavelu, K.G. 1989. Production technology of vegetable crops. *Oxford and IBH Co.Pvt.Ltd* :132.

Sheshadri,C.V., Bai Jeeji,N. and Suriyakumar,C.R. 1993. Composting through earthworms. *Monograph series on the engineering of photosynthetic systems* : 23-35.

Shibhila Mary, S., and Balakrishnan,R. 1990. Effect of irrigation, nitrogen and potassium on pod characters and quality in chilli (*Capsicum annum L*) cv. k -2. *S. Indian Hort.*, 38(2): 86-89.

Shinde,S.T., Aple,R.G. and Singh,T. 1977.Influence of Azotobacter on germination of rice and cotton seeds.*Curr.Sci.*, 46:675.

Shrestha,G.K., 1983. Effect of spacing and nitrogen fertilizers. Pusaswani 'Okra' (*Abelmoschus esculentus*) in Nepal Experimental Agriculture., 19 (3): 239-242.

Shukla, B. and Kundu, B.S. 1986. Ammoniacal nitrogen fixation quoted from Yadav, K. *Role of Biofertilizers in nutrient economics on integrated nutrient management for sustainable agriculture.* B.Prasad (Ed): 258-277.

Shukla, V., Srinivas, K. and Prabhakar, B.S. 1987. Response of bell pepper to nitrogen, Phosphorus and potassium fertilization. *Indian J. Hort.*, 44(182): 81-84.

Singh,Kirty and Srivastava,O.P. 1970.Effect of organic manures on soil fertility as shown by nutrient availability and yield response in potato.*Proc.Int.Symp.Soil.Fert.Eval.*New Delhi , 1:815-820.

Singh, K.,Minhas. M.S. and Srivastava, O.P. 1973. studies on the poultry manure in relation to vegetable production II Potato. *Indian J. Hort.*, 30(3-4): 537-541.

Singh, N.P. 1979. Effect of NPK on bhindi [*Ablemoschus esculentus (L) Moench*]. *Prog. Hort.*, 10(4): 21-28.

Singh, M.P., Kashyap, K. and Sharma, C.P. 1986. Effect of foliar spray of urea in bhindi [*Abelmoschus esculentus (L) Moench]. Indian J. Agric. Res.*, 20(2): 90-92.

Singh, K. and Srivastava, B.K. 1988. Effect of various levels of nitrogen and phosphorus on growth and yield of chilli (*Capsicum annum L) Indian. J. Hort.*, 45:19-24.

Smith,R. 1950. Poultry manure a fertilizer. *Poultry Digest*,9:550-551.

Smith, R.L., Sehak, S.C., Bonton, J.H. and Qusenberry, K.H. 1978. Yield increase of tropical grasses after inoculation with *Azospirillum lipoferum. Ecol. Ball.* (Stockholm)., 26: 380-385.

Snedecor,G.W. and Cochran, W. G. 1967. *Statistical Methods.* (6th ed.). Oxford and IBH publishing Co. Calcutta 16: 349-351.

Splittstoesser,W.E. and Gerber,J.M. 1986. Response of bell pepper to high rates of side dressed nitrogen. *Proc. Inter American Soc. Trop. Hort.*, 30: 171-176.

Song,S.J. 1987. Studies on the time of applying nitrogen fertilizer to capsicums. *Acta. Hortic. Sinica*, 14(8): 185-191.

Srinivas, K. and Prabhakar, B.S. 1982. Response of capsicum to nitrogen fertilization. *Veg. Sci.*, 9(2): 71-74.

Srinivas, K. 1983. Response of green chilli to nitrogen and phosphorus fertilization. *South.Indian. Hort.*, 31(1):37-39.

Starnes,W.J.and Hadley,H.H. 1965. Chlorophyll content of various strains of soyabeans. *Crop.Sci.*, 5: 9-11.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Current Sci.* 25(8) :259-260.

Subbiah, K., Helkian, J., Ravikumar, V. and Rajagopal, C.K. 1982. Effect of combined applicationn of organic and inorganic fertilizer in yield of nutrient uptake of chilli. MDU-1. *South Indian Hort.*, 30(1) :45-47.

Subbiah, K., Sundararajan, S. and Muthuswami, S. 1983. *South Indian Hort.*, 31: 287-290.

Subbiah, K. 1990. Nitrogen and Azospirillum interaction on fruit yield and nitrogen use efficiency in tomato. *South Indian Hort.*, 38(6): 342-344.

Subbiah, K. 1991. Studies on the effect of nitrogen and Azospirillum in Okra. *South Indian Hort.*, 39(1):37-44.

Subbiah, K. 1993. Effect of biofertilizers in the presence of nitrogen and potassium on yield in chilli and bellary onion. *Golden jubilee sym. Hort. Res. Changing scenario, Bangalore,* May 24-26, P. 129.

Subbiah, K. and Sundararajan, S. 1993. Influence of organic and inorganic fertilizers on the yield and nutrient uptake in bhindi. MDU-1.*Madras Agric. J.*, 80: 25-27.

Subbiah,K.1994. Effect of nitrogen, potassium and biofertilizers on yield and nutrient uptake in chilli and bellary onion. *Madras Agric. J.*, 81(5): 277-279.

Subhani, F.M., Ravisankar, C. and Narayana, N. 1990. Effect of graded levels and time of application of nitrogen and potassium on flowering, fruiting and yield of irrigated chilli. *Indian Cocoa Arecanut Spices. J* 14(2) :70-73

Subramonian. 1980. Effect of graded doses of nitrogen phosphorus and potassium on growth, yield and quality of bhindi *[Abelmoschous esculentus (L) Moench Var.Co]. M.Sc. (Ag.) thesis, Kerala Agric. Univ.,Thrissur.*

Sukhada Mohandas. 1987. Field responsse of tomato to inoculation with VAM fungus *Glomus fasciculatum* and *Azotobacter vinelandi. Plant and soil*, 98:295-297.

Sundra Rao, W.V.B., Mann, H.S., Pal, N.B. and Mathur, R.S. 1963. Bacterial inoculation experiments with special reference to Azotobacter. *Indian J.Agric.Sci.,* 33:279-290.

Sutapradia, H. 1979. *Bulletin Penelitan Hortikultura*. 7: 9-13

Sundstrom, F.J., Thomas, C. H., Edwards, R.L. and Baskin, G.R. 1984. Influence of nitrogen and plant spacing on mechanically harvested tobacco pepper. *J. Amer. Soc. Hort.,* 109 (5): 642-645.

Tapia, M.L. and Dabed, R. 1984. Nutrients uptake by sweet pepper grown in quartz. *Proc. IX Int.Cong. Soilless Culture, Luntern*, ISOSC, 683-696.

Thiagarajan, C.P. 1990. Influence of nitrogen, phosphorus and potassium on the yield and quality of chilli seed. *S. Indian Hort.,* 38(3): 159-160.

Thomas, M.B. and Leong, A.G.B. 1984. The effect of shade and nitrogen on production of container grown ornamental peppers (*Capsicum annum L.*). *Annual J. Royal Newzealand Ins. Hort.*, 12: 57-67.

Tien, T.M., Gaskins, M.H. and Hubbel, D.H. 1979. Plant growth substances produced by *Azospirillum brasilience* and their effect on the growth of pearl millet (*Pennisetum americanum*). *Appl. Environ. Microbiol.*, 37:1016-1024.

Tisdale,S.L., Nelson.W.L. and Beaton,J.D. 1985. *Soil Fertility and Fertilizers*. Mac Millan Publishing Co., Inc. New York, 4th ed:1-733.

Tomar, S. and Rathore, S.S. 1988. Studies on relationship of growth and sink parameters with nitrogen and duration of picking intervals on yield in Okra [*Abelmoschus esculentus (L).Moench]. Gujarat.Agrl. Univ.Res.Journal.*,13(2) PP.8-11.

Ushakumari, K., Prabhakumari, P. and Padmaja, P. 1996. Seasonal response of bhindi *(Abelmoschus esculentus)* to vermicompost/vermi culture. *National seminar on organic farming and sustainable agriculture*, Oct 9-11, Bangalore.

Wam, P.V. and Konde, B.K. 1986. A study on Azospirillum a review. *J.Maharashtra University.*, 11(3) :203.

Wani, S.P. 1990. Inoculation with associative nitrogen fixing bacteria; Role in cereal grain production improvement. *Indian J. Microbial.*, 30:363-393

Wankhade, B.N. and Morey, D.K. 1986. Effect of levels of irrigation, nitrogen and potash on the growth and yield of chilli *(Capsicum annum L.). Punjabrac krishi vidyapeeth Res. J.*, 8(2): 22-25.

Waterer, D.R. and Coltman, R.R. 1989. Response of mycorrhizal bell peppers to inoculation timing, P and water stress *Hort.Sci.*, 24(4): 688-690.

Yoshida, K., Mosi, S. , Hasegawa, K., Nishizaws, N. and Kumazawa, K. 1984. *J. Jap. Soci. Nutri. Food Sci.*, 37:267-272.

Zachariah,A.S. 1995.Vermicomposting of vegetable garbage. *M.Sc.(Ag.) thesis, Kerala Agri. Univ. Thrissur.*

Zayed, E.A., Eh-Zawily, A.I. and Nofal, E.S. 1985. Studies on growth, productivity and some physiological aspects of hot pepper (*Capsicum annum L.*) var.Red Cherry. I.Effects of interaction between morphactin, GA and nitrogen, phosphorus and potassium fertilization. *J.Agric.Sci.Mansouria Univ.*, 10(1): 191-198.

Zhang, C. L., Zhang, Y. D., Gao,Z. M., Xu, G. H., Wang, L.Y. and Zhou, Q. S. 1988. Effect of combined use of organic and inorganic fertilizers on the yield and quality of tomato. *J. Soil. Sci. China 19 (6): 276-278.*

* *Original not seen*

APPENDICES

APPENDIX - I

Meteorological data during the cropping period

Period	Standard Week	Rainfall (mm)	Maximum temperature (°C)	Minimum Temperature (°C)	Relative Humidity (%)	Evaporation (mm)
12	50	-	30.5	21.1	78.5	2.4
	51	-	31.5	23.1	81.5	1.5
	52	-	31.8	22.0	77.2	1.8
1	1		31.8	22.6	80.4	3.4
	2	1.2	32.0	23.2	74.7	3.5
	3		30.9	23.1	81.4	3.8
	4		30.9	21.5	73.8	3.4
	5		31.8	22.7	70.8	4.0
2	6		32.2	23.0	69.5	4.0
	7		31.3	23.2	73.5	3.7
	8		31.9	23.0	72.6	4.8
	9		31.9	27.7	72.4	4.2
3	10		32.2	19.8	74.6	5.5
	11	0.5	32.5	23.5	70.8	5.4
	12		33.3	23.4	69.8	5.0
	13		33.5	25.5	72.5	5.3

ABSTRACT

NITROGEN MANAGEMENT IN VEGETABLE CHILLI GROWN IN POTS WITH MODIFIED DRIP IRRIGATION SYSTEM

BY

ANITHA V. B.Sc. (Ag.)

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE,
KERALA AGRICULTURAL UNIVERSITY

Department of Agronomy
College of Agriculture
Vellayani, Thiruvananthapuram

1997

ABSTRACT

A pot culture study was conducted at the College of Agriculture, Vellayani to assess the effect of level of nitrogen, organic amendments and Azospirillum inoculation on the growth and productivity of vegetable chilli grown in pots under modified drip system of irrigation. The experiment was conducted with chilli cultivar 'Jwalamukhi' as test crop. The treatment included seven levels of nitrogen (N_0 - 0.0, N_1 -0.4, N_2 - 0.8, N_3 - 1.6, N_4 - 3.2, N_5 - 6.4 and N_6 - 12.8 g plant-^{1}) three types of organic amendment application (O_0 - Control, O_1 - Vermicompost @ 200 g plant $^{-1}$, O_2 - Poultry manure @ 100 g plant $^{-1}$) and 2 types of microbial inoculation (M_0 - No inoculation and M_1 - Azospirillum inoculation). Potting mixture preapred by mixing sand, soil and cowdung in 1:1:1 proportion by weight was used in the rooting medium. The medium was low in available nitrogen, medium in available phosphorus and low in available potassium. The irrigation was provided by modified drip system @ 1.5 litre of water plant^{-1} day^{-1}. The experiment was laid out in completely randomised design with three replications. The results of the investigation are summarised below.

Plant height, number of branches, DMP, canopy spread and RGR at different growth stages differed significantly with levels of nitrogen, application of different types of organic amendments and microbial inoculation. All these parameters were better under N_6 level of nitrogen, application of poultry manure and with Azospirillum inoculation. Time of 50 percent flowering was minimised by N_3 level of nitrogen, with poultry manure application and with Azospirillum inoculation. Other yield parameters like number of flowers plant^{-1}, fruits plant^{-1} , fruit girth and fruit length were better under N_6 level of nitrogen, with poultry manure application and with Azospirillum inoculation.

Maximum yield was obtained for N_6 level of nitrogen, with poultry manure application and with Azospirillum inoculation.

Uptake of N and P by plant was maximum at N_6 level of nitrogen, with poultry manure application and with Azospirillum inoculation. But in the case of K uptake it was maximum at N_6 level, with vermicompost application and with Azospirillum inoculation.

Profit pot^{-1} was maximum at N_6 level of nitrogen, with poultry manure application and without microbial inoculation.

The interaction between nitrogen, organic amendment and microbial inoculation $N_6O_2M_1$ registered maximum value for plant height, number of branches $plant^{-1}$, RGR (final stage, DMP, canopy spread, number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, ascorbic content of fruit, chlorophyll content of leaf, N uptake and P_2O_5 uptake. In the case of 50 percent flowering $N_3O_2M_1$ showed the minimum number of days. $N_6O_1M_1$ recorded the maximum value for K_2O uptake. $N_6O_2M_0$ registered maximum profit pot^{-1}.

Practical utility of this experiment is, where little land is available and scarcity of water, vegetables can be profitably grown in pots with modified drip irrigation and under integrated nutrient management system.