INTEGRATED NUTRIENT MANAGEMENT IN SPINE GOURD (*Momordica dioica* Roxb.)

A THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY,
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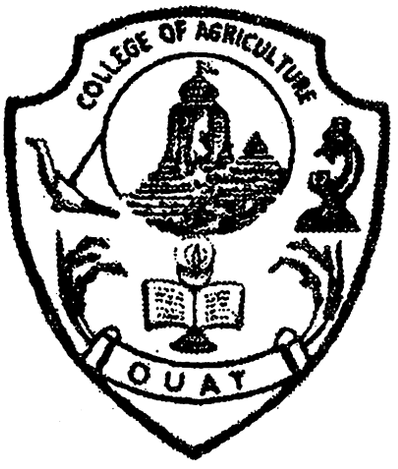
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(HORTICULTURE)

By
Debi Archana Nayak



DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR, ORISSA
2009

THESIS ADVISOR: **DR. P. MAHAPATRA**

Dedicated to my

Dearest

Maa and Bapa

ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE

Dr. P. Mahapatra
Professor

Dated 5/9/09

CERTIFICATE- I

This is to certify that the thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT IN SPINE GOURD (*Momordica dioica* Roxb.)"** submitted for the award of Degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **HORTICULTURE** of the Orissa University of Agriculture and Technology, Bhubaneswar is a faithful record of bonafide and original research work carried out by **DEBI ARCHANA NAYAK** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation has been fully acknowledged.

Place: Bhubaneswar
Date: 5/9/09

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CERTIFICATE – II

This is to certify that the thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT IN SPINE GOURD (*Momordica dioica* Roxb.)"** submitted by **DEBI ARCHANA NAYAK** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the award of Degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject **HORTICULTURE** has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with an External Examiner.

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ABSTRACT

A study entitled " **INTEGRATED NUTRIENT MANAGEMENT IN SPINEGOURD (*Momordica dioica* Roxb.)** " was carried out with the sole purpose of studying the affect of biofertilizers, inorganic fertilizer levels and amendment on the growth, yield and quality of spine gourd and the most appropriate combinations which could be considered for the commercial cultivation of the crops under Bhubaneswar agro-climatic conditions. Application of different levels of inorganic fertilizer in combination with biofertilizer and amendment increased the yield of fruits, fruits per plant and there by, increasing the yield per hectare. Maximum yield (53.43 q/ha) was recorded using the recommended dose of chemical fertilizers with biofertilizers and amendment. The highest yield under this treatment was the sum of the affect of the yield attributing characters particularly number of fruits per plant, individual fruit weight, fruit length and fruit girth etc. Other biometric observations also exhibited higher value because of the fact that the growth characters topped the list. The maximum plant height, number of braches per plant, number of leaves per plant and leaf area was also recorded higher value under this treatment. Yield per unit area have also increased significantly over control by applying chemical fertilizers but the combined affect of chemical fertilizers along with bio fertilizer and amendment produced the highest yield where biofertilizers have boosted the yield attributing characters to exhibit maximum level.

So far the investigation on the aspect of uptake of nutrients particularly nitrogen, phosphorous and potash are concerned, spine gourd plants treated with biofertilizers + chemical fertilizers + amendments produced higher yield which is significantly superior than the control due to maximum utilization of N, P, K resulted increased vegetative growth which has been reflected in higher foliage production, taller plant, more production of fruits and finally the yield.

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ABBREVIATIONS

Kg	:	kilogram
g	:	gram
mg	:	milligram
m	:	meter
cm	:	centimeter
mm	:	millimeter
l	:	litre
t/ha	:	Tonnes per hectare
q/ha	:	Quintals per hectare
°C	:	Degree centigrade
%	:	percentage
@	:	At the rate of
DAS	:	Days after sowing
DAT	:	Days after transplanting
df	:	Degree of freedom
S.S.	:	Sum of square
M.S.S.	:	Mean sum of square
F(Cal)	:	F (Calculated Value)
SE m(±)	:	Standard error mean
C.D.	:	Critical difference
Fig.	:	Figure

Chapter-1

Symbiotic association between leguminous plant and nodule forming bacteria have already been established and has been estimated to fix atmospheric nitrogen ranging from 50-360 kg/ha in agricultural fields and the remaining being contributed by other symbiotic and non-symbiotic means. The rod shaped bacteria viz. *Azotobacter* and *Azospirillum* which can add a substantial amount of nitrogen in case of non-legumes have been identified. The *Azospirillum* produce growth promoting, anti-fungal and anti-bacterial substances which prevent the plant root from fungal and bacterial infection. These organism synthesize and secrete thiamine, riboflavin, pyridoxine, cyanocobalamine, nicotinic acid, pentothenic acid, IAA and GA which directly influenced the germination of the seed, growth of the plant and yield . On the other hand the phosphate solubilizing microorganisms possess the ability to convert insoluble phosphate into soluble from by secreting different organic acids and bring about dissolution of bound form of phosphate to available form. Pandey *et al.* (1998) reported significant effect of biofertilizers in vegetable crops up to the extent of 10-40 % and 8-36 % when symbiotic and non-symbiotic nitrogen fixers were inoculated alone and along with PSM respectively. Encouraging results in yield were also observed by applying lower dose of chemical fertilizers.

The quality of the vegetables was also improved with the application of biofertilizers. There was an increase of 10-30 % crude protein, 15-35 % phosphorus. 10-15 % potassium content as well as vitamin C when these symbionts were applied alone or with PSM.

The research work on the effect of biofertilizers on spine gourd crop in Orissa is scanty. No systematic guideline has been generated scientifically till today. Keeping the above background in view, the present study "Integrated Nutrient Management□ in spine gourd (*Momordica dioica* Roxb.) was

INTRODUCTION

Green Revolution as coined by Dr. Willium Gaud of the U.S. Department of Agriculture (1968) which has been associated with higher production accomplished through enhanced productivity, the successful translation of this concept no doubt help a lot increasing the 'Begging Bowl' image of Indian subcontinent. However, for improving the productivity by adoption of modern production technology has created unprecedented pressure on the limited natural resource base which ultimately disturbs the ecology, thereby affecting the social scenario too. Indiscriminate, injudicious and improper use of chemical fertilizers and pesticides, apart from causing serious damage to the environment, have also threatened the health of millions. Under such a predicament, Dr. M. S. Swaminathan advocated to launch an evergreen revolution that can help to increase not only the yield but also the income from the available land, water and labour resource without having any adverse impact on ecological and social scenario.

It is needless to emphasize the contribution of vegetable in the human dietary schedule for the purpose of complementing and supplementing nutrients, minerals and vitamins vis-à-vis providing carbohydrates and fibers. India has the credibility of producing 90 million tonnes of vegetables per annum, positioning 2nd among the vegetable producing countries of the world. The productivity and per capita availability of vegetables in India is also low as 160g against 285g as per recommendation (Hindu Survey of Indian agriculture, 2002). Further projections indicate the need of 110 million tonnes of vegetables in the beginning of 3rd millennium raising per capital availability of vegetables to the tune of 200g .Swarup (1998) has estimated the need of 250 million tonnes of vegetables for India by the year 2020 A.D.

The target of vegetable production is achievable through increasing vegetable area, enhancing productivity per unit area and also per unit time. At present India's productivity is 13.0 tonnes per hectare which is very low and there is a need for targeting 20 tonnes per hectare. A pragmatic break through has been realized else where through development of new cultivars with high genetic yield potentiality, multiple resistance, better organoleptic quality and prolonged storability. Among the possibilities, cultivation of better type vegetables using advanced technology is the solution for enhancing the productivity of the crop.

Nutrient management practice, adopted at present for different horticultural crops, forms important part of the production technology, also needs to be recognized taking the logic of "Integrated Nutrient Management □ concept, so as to sustain the productivity of the crop and also to safeguard the environment. Increased fertilizer cost and possibility of environmental pollution due to fertilizer runoff, necessitated the use of biofertilizer for the fertility management programme. The use of biofertilizer started since mid eighties and thereafter, it has become an important component of nutrient management strategies in different agri-horticultural crops.

Biofertilizers are the micro organisms capable of fixing atmospheric nitrogen, solubilizing phosphorus from non-usable form to usable form through biological process. Biofertilizers are economically lucrative, ecologically sound and are also self generating sources without any negative influence on environment. They do not require non-renewable energy in huge quantities during their production and improve crop growth as well as the quality of the produce. These are also biocontrol agents as they control many pathogens and micro-organisms. The beneficial microbes are the biological nitrogen fixers (*Azotobacter, Azospirillum*, BGA, *Azolla* and *Rhizobium*), Phosphate solubulizing microbes (PSM) and nutrient mobilizers (Mycorrhizal fungi) in the soil which are of great significance to different horticultural crops.

Symbiotic association between leguminous plant and nodule forming bacteria have already been established and has been estimated to fix atmospheric nitrogen ranging from 50-360 kg/ha in agricultural fields and the remaining being contributed by other symbiotic and non-symbiotic means. The rod shaped bacteria viz. *Azotobacter* and *Azospirillum* which can add a substantial amount of nitrogen in case of non-legumes have been identified. The *Azospirillum* produce growth promoting, anti-fungal and anti-bacterial substances which prevent the plant root from fungal and bacterial infection. These organism synthesize and secrete thiamine, riboflavin, pyridoxine, cyanocobalamine, nicotinic acid, pentothenic acid, IAA and GA which directly influenced the germination of the seed, growth of the plant and yield . On the other hand the phosphate solubilizing microorganisms possess the ability to convert insoluble phosphate into soluble from by secreting different organic acids and bring about dissolution of bound form of phosphate to available form. Pandey *et al.* (1998) reported significant effect of biofertilizers in vegetable crops up to the extent of 10-40 % and 8-36 % when symbiotic and non-symbiotic nitrogen fixers were inoculated alone and along with PSM respectively. Encouraging results in yield were also observed by applying lower dose of chemical fertilizers.

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The research work on the effect of biofertilizers on spine gourd crop in Orissa is scanty. No systematic guideline has been generated scientifically till today. Keeping the above background in view, the present study "Integrated Nutrient Management□ in spine gourd (*Momordica dioica* Roxb.) was

undertaken in the campus of College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar during Kharif season of 2008 with the following objectives:

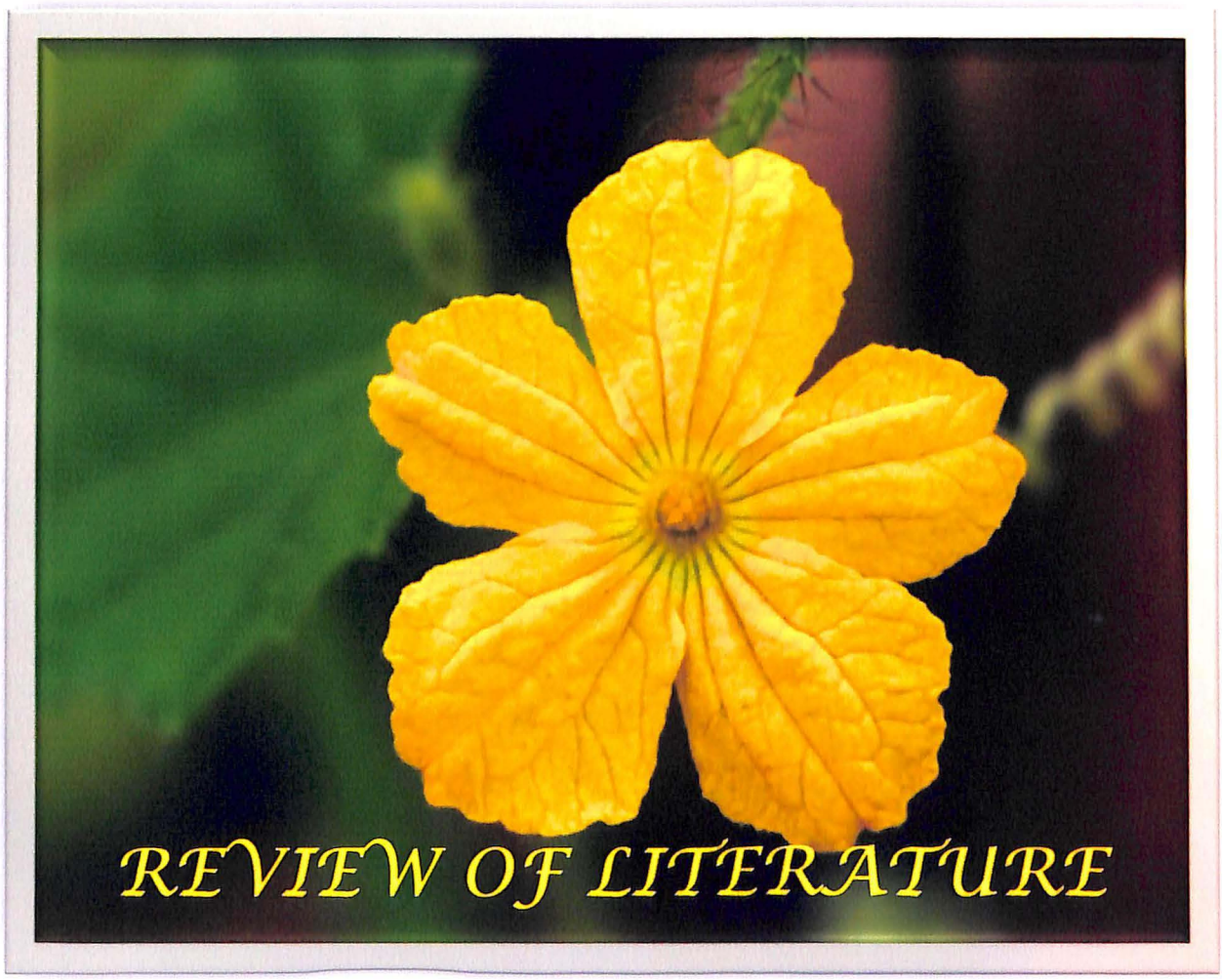
i) To study effect of chemical fertilizers with or without biofertilizers on the growth, yield of spine gourd crop.

ii) To study the nutrient uptake and recovery by the spine gourd crop.

iii) To study the effect of integrated nutrient management on quality of the produce.

iv) To study the effect of INM and post harvest soil properties.

Chapter-2



REVIEW OF LITERATURE

The research workers working in biofertilizer use in different vegetable crops, to keep himself abreast of the detail aspects of literature available in the relevant line of research to establish his own research findings. The production technology of spine gourd has taken a paradigm shift in recent years so far as nutrient management is concerned. The recent trend of integrated nutrient management emphasizes on minimal use of inorganic inputs and substituting it with different organic components like organic manures, biofertilizers etc. It is a well known fact that different biofertilizer can supplement a sizeable quantity of chemical fertilizers which is ultimately available to the crop. Different biofertilizers can supply lot of nitrogen, phosphorus and potash to the crops. Lot of literatures are also available emphasizing on the facts that application of biofertilizer, improves the quality of the economic product of the vegetable crops and protect the plant from the incidence of pests and diseases, apart from nutrient supplement. The present chapter is just a cross-section of an attempt made to have a thorough review of literature contributing to the knowledge of growth and yield of spine gourd and other cucurbitaceous vegetables on their effect of biofertilizers as well as chemical fertilizers.

Spine gourd

Tripathy *et al.* (1993) investigated the effect of N, P and K at 0, 30, 60 and 90 kg/ha level on the stem cuttings of spine gourd planted in the field and found that N, P_2O_5, K_2O each at 90 kg/ha resulted in the highest number of nodes and leaves per plant. Plant height and leaf area were greater with N, P_2O_5, K_2O each at 60 kg/ha level while highest yield and largest fruit were produced with each at 30 kg/ha.

Tripathy *et al.* (1994) studied the propagation in spine gourd (*Momordica dioica* Roxb.) An experiment was conducted at Bhubaneswar during 1990 to find out the type of cuttings, node number and levels of NPK mixture for getting better growth and yield of spine gourd. Fruit yield was better with basal cuttings. Two and three node cuttings were equally good. On kg/ha basis, the level $N_{30}P_{30}$ K_{30} was best for higher fruit yield. Fruit yield was highly and positively correlated with plant height, leaf area, fruits per plant and fruit weight.

Goswami and Sharma (1997) studied the effect of phosphorus on growth, yield and quality of spine gourd *(Momordica dioica* Roxb.) in a trial at Jorhat, Assam. P_2O_5 was applied at 0, 20, 40 or 60 kg/ha to plant of a local cultivar grown in raised beds on an acidic sandy loam soils. Fruit yield increased as P_2O_5 rates increased. The ascorbic acid content was highest when P_2O_5 was applied at 40 kg/ha.

Cucumber

L.G. Villegas (1982) studied organic and inorganic fertilizers and their combinations on growth and yield of Cucumber. This study was conducted in the Philippines to determine the response of cucumber to chicken manure, burned rice hull and urea applied as fertilizer singly or in combination with each other. The study also sought to evaluate the effect of organic and inorganic fertilizers on the chemical properties of the soil.

Alan (1984) studied the effect of N concentration on the mineral content of cucumber plants grown in solution culture and reported that fruit yield and N contents of stems, leaves and roots increased with increase in N concentration in the solution but P and K contents in all the plant parts decreased.

Forbes and White (1986) reported that side dressing of N and K at 90-135 kg/ha gave high yield of slicer cucumber in central Florida during both spring and autumn.

Bolotskikh and Leivi (1987) got the highest yield of cucumber (28.2 t/ha) and also the economic return with the application of 90 kg N_2, 60 kg each of P_2O_5 and K_2O and 40 tonnes of FYM per hectare in a plant density of 15,000/ha.

Maurya (1987) studied the effect of nutrients on sex expression and affecting the yield and quality of cucumber and reported that the highest number of female flowers and yield (242.26 q/ha) and best fruit quality were obtained with 80 kg N/ha plus Boron (0.25 % foliar spray at 6 leaf stage and again at flower bud initiation) application.

Tondon (1987) recommended the following dose of chemical fertilizers for muskmelon and cucumber in different states of India.

Sl. No.	Name of the states	Muskmelon (Nutrients kg/ha)			Cucumber (Nutrients kg/ha)		
		N	P	K	N	P	K
1	Punjab	125	62	62	100	50	50
2	Haryana	50	25	25	-	-	-
3	Karnataka	100	75	50	60	0	50
4	Himachal Pradesh	-	-	-	100	50	50
5	Uttar Pradesh	80	75	50	-	-	-
6	Tamil Nadu	80	60	30	35	0	0
7	Maharashtra	-	-	-	50	40	0
8	Rajasthan	80	60	40	-	-	-
9	Orissa	-	-	-	50	30	75

Alan (1989) made an exhaustive study on cucumber to ascertain the effect of nitrogen nutrition and reported that nitrate significantly increased the dry weight of fruits, leaves and roots whereas ammonium decreased it. The N content of the fruits, leaves, stems and roots and the P content of the fruits, leaves and stems significantly increased when 50 % or more of N source was NH_4 but NO_3 decreased the N and P contents of all plant parts. With 100% NO_3, there was an increase in the K and Mg contents of the fruits and a large increase in the Ca levels in the fruits, leaves, stems and roots. Supplying 50 % or more of N as urea significantly increased the N content of the leaves and roots and P content of all tissues, the K content of the fruits and the Mg content of the fruits and leaves. Ammonium as N from decreased the K, Ca and Mg contents of all tissues. Ammonium toxicity and necrotic effects of urea were observed when these N sources represented more than 50% of N in the nutrient solution.

Csermi *et al.* (1990) got the best result from cucumber with 120 kg N, 90 kg P and 180 kg K/ha.

Um-ye *et al.* (1994) studied the effect of N (200, 400, 600 or 800 kg/ha) and K (200, 400, 600 or 800 kg/ha) top dressing on the growth, quality and yield of 2 cucumber cultivars and found the best performance by the application of N and K both @ 600 kg/ha.

J.M.Stephens and S.R.Kostewicz (1994) studied the response of cucumber Cv. Poinsett 76 to organic soil amendments. Amendments (Sheep litter, fresh chicken litter, composted poultry manure, commercial organic fertilizer, yard waste compost and combinations) were applied at a high and low rate. Highest (44 fruits/plant) yields were observed with the combination of sheep + poultry + yard waste compost. Lowest yields (8-10 fruits/plant) were obtained where yard waste compost was applied alone.

Ismail *et al.* (1994) studied the effect of composted materials on soil properties, nutrient status and yield of cucumber. Different vegetable residues and chicken feathers were used as raw organic materials. Data reveals that application of 2.5 kg/m^2 of both types of composted materials slightly increased pH values while application of 2 % of such materials increased TSS, Fe and Mg. Application of composted feather materials increased dry weight and content of macro and micronutrients in cucumber plants in comparison with composted vegetable residues (tomato + marrow + artichoke) or mineral fertilizers. Application of 5 kg/m^2 of composted feather materials increase the number and weight of fruits per plant.

Liu Minchi and Chen Diankui (1996) reported that with high rate of nitrogen, cucumber yield showed no further increase but the nitrate accumulation in the fruit continued to increase.

Shousen Yan *et al.* (1996) studied the effect of N forms on growth and sex expression in cucumber and the result showed that vegetative growth was best with 100% NO_3-N when NH_4+ N was 25 % or 50 % of the total N, reproductive growth was promoted, the height of the first female flower was decreased and the percentage of female flowers and the yield/plant were increased compared to the plants receiving 100 % NO_3-N .The mineral content of the leaves was also affected by N source and the young plants were also sensitive to NH_4^+ than the older ones.

Z.Lamrani *et al.* (1996) studied influence of N, P and K on pigment concentration in cucumber leaves. Different doses of N (N_1 = 5g/m^2, N_2 = 10g/m^2, N_3 = 20 g/m^2, N_4 = 40 g/m_2) as NH_4NO_3, P(P_1 = 7g/m^2, P_2 = 14 g/m^2) as H_3PO_4 and K(K_1 = 20 g/m^2; K_2 = 40 g/m^2) as K_2SO_4 was applied together with organic matter and a micronutrients solution to cucumber plants and the leaves were assayed for their chlorophyll a and b, carotene and licopene contents. Results showed that N affected the pigment content, specially the

photosynthetic pigments (Chlorophyll a and chlorophyll b).High doses of P acted negatively on all the pigments studied while higher doses of K acted positively on chlorophyll a and carotene pigments and chlorophyll b did not vary significantly due to the K doses.

Pinamonti *et al.* (1997) evaluated the compost prepared from bark and sewage sludge amendment for 4 growing media i.e., Rock wool, white peat, 8:7:5 mix of white peat and rice chap, used in soil less cultivation in cucumber, tomato, straw berry and gerbera and found that white peat is better in all the above crops. Further more, the use of the compost did not lead to dangerous increase in the content of heavy metals (Zn, Cu, Ni, Pd, Cd and Cr) in the fruits of the species tested.

Premalakshmi *et al.* (1997) observed that the application of nitrogen at 150 kg and potassium at 100 kg/ha in *Cucumis sativus* recorded significantly higher vine length, more number of leaves and higher number of branches than control and low level of N and K at 50:50 kg/ha. Application of N and K did not have any effect on number of days taken for appearance of first pistillate flower. Application of N and K at 50:50 kg/ha recorded the earlier appearance of pistillate flowers. Plots received N and K at 150:50 and 150:100 kg/ha recorded more number of pistillate flowers per vine as compared to vines received N and K at 50:50 kg/ha and without N and K. Number and weight of fruits per vine were also increased due to application of N and K at 150:100 kg/ha as compared to other treatments. The vines which received N and K at 50:50 kg/ha produced maximum number of fruits and low weight of fruits per vine. Crude fibre content of fruits were more in both the seasons (June-August, Dec-March) due to application of N and K 150:100 kg/ha as compared to lower level of N and K or without application of N and K.

Patil *et al.* (1998b) reported that sex ratio and yield of cucumber cv. Himangi was significantly influenced by major nutrients *viz.*, nitrogen,

phosphorus and potash. Maximum number of staminate flowers were produced with 200 kg N+ 50 kg P_2O_5 + 50 kg K_2O per hectare, while the highest number of pistillate flowers were recorded with 50 kg N + 50 kg K_2O per hectare. More number of fruits as well as high average fruit yield per vine was obtained from 150 kg N + 50 kg P_2O_5 + 50 kg K_2O per hectare.

Sainz *et al.* (1998) studied growth, mineral nutrition and mycorrhizal colonization of cucumber plants grown in a soil amended with composted urban wastes. Results showed that neither mycorrhizal plant species grew when soil was mixed with composted urban waste or when compost was used as the only substrate. However, amendment of soil with 10 or 50 % vermicompost significantly increased dry matter yields of cucumber plants, compared to treatments where soil was the only substrate.

Moreno *et al.* (1998) studied the yield of cucumber (*Cucumis sativus,* Cv. Brunox F.) Fertilized with N, P and K. Cucumber plants were grown in containers in a loamy sandy soil under controlled greenhouse condition. Treatments were 4 rates of N (N1-4=5, 10, 20 and 40 g/m) as NH_4NO_3, 2 rates of P (P1-2=8 and 16g/m) as H_2PO_4 and 2 rates of K (K1-2=20 and 40 g/m) as KSO_4. All pots were covered with a 2 cm deep layer of manure. Comparison of yields showed that moderate N rates promoted positive and highly significant effect. Both P and K at high rates and negative effects. The best nutrient combinations to promote cucumber yield under these experimental conditions were with N-10g, P_2O_5-8g and K_2O-20g per square meter.

Altunlu *et al.* (1999) studied the effect of N and K on growth, yield and fruit quality in cucumber grown in perlite and found that nitrogen concentration at 200 ppm and K concentration in between 200-300 ppm was found to be profitable for cucumber production.

Onder Turkmen *et al.* (2000) studied effect of K on emergence and seedling growth of cucumber grown in salty conditions. K doses of 0, 75, 150 and 300 mg/kg were applied in to the seedling growing media consist of 0, 10, 20 and 30 mm of NaCl. It was found that increasing amount of K and NaCl generally affected the cucumber emergence and seedling growth negatively.

Valentine *et al.* (2001) studied the interactions between phosphorus supply and total nutrient availability on arbuscular mycorrhizal (*Glomus mosseae)* colonization, growth and photosynthesis of cucumber, with three different nutrient solutions. These were high P + high concentrations of the other essential nutrients, low P + high concentrations of other nutrients and low P + low concentrations of other nutrients. Plants grown at low P with high concentrations of other nutrients had the highest AM infection, and a higher biomass due to an enhanced maximum net photosynthetic rate. Overall the present study indicates that any advantages or disadvantages associated with AM infection in cucumber are a result of complex interactions between P supply and the availability of other essential nutrients.

Sahar Tanweer *et al.* (2003) studied the effect of seedling age (21 days, 28 days and 35 days after germination and different levels of P (45, 90 and 135 kg/ha) on growth and yield of cucumber. Results indicated that highest survival percentage (100.00 per cent, position of first female reproductive node (3.00), female to male flower percentage (48.10 %), number of fruits per plant (14.33), fruit yield per plant (1.72 kg) and fruit yield per hectare (67270 kg) were obtained with 28 days seedling age + 90 kg P_2O_5/ha. The maximum number of leaves per plant (35.00) and individual fruit weight (138.67 g) were recorded with 21 days seedling age + 90 kg P_2O_5/ha.

J.C. Zambrano *et al.* (2003) studied growth and yield of cucumber plants with different rates of fertilizer. Three rates of NPK fertilizers (60:40:30, 120:80:60 and 240:160:120 kg NPK/ha) were applied. The lowest fertilizer

rate negatively affected the growth, dry weight leaf area, yield and fruit size. The medium and high rates had comparable results, although the medium rate tended to bè better.

Umamaheswarappa *et al.* (2004) studied the effect of N, P and K on cucumber Cv. Poinsette grown in dry regions of South India. Application of N and P fertilizers increased the growth and yield of cucumber. N improved most of the quality parameters but P and K had no significant effect on growth, yield and quality.

Bagwan *et al.* (2004) has studied significantly highest fruit yield (15.79 t/ha) was recorded with application of recommended dose of fertilizers (100:50:50 kg NPK/ha) + Bio-organic manure at 2.5 t/ha in case of cucumber grown in inceptisol.

Guo Xisheng *et al.* (2004) studied the effect of different K sources and rates on the yield and quality of cucumber. The yield and quality improving effect of potassium sulphate greater than that of potassium chloride .K application enhance the contents of ascorbic acid and sugars, with potassium chloride being better than potassium sulphate. Potassium sulphate facilitated the transport of nutrients to the fruit, while potassium chloride favoured nutrient accumulation in the vegetative organs of plants. It is, therefore, recommended that combined K fertilizer of different formulations be applied.

K.S. Krishnappa *et al.*(2005) studied effect of various levels of N, P and K on fruit characters and uptake of N,P and K by plant of cucumber Cv. Poinsette. Effect of varying levels of N was found to be significant on fruit weight, fruit length, fruit girth, fruit volume, flesh thickness of fruit and NPK uptake by plant. Application of various levels of P also had positive influence on fruit length, fruit volume and NPK uptake by plants where as application of K levels had no significant effect on fruit characters and uptake of P and K by plants.

H.S. Han *et al.* (2006) studied effect of co-inoculation with phosphate solubilizing bacteria (PSB) *Bacillus megaterium* var. Phosphaticum and potassium solubilizing bacteria (KSB) *Bacillus mucilaginasus* on mineral uptake and growth of cucumber. Results showed that rock P and K applied either singly or in combination did not significantly enhance soil availability of P and K indicating their unsuitability for direct application. Co-inoculation of PSB and KSB resulted inconsistently higher P and K availability than in the control without bacterial inoculum and rock material fertilizer. Integrated rock P with inoculation of PSB increased the availability of P and K in soil, the uptake of N, P and K by shoot and root and the growth of cucumber.

Ahmed A.M. *et al.* (2006) studied effects of VA mycorrhizal inoculation on growth, yield and nutrient content of cucumber under different water regimes. Cucumber seedlings were grown under three levels of water regime i.e., 70, 85 and 100 per cent of the soil water holding capacity. Developed plants were sampled after 30, 60 and 90 days from transplantation .Results shows that increase of VA mycorrhizal development was more obvious with 85 and 100 per cent water regime and little increase was detected with 70 per cent at 90 days .Generally growth, NPK content and yield were higher in mycorrhizal plants grown under the 85 per cent water regime than those of the superphosphate amended plants grown with 100 per cent water regime.

M. Prabhu *et al.* (2006) studied integrated nutrient management in cucumber, var Green Long. The results revealed that application of 50 per cent recommended dose 20:30:30 NPK kg/ha + biofertilizers (2 kg in each of *Azospirillum* and phosphobacteria @ 2 kg/ha) increased the vine length, earliness in flowering, yield and yield components.

Changxian Wang *et al.* (2008) studied Effect on Arbuscular mycorrhizal fungi on growth and yield of cucumber plants. Cucumber (*Cucumis sativus* Cv. Jinlu No.3) Seedlings were each inoculated with one of three arbuscular

mycorrhizal fungi (AMF), *Glomus mosseae*, *Glomus intraradices* and *Glomus Versiforme*. The results indicate that growth of seedling was significantly enhanced by *G. mosseae*, inhibited by *G. versiforme*, and not significantly influenced by *G. intraradices*.

Kashif Waseem *et al.* (2008) studied the effect of different nitrogen levels (0, 20, 40, 60, 80 and 100 kg/ha) on growth and yield of cucumber. The results revealed that 100 kg N significantly increased fruit length, fruit weight and vine length. 80 kg N was found as the most economical dose for minimizing days to flowering, days to fruit setting and days to fruit maturity with higher number of fruits and ultimately higher yield.

Bitter gourd

About 23 t/ha of farm yard manure has been recommended by Nath (1965) on light soils of Rajasthan, where as green manuring with sun-hemp is practiced in West Bengal.

Nath *et al.* (1987) suggested 50-56 kg N/ha for Bitter gourd.

Lingaiah *et al.* (1988) studied the effect of N (0-80 kg/ha), P (0-30 kg/ha) and K (0-15 kg/ha) on the yield of bitter gourd (*Momordica charantia* L.) Cv.Coimbatore Long and reported that plants which received N, P, K @ 80, 30 and 0 kg/ha respectively gave the highest yield.

Singh (1989) suggested 30 kg K_2O/ha case of bitter gourd in a trial conducted at Karnal.

Yadav *et al.* (1989) reported that with each increase in the level of N from 40 to 80 kg/ha resulted in the corresponding increase in the number of edible fruits, vine length and total yield in bitter gourd. N rate had however, no effect on the number of fruits per plant and T.S.S.

Singh (1989) recommended 40:30:30 kg NPK/ha for bitter gourd in Karnal.

Nawab *et al.* (1995) studied the response of *Momordica charantia* cultivars to N levels and reported that the highest number of female flowers (36.13) and fruitset (34.4 9) were recorded with 120 kg N. Individual fruit weight was, however, greater (55.26 kg) with 80 kg N without having any significant difference. The highest yield was also recorded with 80 kg N.

Vijay Kumar *et al.* (1995) reported from Tamil Nadu that *Momordica charantia* Cv. MDU-1 gave the highest seed yield with application of 60 kg N + 30 kg P_2O_5 + 60 kg K_2O/ha. The percentage of seed germination was 92 % in a second trial, the same cultivar was given 5 different rates of NPK. Application of neem cake at 100 g/plant in addition to moderate level of NPK (40 kg N + 30 kg P_2O_5 + 60 kg K_2O/plant) increased the seed yield.

Rajput and Gautama (1995) studied the effect of nitrogen and phosphorus on the performance of bitter gourd. N was applied at 0, 30 or 60 kg/ha and P_2O_5 at 0, 40 or 80 kg/ha. Seed yield was highest with 60 kg N and 80 kg P/ha.

Rekha *et al.* (2001) studied the effect of levels and frequencies of organic manures and inorganic fertilizers on growth and productivity of bitter gourd (*Momordica charantia* L.). Basal application of 20 tonnes of dry cow dung, 2.5 tonnes of poultry manure, fortnightly drenching 2.5 tonnes of cow dung and a fertilizer dose of 70:25:25 kg NPK/ha, was found superior to all other treatments. More or less equal fruit yield and fruit size were also recorded in plants received same manures but lacked inorganic fertilizers. So reasonably good yield can be achieved by basal application of dry cow dung, top dressing with poultry manure and by drenching cow dung slurry at fortnightly interval.

Wu-Tian Yih and Chen- JenHshuan (2004) studied soil fertility and the growth of bitter gourd affected by the application of different composted animal manure. Three kinds of composted animal manure (Chicken compost, cattle compost and cattle-hog compost) and Chemical fertilizers were applied to different treatment plots along with one control. Results showed that exchangeable K and exchangeable Ca increased, the percentage of misformed fruit decreased with the addition of three composts and chemical fertilizers. The contents of organic matter, exchangeable Mg and the growth of bitter gourd improved especially when the chicken and cattle compost treatments were used.

N. F. Assubaie and M. M. El-Garuwang (2004) evaluated fruits and leaves of *Momordica charantia* for protein, vitamin C, total chlorophyll, Chlorophyll a, Chlorophyll b, N, P, K, Cu, Fe, Mg and Zn. Other cultivation was performed with NPK (20 % N, 20 % P and 20 % K) fertilizers and the same constituents were determined. The study concluded that the nutritional contents in the edible parts of *Momordica charantia* L. can be improved by using NPK fertilizer during cultivation and plantation.

M. Meerabai *et al.* (2007) studied biofarming in bitter gourd. Eight different organic manures and two levels of *Azospirillum* in an possible combinations and were applied and compared with two controls. (25 t FYM/ha + 70:25:25 kg NPK/ha) as control-1 and sole application of chemical fertilizer without organic manure as control-2. Among the various organic nutrient sources, poultry manure was found best in increasing the number of harvests, number of fruits/plant, total fruit yield. Keeping quality was best when vermicompost was applied as the organic source. *Azospirillum* significantly improved the quality (Vitamin C and protein content). Basal dose of FYM (25 t/ha) and application of poultry manure to supply the recommended dose of 70 kg N/ha in combination with *Azospirillum* (1 kg/ha) was the best organic nutrient schedule in bitter gourd.

Pumpkin

Rajendran *et al.* (1983) found highest fruit yield of pumpkin with 77 kg N/ha at Coimbatore, Tamil Nadu.

Oblagwu *et al.* (1995) conducted experiments in the year 1991 and 1992 on pumpkin and suggested that application of N, P and K (50 kg N, 22 kg P and 42 kg K/ha) at different rates on vine number/plant, length of vine, girth and fresh matter yield etc, gave better result by applying in band method than ring or point placement.

Karuthamani *et al.* (1995) assessed the effect of inorganic and biofertilizer on growth, flowering and yield of pumpkin (*Cucurbita moschata*) Cv. CO_2 in a field trial at Coimbatore. The highest yield was obtained by application of N 9 kg/ha + P_2O_5 18 kg/ha together with *Azospirillum* and Phosphobacteria.

Sirohi (1997b) suggested that for commercial cultivation of pumpkin "Pusa Vikas"; 25 tonnes of farm yard manure per hectare coupled with 150 kg ammonium sulphate and 50 kg potassium sulphate should be applied at the time of soil preparation before sowing. A dose of urea (80-100 kg/ha) should be top dressed in 3 split doses when the plants become 20, 40 and 60 days old, which produced 30 tonnes of fruits per hectare.

Agu (2004) studied growth and yield responses of Pumpkin (*cucurbita maxima)* to poultry manure applications in south eastern Nigeria. Effects of poultry manure at 0, 5, 10 and 20 t/ha were studied for impact on pumpkin growth and yield. Results indicated that poultry manure at 20 t/ha significantly increased growth and yield, resulted in whole plant total dry matter accumulation of 280.94 % above the control. A maximum yield of 21.76 t/ha of pumpkin fruits was also obtained with an application rate of 20 t /ha of poultry manure.

Muskmelon

Padda *et al.* (1969) studied the response of N, P and K fertilization and found that application of 56 kg N, 36 kg P_2O_5 and 20 kg K_2O/ha were economical for muskmelon.

Randhwa *et al.* (1981) working on the effect of N, P and K on vegetative, reproductive and quality characters of muskmelon (Cv. Punjab hybrid and Punjab Sunehari) have recorded promising results in plant growth, fruit yield/plant, single fruit weight and fruit quality (TSS, Vit-C and acidity) with the application of 50 kg N and 37.5 kg each of P and K per hectare.

Meisheri *et al.* (1984) studied the effect of N and P on the yield of muskmelon and reported that the average fruit yield ranged from 15 t/ha at 80 kg N and 40 kg P_2O_5 per hectare to 11.1 t/ha at 200 kg N and 40 kg P_2O_5 per hectare.

Srinivas and Doijode (1984) observed a significant increase in the number of perfect flowers and also the yield of fruits in muskmelon (*Cucumis melon* L. Cv. Haramadhu) with the application of N, P and K @ 50, 60 and 80 kg per hectare respectively.

Managal *et al.* (1985) studied the effect of N fertilization under various soil moisture regimes on round melon. They reported that both plant growth and fruit yield were raised with increased irrigation and N rates. N at 40 kg/ha, almost doubled the number of fruits per plant showing no significant difference between 40 and 80 kg levels.

Pravakar *et al.* (1 985) from a 5 year fertilizer-cum-spacing trial on muskmelon (Cv. Haramadhu) inferred that the closest spacing (60 cm) gave the highest yield .Application of N and P @ 100 kg and 60 kg per hectare respectively gave the highest yield of fruits (63.82 q/ha).

Buwalda and Freeman (1986) reported that by increasing N application from 30 kg to 120 kg per hectare the total fruit yield in melon cultivars Prince PR and Tenekei increased by 11 and 28 per cent and marketable yield by 20 and 34 % respectively.

Singh and Chhonkar (1986) from a fertilizer cum spacing trial on muskmelon Cv. Taunpuri reported that application of 100 kg N, 60 kg P and 50 kg K per hectare exhibited the best results in respect of vegetative growth, single fruit weight and yield.

Ramachander *et al.* (1988) reported that the response of muskmelon to N varied from season to season. Under high yielding environment 75 kg N/ha was optimum, whereas under low yielding environment 50 kg N/ha was optimum. 60 kg P_2O_5/ha was optimum under both low and high yielding environments. Response to K also varied from season to season and it was not possible to make general recommendation. However, various states recommended 30-60 kg K_2O/ha. Potash maybe applied through soil or as foliar spray.

Nandapuri (1989) recommended 125 kg N, 62 kg P_2O_5 and 62 kg K_2O/ha for muskmelon in Punjab.

Rao and Srinivas (1990) studied the effect of different levels of N (0, 50 or 100 kg/ha), P (0 or 60 kg/ha) and K (0 or 60 kg/ha) on petiole and leaf nutrient levels in muskmelon and reported that N significantly increased fruit yield, TSS content and leaf and petiole N levels but reduced petiole P and K contents. P increased petiole K content; K markedly increased fruit yield, TSS content, leaf N, Ca, Mg content and petiole Mg content. According to them the leaf nutrient level provided a better index than petiole nutrient level for assessing muskmelon nutrient requirements.

Longmelon

Shukla and Prabhakar (1988) conducted an experiment to study the response of long melon to spacing and fertilization and they recommended a fertilizer application of 180 kg N + 100 kg P_2O_5 + 100 kg K_2O/ha with plants spaced at 45 x 200 cm with 1 plant /hill.

Rivera Segovia (1988) made a study to evaluate the effects of manuring on the development and yield of melons in tunnels and they reported that application of 10 t or 20 t poultry manure per hectare or 160 t or 240 t cattle manure per hectare gave the highest yield in melons Cv.Topmark growing in a clayey soil in plastic tunnels and receiving 100 kg N and 60 kg P_2O_5/ha without showing any external symptoms of toxicity.

Summer squash

Al-Mukhtar *et al.*(1988) studied the effect of different levels of NPK fertilizers on growth and yield of two summer squash cultivars and observed that plant growth and development were best with the highest in both the seasons and in both the cultivars with 500 kg per hectare (N,P, K ;18:18:5).

Dweikat and Kostewicz (1989) reported that total squash yield increased with the increase in level of N from 67 to 202 kg/ha but however, decreased at 268 kg/ha.

Shivashankar Murthy *et al.* (2006) studied influence of N, P and K on the vegetative characters of gherkin (*Cucumis anguria* L.) and reported that overall improvement of gherkin in terms of vegetative characteristics was found to be best in combination of NPK @ 175:125:125 kg/ha.

L. Martinetti *et al.* (2006) studied effect of organic and mineral fertilization on yield and quality of Zucchini squash. Treatments each with 250 kg N, 280 kg P_2O_5 and 250 kg K_2O per hectare: organic fertilizer (Pelletted

FYM) preplant; slow release fertilizer (15-9-15) integrated with superphosphate preplant; 2/3 organic fertilizer preplant and 1/3 mineral fertilizer (15-15-15) as 3 top dressings (starting from fruit setting); 2/3 slow release fertilizer preplant and 1/3 mineral fertilizer. Each treatment was combined with 3 levels of sodium silicate; 0, 6 and 12 l/ha , applied 3 times as top dressing in combination with 10 kg humic acid/ha. Results showed that all treatments significantly increased size, weight and number of fruits, number of male flowers, weight of leaves and stems as compared to control. Sodium silicate increased the fruit dry weight, but did not show any significant effect on other parameters. The yield was significantly higher in the treatments with slow release fertilizer, organic + top dressing, slow release + top dressing than the organic manure and control.

Ruchi Sood and Vidyasagar (2008) reported that the treatment combinations 80% N + *Azospirillum* (Soil application) and 80 % N + *Azotobacter* (Soil application) produced higher marketable yields. They also pointed out that Nitrogen uptake was higher than control by applying 80 % N + *Azotobacter* (soil/seed application). They also concluded that biofertilizers could affect economy up to 20 % than the recommended dose of nitrogen in case of summer squash (*Cucurbita pepo* L.).

Bottle gourd

Mahakal *et al.* (1977) studied the effect of N, P and K at different rates and combinations on tinda. N, P_2O_5, K_2O at 75:50:100 kg /ha had significant effect on yield, which rose from 3208 kg per ha to 3698 kg per ha.

Vishnushukla and Prabhakar (1987) studied the effect of plant density and fertilizer on yield of bottle gourd (*Lagenaria siceraria* cultivar Arka Bahar). They recorded the highest average yield of 384.54 q/ha when plants were spaced, at 300 x 45 cm with 1 plant/hill. The highest average yield (385.37 q/ha) as obtained with the application of NPK at 180:100:100 kg/ha.

Sirohi (1997a) noticed that bottle gourd grows well with 20 tonnes of well rotten farm yard manure along with a mixture of 150 kg single super phosphate, 100 kg ammonium sulphate and 50 kg muriate of potash per hectare applied at the time of preparation of channels and hills before sowing .Another dose of urea (80-100 kg/ha) should be top dressed in 2 split doses when plants are 20 and 40 days old. The average yields of bottle gourd var. Pusa Sandesh during spring, summer and kharif season were 25.0 t and 27.20 t/ha respectively.

M. Iqbal *et al.* (2000) studied the effect of NPK fertilizers on the yield of bottle gourd (*Lagenaria siceratia* M.). Results showed that the NPK fertilizer doses (T_1 = control, T_2 = 104-54-104, T_3 = 124-74-124, T_4 = 144 - 94-144 and T_5 = 164-114-164 kg per hectare) has significant effect on days to germination, fruit weight (g), fruit volume (ml), number of fruits per vine, vine length (cm) and yield per hectare (tonnes). Maximum yield (20.403 t/ha) was obtained from T_5 (164-114-164 kg per hectare). Incurring NPK fertilizer doses increased the above mentioned parameters.

P.umamaheswarappa *et al.* (2005) studied effect of NPK on dry matter accumulation and primary nutrient content in leaf of bottle gourd Cv. Arka Bahar.N is significantly affected the dry matter accumulation in vine, fruit, leaf and root. P also showed positive influence on dry matter accumulation in vine, fruit, leaf and root whereas potassium application had no significant effect on various characters. Application of 120:100:30 kg NPK/ha respectively, recorded the highest yield and appeared to be optimum fertilizer dose under southern dry region of Karnataka to bottle gourd Cv. Arka Bahar.

Spong gourd

Siyag and Arora (1988) studied the effect of N and P on fruit yield and quality of sponge gourd Cv. Pusa Chikni. They reported that maximum number of fruits and weight of fruits per plant were obtained with a combined

application of 50 kg N + 40 kg P/ha. Maximum fruit dry matter content were obtained by applying 25 kg N + 40 kg P/ha. Maximum fruit dry matter content were obtained by applying 25 kg N + 40 kg P/ha in the summer crop and 40 kg P/ha in the rainy season crop.

Arora and Siyag (1989) studied the effect of N (0-75 kg/ha) and P (0-40 kg/ha) on growth, flowering and sex expression of sponge gourd Cv. Pusa chikni during both summer and rainy season and observed the highest number of female flowers (15.1 per plant) with N at 50 kg/ha in winter season (21.8 per plant).

Ridge gourd

Arora *et al.* (1995) experimented with N fertilizer at 30, 60 and 90 kg/ha on fruit quality of ridge gourd (*Lufa acutangula*) and found that the ascorbic acid content in the fruit was the highest with 60 kg N/ha and the lowest with 90 kg.

Sreenivas *et al.* (2000) studied the application of four levels of NPK fertilizers (0, 25, 50 and 100 %) of the recommended dose and vermicompost (0, 5, 10 and 15 t/ha) in ridge gourd and found highest N-uptake and highest yield with 50 % of the recommended fertilizer dose + 10 t vermicompost/ha.

S.C. Prasanna Kumar *et al.* (2004) studied the effect of varying levels of NPK on growth and yield of Ridge gourd Cv. Arka Sujath in southern dry regions of Karnataka. Studies showed that N significantly increased the vine length, number of branches per vine, dry weight of leaf, vine and ultimately yield .P and K were also showed positive influence on various characters. Application of N, P and K at 50:50:60 kg/ha respectively recorded the maximum yield and appeared to be optimum fertilizer dose under southern dry region of Karnataka to ridge gourd Cv. Arka Sujath.

S.C. Prasanna Kumar *et al.* (2004) studied yield and yield components of Ridge gourd in relation to varying levels of NPK. Nitrogen significantly increased number of fruits per vine, fruit weight, fruit length, fruit girth, fruit yield per vine and fruit yield per hectare Phosphorus and potassium were also showed positive influence on various characters. Application of 50:50:60 kg NPK/ha found to be optimum fertilizer dose for ridge gourd Cv. Arka Sujath in eastern dry zones of Karnataka.

pointed gourd

According to Rajakumar (1962) about 63 to 90 kg of N is required to obtain good yield of pointed gourd from a hectare of land.

Premnath and Subramaniya (1972) reported that application of 20 to 25 tonnes of FYM and 40:40:40 kg N: P: K per hectare is beneficial for pointed gourd.

Das *et al.* (1987) studied the effect of N (0, 30, 60 or 90 kg/ha) and P (0, 20, 40 or 60, kg/ha) on growth and yield of pointed gourd CVSL-2.They obtained maximum average early yield (45.9 q/ha) and total yield (138.8 q/ha) by applying 90 kg N and 60 kg P.

Rajesh Kumar *et al.* (1990) studied the effect of N (0, 30, 60 or 90 kg/ha) and P (0, 20, 40 or 60 kg/ha) on pointed gourd and reported that the number of fruits per plant increased from 111.3 at 0 kg/ha to 167.16 at 60 kg N/ha and declined to 165.44 at 90 kg N/ha. With the increase in the level of P from 0 to 60 kg/ha, a corresponding increase in the number of fruits per plant was also noticed.

Tripathy *et al.* (1994) studied the effect of sex type and level of NPK mixture on growth and root tuber yield of pointed gourd. In a field trial conducted in 1990 revealed that female plants were more vigorous than male plants but there was no difference in tuber fresh weight between the sexes.

Among various NPK application rates 60:60:60 kg/ha NPK gave the highest tuber fresh weight (58.58 g/plant) and the best tuber size.

Mishra *et al.* (1994) studied the effect of N (50, 100 or 150 kg/ha), P (40 or 80 kg/ha) and K (40 or 80 kg/ha) on parwal (*Trichosanthes dioica* Roxb.) during two consecutive seasons and obtained highest yield of fruits with 150 kg N plus 80 kg each of P_2O_5 and K_2O per hectare.

Mahapatra *et al.* (1996) studied the effect of N and its application on the performance of pointed gourd and observed that with each increase in the level of N from 60 to 150 kg per hectare, there was a corresponding increase in the length of vine, number of branches, leaf area, fruit size, fruit weight, number of fruits per plant and ultimately the yield of fruits. Days taken for the appearance of first female flower and the node number for the first female flower appearance increased with increase in level of nitrogen. The maximum fruit yield and the values relating to yield attributes such as fruit length and number of fruits per plant were recorded under 150 kg N/ha. The dose however, was not found to be significantly superior to 120 kg N/ha.

Singh and Krishna Mohan (2007) conducted an experiment on pointed gourd and reported that maximum fruit yield of parwal was obtained by substitution of 25 % inorganic nitrogen fertilizer through FYM and 75 % commercial inorganic fertilizer (urea).They also observed that split (three) application of inorganic nitrogen produced higher fruit yield and the recommended dose of inorganic fertilizer is 80:60:40 kg NPK/ha.

Watermelon

Locascio *et al.* (1972) observed enhanced growth and yield of watermelon by broad-caste application of N, P and K 160:70:135 kg/ha respectively.

Deswal and Patil (1984) studied the effect of NPK on fruit yield of watermelon and found the best result with 70 kg N/ha, 50 kg P_2O_5/ha and 50 kg K_2O/ha in West Bengal.

Gezerel and Donmez (1986) reported the beneficial effect of foliar fertilizer application on the yield and fruit quality of water melons.

Hegde (1987) reported that increasing N application (60-180 kg/ha) significantly increased dry matter (54%), fruit yield (32%) ,mineral uptake (51 %) and field water use efficiency (32%) only up to 120 kg N/ha in watermelon.

Virupaksha (1988) found significant response of K_2O at 50 kg per hectare in watermelon.

Virupaksha (1988) reported significant response of nitrogen at 150 kg/ha in watermelon.

Singh and Naik (1989) observed 58 kg N per hectare to be optimum for watermelon at Ranchi.

E.A. Hanlon *et al.* (1992) studied P and K fertilizer recommendations for muskmelon and watermelon in Florida .Results showed that yield response to added fertilizer optimized well before recommended rates were reached. Extensive changes were also made in fertilizer recommendations for N, P and K for vegetable production, including a recommendation for no fertilizer P and K when the Mehlich-1 soil tests is interpreted as high or very high.

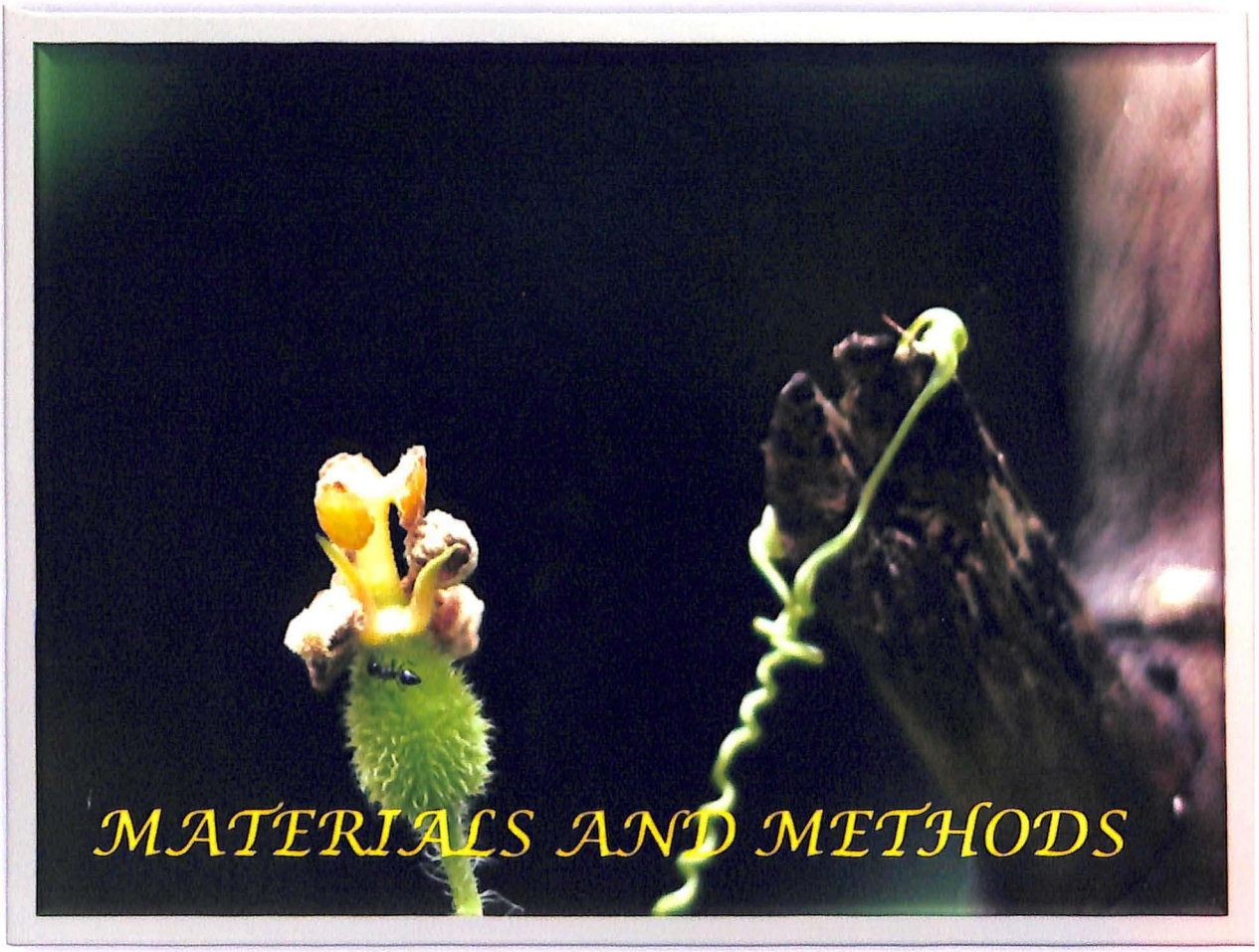
Gao Muqiang (1995) studied rate effect of N and K on watermelon yield and quality. Nine treatment combinations of 0, 60 and 120 kg N/ha and 0, 60 and 120 kg K/ha were compared .Significant increase in the total yield and average fruit weight were obtained with increasing rates of nitrogen fertilizers. Excessive K fertilizer application in this field has no effect on the total yield, soluble solids and other characters. Watermelon had greater response to the increasing of N than the increasing of K.

V. S. Yadav and J.P.Luthra (2002) studied the effect of NICAST (organic manure) on growth and yield of watermelon Cv.Durgapura Lal. Nicast is an organic manure (eco-friendly component), based on rural waste organics i.e. the mixture of crop waste ,animal waste and concentrated organic manures namely tobacco plant waste powder, Caster cake, bone meal powder, calcium-rich filler (Cooked gypsum and dolomite).Treatments consisted of a combination of recommended rate of FYM: 20 t/ha, Nicast at 250, 500 and 750 kg/ha with and without the recommended rate (100:40:40 kg/ha) of N:P:K fertilizers, two treatments of recommended rate of vermicompost (10 t/ha)and fertilizers, one treatment of recommended rate of fertilizer alone. The highest significant fruit yield with highest average fruit weight, dry matter content and fruit diameter were recorded upon treatments with Nicast at 500 kg/ha + recommended rate of N:P:K which was at par for fruit yield with the treatment. Nicast at 750 kg/ha and with the recommended rate of N: P: K.

B. Okur and B. Yagmur (2004) studied effects of enhanced potassium doses on yield, quality and nutrient uptake of Watermelon Cv. Pannonia F_1. Three enhanced doses control 120 K1 -240 K_2-360 K_3 kg/ha of K_2O are applied to watermelon N and P fertilization were practiced according to the recommendation as 120 kg N/ha and 80 kg P_2O_5/ha respectively. Results showed that the K_2 dose yielded the highest as 54320 kg/ha. Related to the quality parameters, positive impacts of K are determined on number of fruits, fruit weight and fruit width.

Dauda *et al.* (2005) studied the growth and yield of watermelon as affected by poultry manure (at the rates of 0, 3.3, 6.6 and 9.9 t per hectare) application. The results showed that application of poultry manure significantly enhance growth parameters, vigour, weight and number of fruits.

Chapter-3



MATERIALS AND METHODS

A field experiment entitled "Integrated Nutrient Management in Spine gourd (*Momordica dioica Roxb.*)" was undertaken at the site allocated for "Network Project on Biofertilizers" in OUAT, Bhubaneswar during 2008. Different techniques of investigation followed have been described in this chapter.

3.1 Experimental site

The field experiment was carried out in the campus of College of Agriculture, OUAT, Bhubaneswar in the year, 2008.

3.2 Cropping history of experimental field

Year	Kharif	Rabi	Summer
2007-08	-	-	Bottle gourd
2008-09	Spine gourd (Present experiment)	Broccoli	-

3.3 Soil

A composite soil sample was drawn from 25 cm depth and was analyzed for status of the soil before the commencement of present investigation. The physico-chemical composition of the soil of the experimental field is given in Table 1 (a and b).

Table 1(a). Mechanical composition of the soil

Sl.No.	Constituents	Percentage (Air dry basis)	Methods followed
1.	Sand	69	Bouycous hydrometer
2.	Silt	13	Bouycous hydrometer
3.	Clay	18	Bouycous hydrometer
4.	Textural class	Sandy loam	International triangle

Table 1(b). Chemical composition of the soil

Sl.No.	Constituents	Amount present (Air dry basis)	Methods followed
1.	Available nitrogen	217 kg/ha	Alkaline permanganate method, (Subbiah and Asija (1956)
2.	Available phosphorus	45 kg/ha	Bray's-1-P, Page *et al.* (1982)
3.	Available potassium	275 kg/ha	NH_4OAc method, Jackson (1967)
4.	Organic carbon	6.48 g/kg	Walkley and Black wet extraction method, Page *et al.* (1982)
5.	Soil PH	5.9	Potentiometric method, Jackson (1967)

3.4 Climate

Bhubaneswar is located on 22°15' north latitude, 80°22' east longitude and on an altitude of 25.5m above the mean sea level. It comes under tropical climate zone. Bhubaneswar is around 62 kms away from Bay of Bengal towards west side. The precipitation during the cropping period was 1521.4 mm which was received between June to November 2008.The maximum temperature during the period varied between 24.9 to 29.0°C. The meteorological data obtained for the cropping period of the experiment i.e., from June 2008 to November 2008 is presented in Table 2 and Figure 1(a and b).

Table 2. Meteorological data from June, 2008 to November, 2008.

Month	Temperature (°C)			Relative humidity (%)			Rainfall (mm)	No. of rainy days
	Max.	Min.	Average	Morn.	AN.	Average		
June'08	32.5	25.6	29.0	92	73	83	341.0	19
July'08	32.2	25.6	28.9	94	75	85	227.3	21
Aug.'08	31.3	25.6	28.5	94	79	87	297.6	23
Sept.'08	32.0	25.0	28.5	94	78	86	617.8	20
Oct.'08	32.6	23.4	28.0	92	59	76	31.8	4
Nov.'08	30.9	18.9	24.9	90	51	70	5.9	2

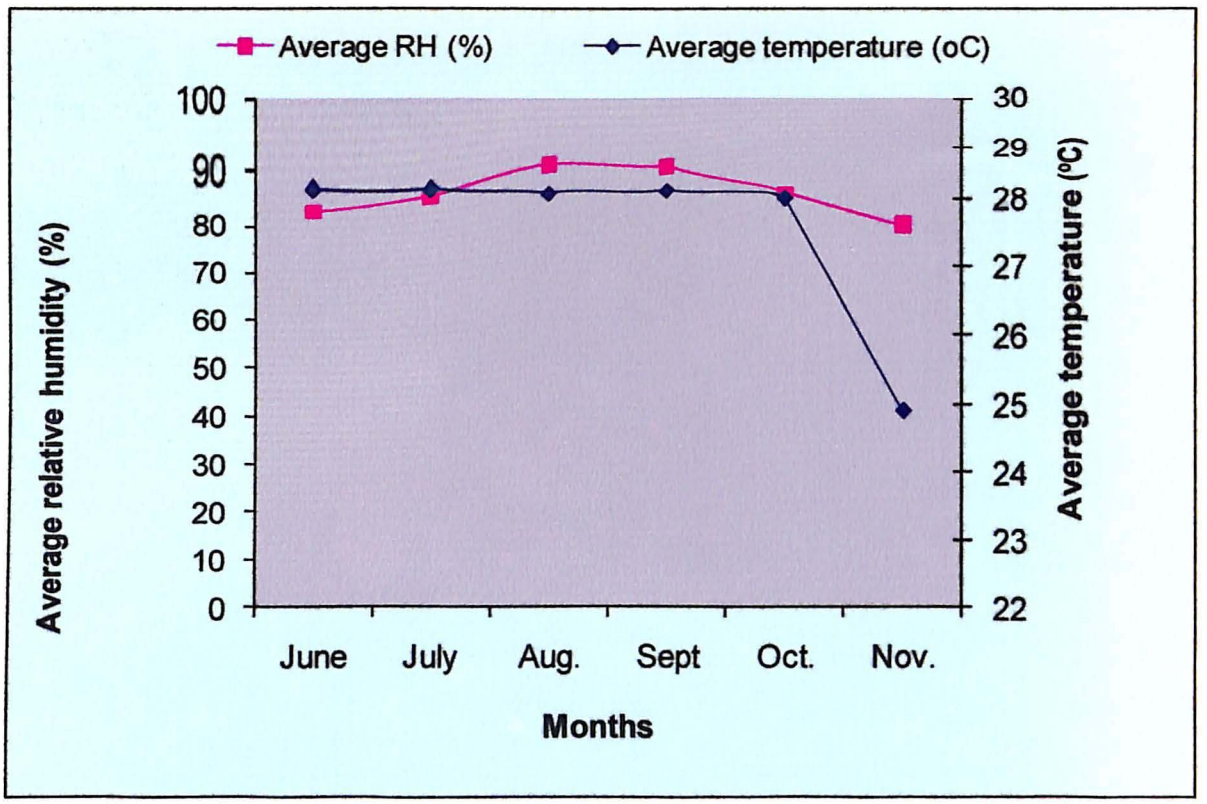


Fig.1 (a). Meteorological data showing average temperature along with average RH

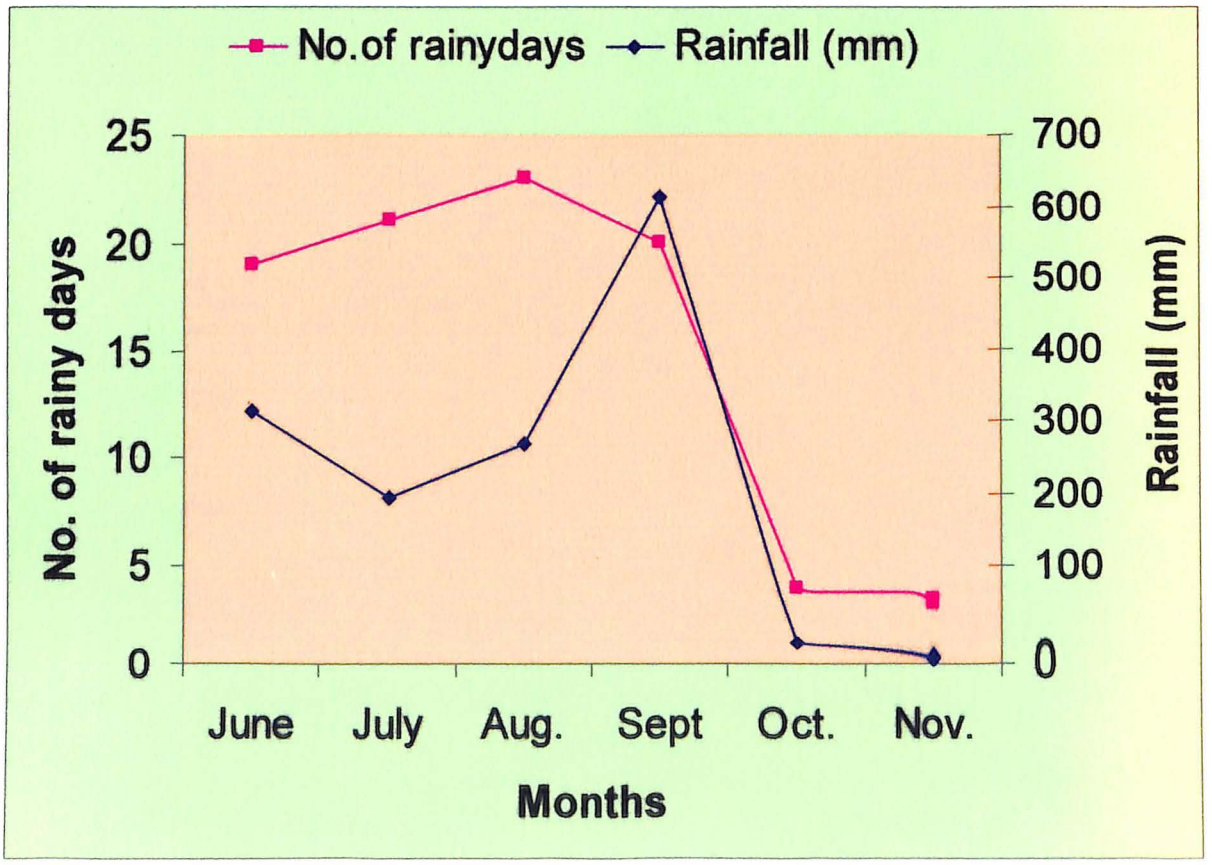


Fig. 1(b). Meteorological data showing average rainfall and number of rainy days.

3.5 Field preparation

The general preparations as well as planting operations carried out in the field are presented below.

Date	Operations	Remark
24.05.08	Nursery bed preparation	By manual labour
28.05.08	Planting of 3 node stem cuttings	By manual labour
01.07.08	Ploughing of main field	By manual labour
02.07.08	Weeding	By manual labour
05.07.08	Preparation of plots for layout after labelling	By manual labour
08.07.08	Application of FYM @ 5 tonnes/ha to the main plot	By manual labour
11.07.08	Irrigation to the nursery	By manual labour
12.07.08	Transplanting of rooted cuttings after imposing the treatment	By manual labour

3.6 Experimental Techniques

3.6.1 Design of the experiment and plan of layout

The present experiment constituted six treatments comprising of control, recommended dose of fertilizers, recommended dose of fertilizers with lime and rest with biofertilizer. The stem cuttings of spine gourd was planted on the nursery bed on 28.05.2008.The transplanting was done on 12.07.2009 .The experiment was laid out in Randomized Block Design with four replications.

3.6.2 Treatments

Notations	Treatments
T_1	Control
T_2	RD = Recommended Dose
T_3	RD + Lime (0.2 LR)
T_4	RD + Bioinoculants (*Azotobacter*+ *Azospirillum* + Phosphate Solubilising Bacteria + *Arbuscular Mycorrhiza*)
T_5	RD + lime + Bioinoculants (*Azotobacter*+ *Azospirillum* + Phosphate Solubilising Bacteria + *Arbuscular Mycorrhiza*)
T_6	75 % RD + lime+ Bioinoculants (*Azotobacter*+ *Azospirillum* + Phosphate Solubilising Bacteria + *Arbuscular Mycorrhiza*)

3.6.3 Details of layout

1	Design of layout		Randomized Block Design
2.	Number of treatments		6
3	Number of replications		4
4.	Plot size		(3.0 x 3.0) m^2
5.	Spacing		
	a) Row to row		50cm
	b) Plant to plant		50 cm
6.	Number of rows per plot		6
7.	Number of plants per row		6
8.	Width of the bond separating the block		30 cm
9.	Width of irrigation channel		90 cm
10.	Length of the experimental field		21.1 m
11.	Width of the experimental field		15.3 m
12.	Area of the experimental field		322.83 m^2

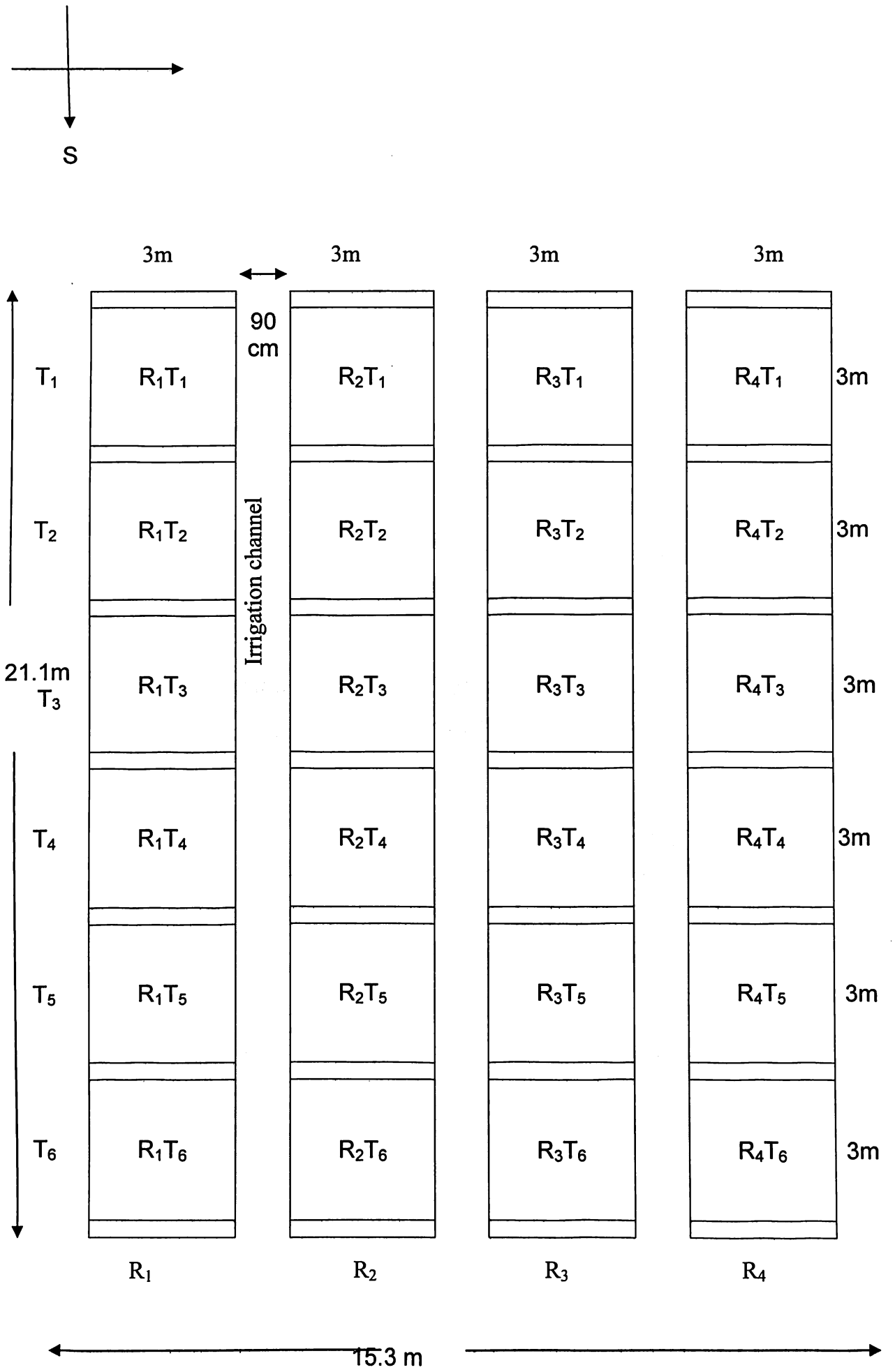


Fig. 2 Plan of layout of the experimental plot

3.6.4 Source of planting material

The spine gourd stem cuttings were collected from the existing local collection from Phulbani area which was planted in Horticultural Research Station (orchard) at Bhubaneswar. Stem cuttings were prepared. Three node stem cuttings were taken and planted in nursery and after rooting (20 to 25 days), the rooted cuttings were again planted in plastic nursery. The rooted cuttings after forty five days were ready for planting in the main field.

3.6.5 Fertilizer requirement

Twenty kg of well decomposed FYM were applied just before the last ploughing. The fertilizer dose of 70:40:60 kg/ha with respect to N, P_2O_5 and K_2O were applied. The total amount of P_2O_5 , one fourth amount of nitrogen as well as half of potash were applied on the pits as a basal dressing before transplanting of the rooted cuttings. Twenty four days after transplanting half of nitrogen and rest of potash were applied as first top dressing. Remaining portion of nitrogen was applied thirty days after top dressing. Lime @ 20 % LR i.e., 1 t/ha was applied to the soil as per treatment allocation. However, biofertilizers (*Azotobacter, Azospirillum,* Phosphorus Solubilizing bacteria, *Arbuscular Mycorrhiza* @ 6 kg/ha were applied in the soil before transplanting.

3.6.6. Irrigation

Watering was given immediately after transplanting of the rooted stem cuttings by rose cane. It was continued at an interval of 3 days till the establishment of the cuttings.

3.6.7 Intercultural operations

Hoeing, weeding and earthing up operations were carried out thrice during the entire cropping period of the experiment.

3.6.8 Plant protection measures

Chloropyriphos @ 2 ml/l were applied as soil drenching just before the transplanting of the rooted cuttings to control the termites. In the subsequent stages Endosulphan @ 2 ml/l were applied twice during the entire cropping period at an interval of twenty days after flowering. One honey bee box with bees was fixed for better pollination after 50 percent of plants entered flowering phase.

3.6.9 Harvesting

Spine gourd fruits were harvested after attaining the marketable size stage. Harvesting of fruits started after fifty days of transplanting which continued for another forty five days.

3.7 Technique of study

3.7.1 Method of sampling

Ten plants were selected in each plot to record the observation time to time, different growth parameters, flowering and yield including yield attributing characters.

3.7.2 Characters studied

Observations on the following characters were recorded on selected plants in each plot.

3.7.2.1 Plant height (cm)

The height of the plant was recorded in cm from the base up to the growing point. Seventy five days after transplanting.

3.7.2.2 Number of branches per plant

The total number of branches was counted for each sample plant at seventy five days after transplanting.

3.7.2.3 Vine girth (cm)

The girth of the vine of individual sample plant was recorded at the base of each plant in cm.

3.7.2.4 Number of leaves per plant

The total number of leaves per plant was counted in each plant at seventy five days after transplanting.

3.7.2.5 Leaf area (cm^2)

The fifth leaf from the top from different branches of each plant were collected at seventy five days after transplanting and leaf area were measured by leaf area meter. The average was calculated and expressed in cm^2.

3.7.2.6 Height at which first flower appeared (cm)

The height at which the first flower appeared was measured from the base of the plant and expressed in cm.

3.7.2.7 Days taken to flowering

The total number of days taken for flowering was calculated from the date of transplanting and expressed in days.

3.7.2.8 Number of fruits per plant

Number of fruits produced from ten randomly selected plants of each replication was noted and the mean value was finally used for calculation.

3.7.2.9 Length of fruits (cm)

Measured the length of ten randomly selected fruits from the sample plants of different treatments in each replication and the mean was calculated and finally expressed in centimeter.

3.7.2.10 Fruit girth (cm)

Measured the girth of ten randomly selected fruits from the sample plants of different treatments in each replication and the average was taken for calculation.

3.7.2.11 Fruit weight (g)

Measured as the mean weight of ten randomly selected fruits of each treatment in grams and the mean weight were tabulated.

3.7.2.12 Fruit Yield (q/ha)

Measured as weight of total quantity of fruits per plant for each treatment in each replication and calculated the per hectare yield.

3.7.3 Laboratory analysis

3.7.3.1 Plant samples

3.7.3.1.1 Plant, fruit and soil analysis

3.7.3.1.1.1 Total chlorophyll (mg/g)

The fifth leaf of the matured plant after fruiting were collected and the chlorophyll content was estimated using 80 percent acetone for extraction of chlorophyll. It was finally measured by spectrophotometer at 645 and 663 nm wavelength .The result was expressed in mg per g fresh material.

3.7.3.1.1.2 Plant analysis

The plant samples were collected at the harvesting stage and washed thoroughly with deionized water. Then the plants were sun dried and finally dried in the oven at 70°C temperature till a constant weight was recorded. The oven dried plant samples were grinded manually and kept for analysis of plant dry weight, uptake of N, P, K, Ca, and S as per standard methods.

3.7.3.1.1.3 Fruit analysis

The fruit samples particularly the second lot was washed thoroughly in the deionized water and analyzed fresh for fruit dry weight and concentration of N, P, K, Ca, and S as per standard methods. Nitrogen in the sample was estimated by digesting the fresh samples using concentrated sulphuric acid following the method Bremner (1965).

The P, K, Ca and S in the sample were estimated by digesting the samples using di-acid (HNO_3HClO_4::32) followed by estimation of P by Vanadomolybdo phosphoric acid method suggested by Jackson (1973), K by flame photometry. S by turbid metric analysis method as suggested by Jackson (1973) and Ca by EDTA complex metric titration method as suggested by Jackson (1973).

3.7.3.1.1.4 Moisture content of the fruit

The moisture content was determined by taking the samples which were placed in the oven at 105°C temperature till a constant weight was obtained.

3.7.3.1.1.5 Soil analysis

The soil samples were collected, shade dried and sieved properly and were kept for further analysis of post harvest soil properties like PH by using PH meter, electrical conductivity by conductivity bridge method, organic carbon by Walkely and Black wet oxidation method using ferroin indicator, available nitrogen by Alkaline permanganate method, available phosphorus by Bray's-1 – P method as suggested by Page *et al.*(1982) and available potash by neutral N ammonium acetate method and estimation by flame photometer .

3.7.4 Statistical Analysis

The mean data and physio-chemical estimates were subjected to proper statistical analysis in randomized block design. The F-tests have been used for testing the significance of findings. Approximately standard error for each factor was worked out and to compare the two treatment means, the critical difference (C.D.) was calculated at 5% level of significance using the following formulae

1. SE (m±) for treatments= $\sqrt{\frac{\text{Error Mean Square}}{\text{Number of replication}}}$

Where, EMS = Error mean sum of square,

r = number of replications.

2. $CD_{0.05}$ for treatment means= $\sqrt{2}$ × SE (m±) × $t_{5\%}$ level at error d.f.

Chapter-4

EXPERIMENTAL FINDINGS

Observation of the plant characters were recorded to study the "Integrated Nutrient Management in Spine gourd" (*Momordica dioica* Roxb.) during the course of present investigation. The detail findings of the experiment are presented in this chapter. Various data were tabulated & were analyzed statistically with a view to find out the significant effect of different characters which were presented in detail in the chapter appendix. The data are presented in tabular form & the relevant standard error of means as well as the critical difference (C.D) at 5% level of significance is also presented. In certain cases the data are presented graphically.

4.1 PLANT HEIGHT (cm)

The plant height has significantly influenced in all the plants among the treatments taken (Table 3, Fig.3). The maximum plant height was recorded with T_5 (110.56 cm) followed by T_2 (104.06 cm).However, the lowest height was recorded with T_1 (80.33 Cm) which was significantly inferior than all the treatments tried in this experiment. The maximum height was recorded in T_5 which was significantly superior to all other treatments. However, T_3 and T_4 remained at par but significantly superior to T_1 that is control.

4.2 NUMBER OF BRANCHES PER PLANT

The data presented in Table .3 and Fig.4 clearly showed a distinct variation on the number of branches per plant as recorded among different treatments. Maximum number of branches per plant was recorded with T_5 (8.81) which was statistically significant than rest of treatments tried. However, the lowest number of branches per plant was recorded with T_1 (6.5) which also remained at par with T_3 (6.87). The other two treatments that is T_2 (7.37) as well as T_4(7.75) also remained at par but statistically superior over T_1 that is control.

4.3 VINE GIRTH (cm)

From the data tabulated and presented in Table 3 and Fig.4 indicated that the vine girth was maximum in T6 (3.25 cm) followed by T_5 (3.20 cm). All the treatments except T_1(2.55 cm) remained at par without any significant difference. However T_2 (2.80 cm) also remained at par with T_1 (control).

Table 3 Plant height (cm), number of branches per plant, vine girth (cm), number of leaves per plant, leaf area (cm^2) as influenced by integrated nutrient management in spine gourd

Treatments		Plant height (cm)	No. of branches per plant	Vine girth (cm)	No. of leaves per plant	Leaf area (cm^2)
T_1	Control	80.33	6.5	2.55	153.67	50.58
T_2	Recommended dose of Fertilizer (RD)	104.06	7.37	2.80	219.08	69.12
T_3	RD + lime (0.2 LR)	91.87	6.87	3.03	194.58	76.01
T_4	RD + BIOINOCULANTS (Azot. + Azs. + PSB + AM)	91.37	7.75	3.17	216.37	76.43
T_5	RD + Lime + BI	110.56	8.81	3.20	249.34	75.63
T_6	75 % RD + lime + BI	103.37	8.18	3.25	238.50	72.06
	SE (m) ±	0.218	0.163	0.156	0.217	0.333
	CD(0.05)	0.656	0.492	0.470	0.653	1.00

4.4 NUMBER OF LEAVES PER PLANT

The number of leaves per plant has also been significantly influenced among different treatments over the control (Table no. 3 and Fig.5). Maximum number of leaves were recorded with T_5 (249.34) which was statically significant than rest of the treatments followed by T_6(238.50) and T_2 (219.08). However, the lowest numbers of leaves were recorded with T_1(153.67).

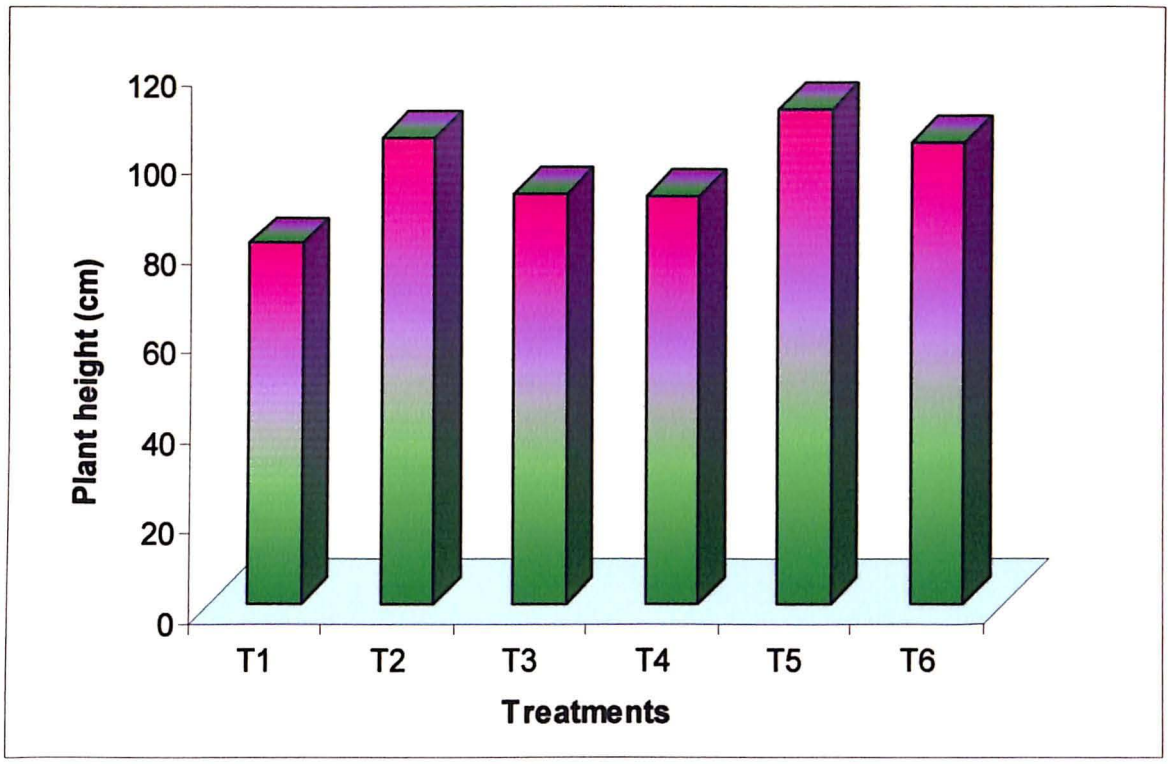


Fig 3. Plant height (cm) as influenced by integrated nutrient management in spine gourd

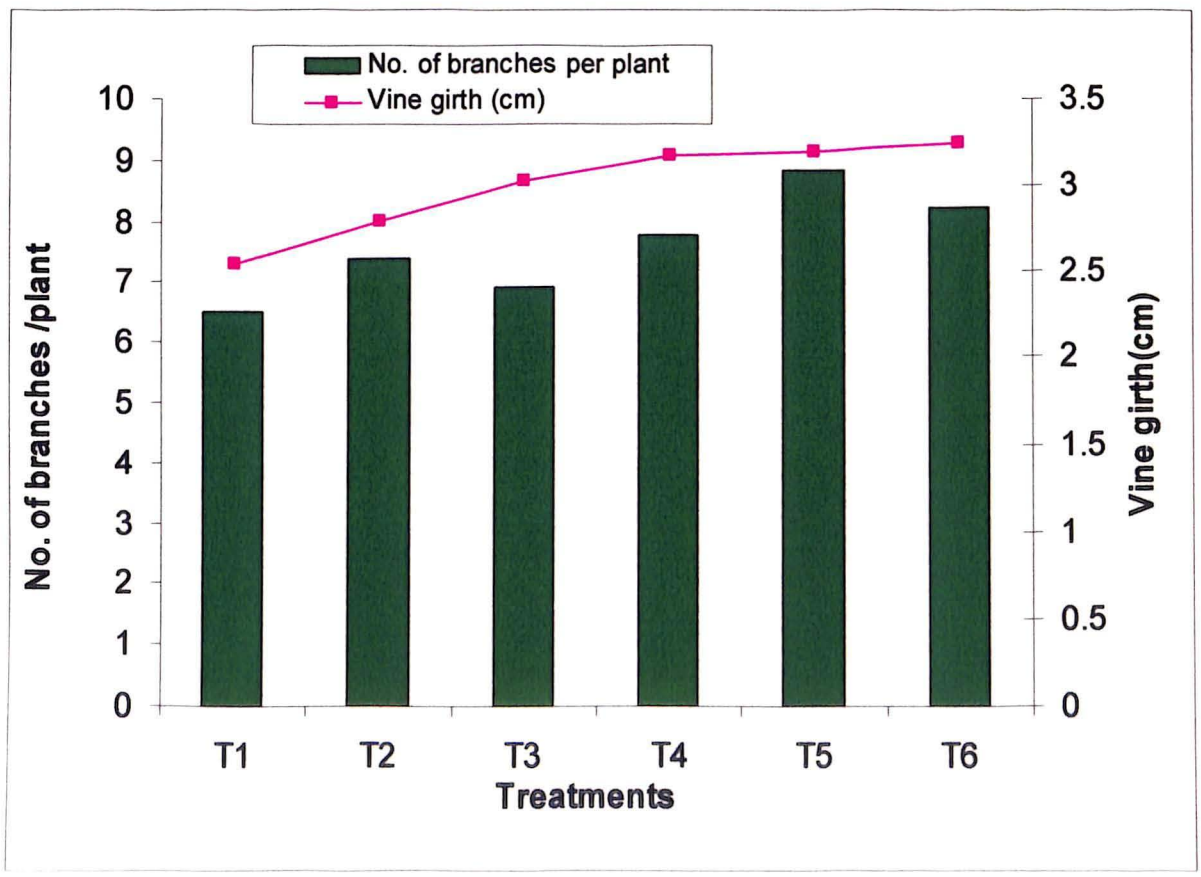


Fig 4. No. of branches per plant and vine girth (cm) as influenced by integrated nutrient management in spine gourd

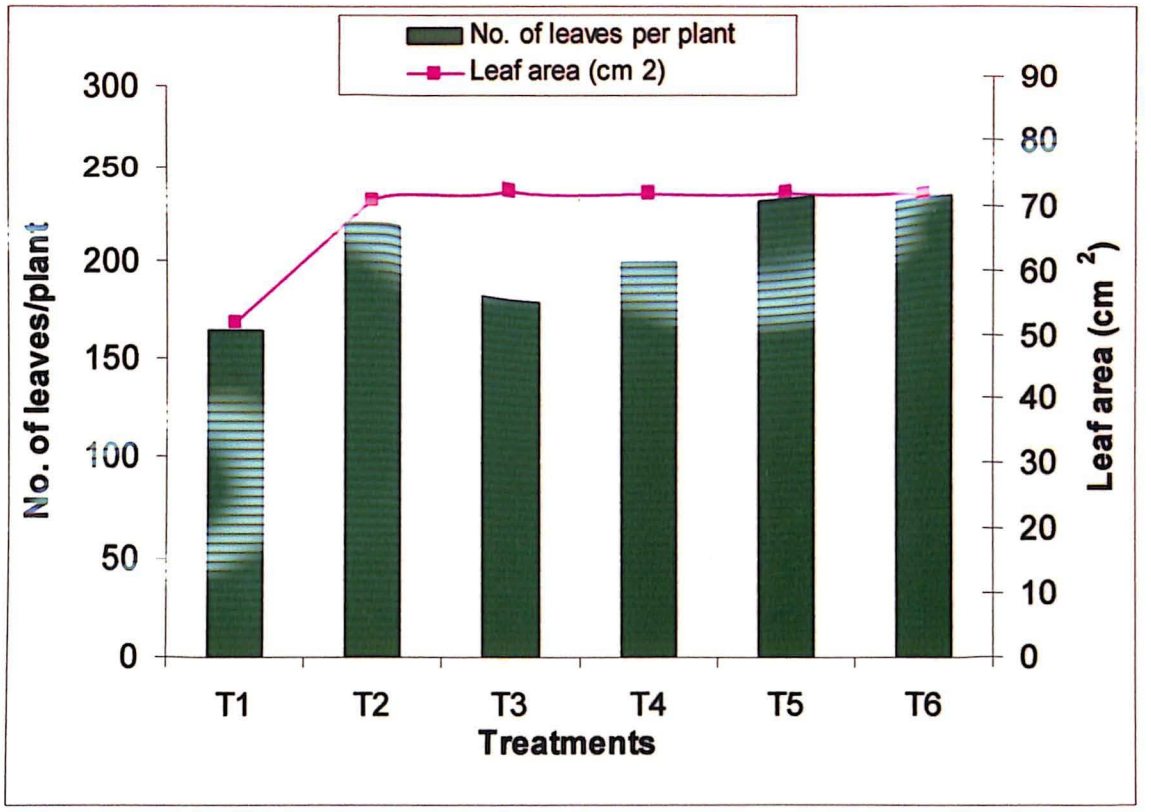


Fig 5. No.of leaves per plant and leaf area (cm^2) as influenced by integrated nutrient management in spine gourd

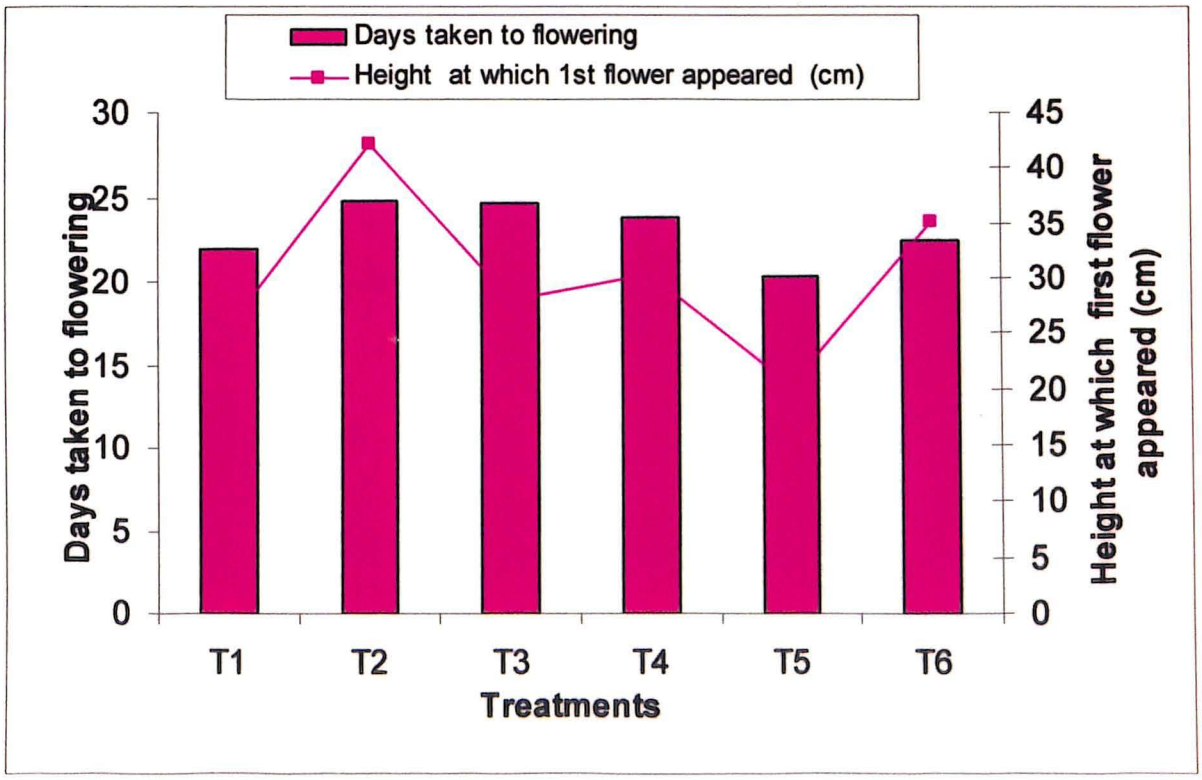


Fig 6. Days taken to flowering and height at which 1st flower appeared (cm) as influenced by integrated nutrient management in spine gourd

4.5 LEAF AREA (cm^2)

Significant differences were exhibited among different treatments with respect to leaf area (Table no.3 and Fig.5). Maximum leaf area was recorded in T_4 (76.43 cm^2) followed by T_3 (76.01 cm^2) and T_5 (75.63 cm^2). However, these three treatments (T_4, T_3 and T_5) remained at par but significantly superior than other treatments. It was further observed that least leaf area was recorded with T_1 (50.58 cm^2) which also happen to be control.

4.6 HEIGHT AT WHICH 1st FLOWER APPEARED (cm)

From the data tabulated and presented in Table no.4 and Fig.6 revealed that the 1st flower appeared at a lower height in T_5 (20.36 cm) which was significantly superior than other treatments tried in this trial. However, 1st flower appeared at a maximum height with T_2 (42.10cm).

4.7 DAYS TAKEN TO FLOWERING

Significant differences were exhibited in days to flowering among different treatments (Table no.4and Fig.6). Least number of days taken for flowering was recorded with T_5 (20.13) which were significantly differed with other treatments. However, maximum days taken for flowering was recorded in T_2 (24.70), which also remained at par with T_3 (24.53) but significantly inferior than other treatments.

4.8 TOTAL CHLOROPHYLL (mg/g)

From the data tabulated and presented in Table no. 4 revealed that much difference is not noticed among the treatments with respect to the total chlorophyll content. But the maximum amount of chlorophyll was recorded with T_5 (2.29 mg/g) which remained at par with rest of the treatments except T_1 that is control (1.59 mg/g).

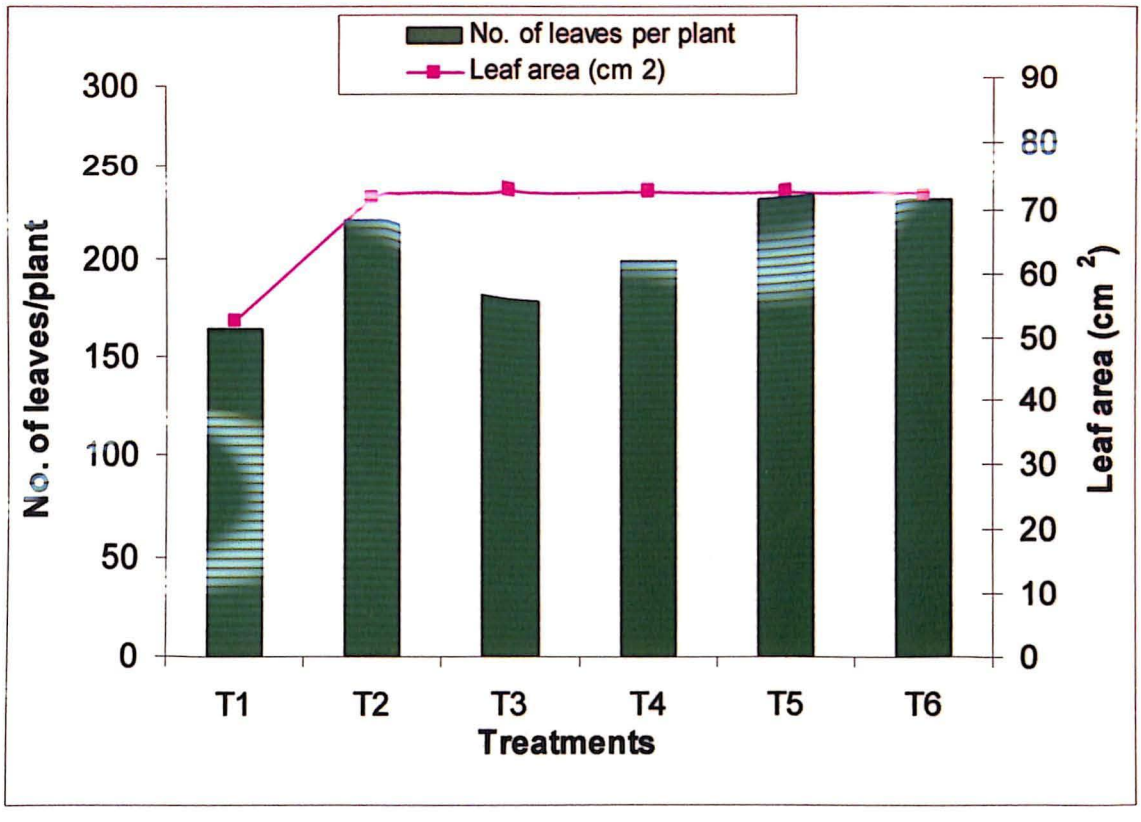


Fig 5. No.of leaves per plant and leaf area (cm^2) as influenced by integrated nutrient management in spine gourd

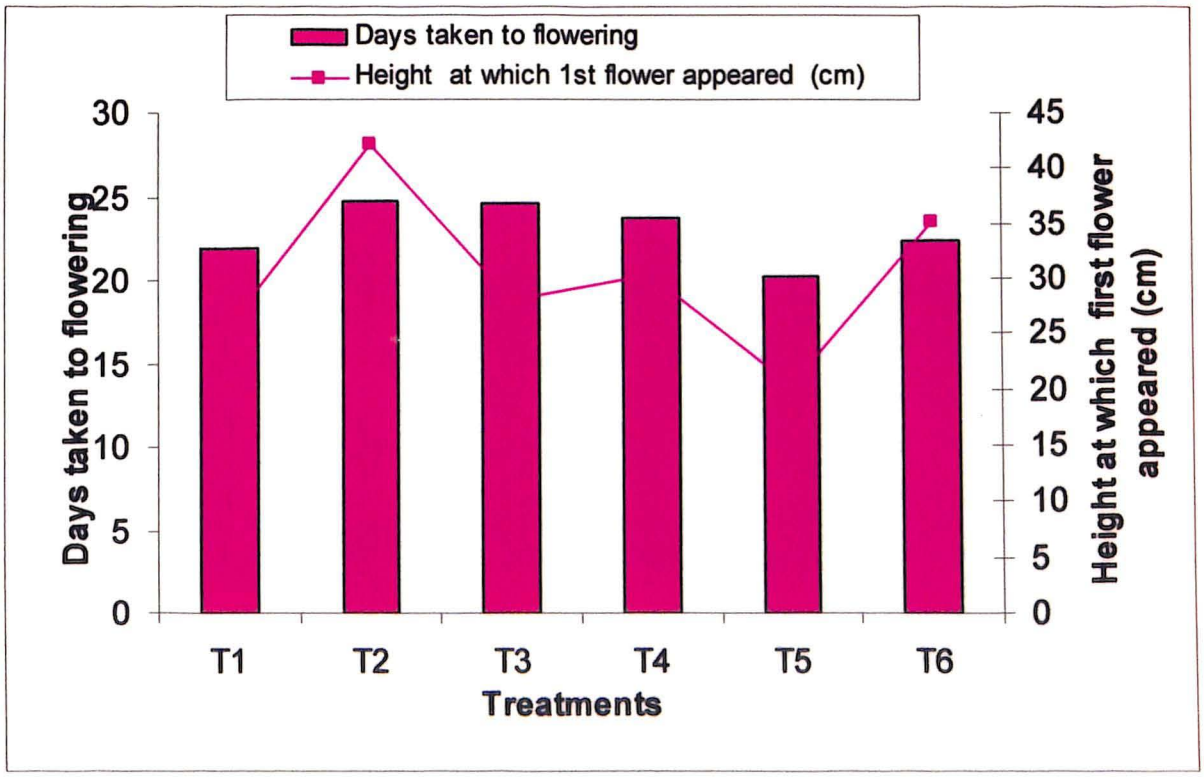


Fig 6. Days taken to flowering and height at which 1st flower appeared (cm) as influenced by integrated nutrient management in spine gourd

4.11 FRUIT GIRTH (cm)

Significant differences were exhibited among different treatments with respect to fruit girth (Table no.5). Maximum fruit girth was marked with T_5 (8.62 cm) which was superior to other treatments. The lowest value was recorded with T_1 (8.08 cm) which is the control.

4.12 FRUIT WEIGHT (g)

From the Table no.5, it is clearly revealed that the fruit weight varies significantly in different treatments. The highest individual fruit weight was recorded in T_5 (14.31 g) which was significantly superior than other treatments and the lowest value was recorded with T_1 (9.48 g) which was significantly inferior than other treatments.

Table 5 Number of fruits per plant, length of fruit (cm), fruit girth(cm), Fruit weight (g) and yield(q/ha) as influenced by integrated nutrient management in spine gourd

Treatments		No. of fruits per plant	Length of fruit (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit Yield (q/ha)
T_1	Control	48.28	4.85	8.08	9.48	30.66
T_2	Recommended dose of Fertilizer (RD)	54.17	5.17	8.38	10.06	36.51
T_3	RD + lime (0.2 LR)	45.16	5.20	8.46	12.85	43.30
T_4	RD + BI (Azot. + Azs. + PSB + AM)	58.97	5.34	8.58	12.33	48.72
T_5	RD + Lime + BI	62.06	5.48	8.62	14.31	53.43
T_6	75 % RD + lime + BI	61.26	5.10	8.39	11.02	45.23
SE (m) ±		0.267	0.141	0.143	0.349	0.149
CD (0.05)		0.803	0.423	0.430	1.05	0.449

Table 4 Height at which 1st flower appeared (cm), Days taken to flowering, total chlorophyll (mg/g) as influenced by integrated nutrient management in spine gourd

Treatments		Height at which 1st flower appeared (cm)	Days taken to flowering	Total chlorophyll (mg/g)
T_1	Control	25.80	21.85	1.59
T_2	Recommended dose of Fertilizer (RD)	42.10	24.70	1.89
T_3	RD + lime (0.2 LR)	28.12	24.53	1.95
T_4	RD + BIOINOCULANTS (Azot. + Azs. + PSB + AM)	30.45	23.69	2.18
T_5	RD + Lime + BI	20.36	20.13	2.29
T_6	75 % RD + lime + BI	35.21	22.31	2.08
	SE (m) ±	0.237	0.305	0.183
	CD(0.05)	0.715	0.918	0.551

4.9 NUMBER OF FRUITS PER PLANT

From the data tabulated and presented in Table no.5 and Fig.7 revealed th at maximum number of fruits per plant was observed with T_5 (62.06) which was significantly superior than other treatments. The lowest number of fruits per plant was recorded with T_1 (48.28) which happen to be control.

4.10 LENGTH OF FRUIT (cm)

Least variation was found in the length of the fruit under different treatments tried (Table no.5). Maximum length was marked with T_5 (5.48 cm) followed by T_4 (5.34 cm), T_3 (5.20 cm), T_2 (5.17 cm) and T_6 (5.10 cm). All these five treatments remained at par but exhibited higher value over control that is T_1 (4.85 cm).

4.11 FRUIT GIRTH (cm)

Significant differences were exhibited among different treatments with respect to fruit girth (Table no.5). Maximum fruit girth was marked with T_5 (8.62 cm) which was superior to other treatments. The lowest value was recorded with T_1 (8.08 cm) which is the control.

4.12 FRUIT WEIGHT (g)

From the Table no.5, it is clearly revealed that the fruit weight varies significantly in different treatments. The highest individual fruit weight was recorded in T_5 (14.31 g) which was significantly superior than other treatments and the lowest value was recorded with T_1 (9.48 g) which was significantly inferior than other treatments.

Table 5 Number of fruits per plant, length of fruit (cm), fruit girth(cm), Fruit weight (g) and yield(q/ha) as influenced by integrated nutrient management in spine gourd

Treatments		No. of fruits per plant	Length of fruit (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit Yield (q/ha)
T_1	Control	48.28	4.85	8.08	9.48	30.66
T_2	Recommended dose of Fertilizer (RD)	54.17	5.17	8.38	10.06	36.51
T_3	RD + lime (0.2 LR)	45.16	5.20	8.46	12.85	43.30
T_4	RD + BI (Azot. + Azs. + PSB + AM)	58.97	5.34	8.58	12.33	48.72
T_5	RD + Lime + BI	62.06	5.48	8.62	14.31	53.43
T_6	75 % RD + lime + BI	61.26	5.10	8.39	11.02	45.23
	SE (m) ±	0.267	0.141	0.143	0.349	0.149
	CD (0.05)	0.803	0.423	0.430	1.05	0.449

4.13 FRUIT YIELD (q/ha)

A significant variation in total fruit yield due to different treatments was observed in the present experiment which varied between 30.66 and 53.43 q/ha (Table no.5 and Fig.7). All the treatments had higher values than T_1 (control). Among the treatments tried, maximum yield was recorded with T_5 (53.43 q/ha) which was significantly superior to all the treatments. The lowest yield of 30.66 q/ha was recorded with T_1 (control).The treatments followed in the order T5>T4>T6>T3>T2>T1.

4.14 PLANT DRY WEIGHT (q/ha)

From the Table no.6 it was revealed that the plant dry weight was significantly influenced by different treatments. Maximum plant dry weight was recorded with T_5 (6.59 q/ha) which was significantly higher than other treatments. But T_3 (6.35 q/ha), T_6 (5.75 q/ha) and T_4 (5.97q/ha) remained at par but significantly superior than control. However, the lowest value was recorded in T_1 (3.9 q/ha) that is control.

4.15 FRUIT DRY WEIGHT (q/ha)

From the data tabulated and presented in Table no.6 revealed that maximum fruit dry weight was recorded with T_5 (7.98 q/ha) which was significantly superior than other treatments tried. But T_4 (6.78 q/ha) and T_3 (6.65 q/ha) as well as T_6 (6.05 q/ha) and T_2 (5.78 q/ha) remained at par. However, the lowest fruit dry weight was recorded in T_1 (4.05 q/ha) which was control.

4.16 DRY MATTER PRODUCTION

The dry matter production (DMP) of spine gourd crop has been presented in Table no.6. The fruit dry matter production was more than vine dry matter production and their ratio varying between 1.21:1 to 1.04:1. The total dry matter production varied between 7.95 and 14.6 q/ha, lowest with control

and highest with the application of recommended dose of fertilizers, soil ameliorated with lime and integrated with biofertilizers application. The harvesting index (Fruit yield compared to total dry matter production) ranged from 0.52 to 0.55. There was significant influence for the application of recommended dose of fertilizer, its integration either with soil amelioration or bioinoculation or mostly with the combination of both. Reducing the recommended dose of fertilizer by twenty five per cent and integrating it with soil amelioration and bioinoculants resulted in at par dry matter production, but reduced the harvesting index indicating the response of the crop to inorganic sources of nutrients.

Table 6 Dry matter production as influenced by Integrated Nutrient Management in Spine gourd

Treatments		Dry matter production (q/ha)			Ratio (Fruit dry matter to vine dry matter)	HI (Harvesting Index)
		Fruit	vine	Total		
T_1	Control	4.05	3.90	7.95	1.04:1	0.52
T_2	Recommended dose of Fertilizer (RD)	5.78	4.95	10.73	1.16:1	0.54
T_3	RD + Lime(0.2LR)	6.65	6.35	13.00	1.15:1	0.54
T_4	RD + BI	6.78	5.97	12.8	1.14:1	0.53
T_5	RD + lime + BI	7.98	6.59	14.6	1.21:1	0.55
T_6	75 % RD + Lime + BI	6.05	5.75	11.8	1.05:1	0.51
SE (m) ±		0.18	0.19	-	-	-
CD (0.05)		0.54	0.57	0.61	-	-

4.17 NUTRIENT UPTAKE

The information on nutrient uptake by spine gourd crop has been presented in Table no.7 and Fig.8.Among the nutrients studied, the crop removed more of K than N and the nutrients followed the order of K > N > P > S > Ca.

Table 7 **Nutrients uptake as influenced by Integrated Nutrient Management in Spine gourd**

Treatments		N			P			K			Ca			S		
		Fruit	Vine	Total	Fruit	Vine	Total	Fruit	Vine	Total	Fruit	Vine	Total	Fruit	Vine	Total
T_1	Control	18.4	7.9	26.3	1.11	11.0	12.1	16.6	28.9	45.5	1.9	1.3	3.2	2.4	3.8	6.2
T_2	Recommended dose of Fertilizer (RD)	28.9	10.9	39.8	2.18	16.0	18.2	21.0	38.3	59.3	2.7	2.0	4.7	3.3	4.8	8.1
T_3	RD + Lime(0.2LR)	37.7	14.6	52.2	2.70	18.8	21.5	27.3	50.3	77.6	3.7	2.8	6.5	4.1	6.0	10.1
T_4	RD+BI (Azot.+Azs+PSB+AM)	35.9	13.9	49.8	2.91	17.8	20.7	26.9	50.8	77.7	3.5	2.5	6.0	4.5	6.5	10.6
T_5	RD + lime + BI	42.6	14.9	57.5	3.20	21.6	24.8	29.8	56.4	86.2	4.0	3.3	7.3	4.8	7.2	12.0
T_6	75 % RD + Lime + BI	29.0	13.8	42.8	2.20	17.4	19.6	22.6	49.1	71.7	2.9	2.4	5.3	3.5	6.7	10.2
SE (m) ±		0.205	0.157	0.284	0.114	0.151	0.292	0.195	0.160	0.210	0.148	0.081	0.177	0.121	0.173	0.160
CD (0.05)		0.61	0.47	0.86	0.34	0.45	0.88	0.59	0.48	0.63	0.45	0.24	0.53	0.36	0.52	0.48

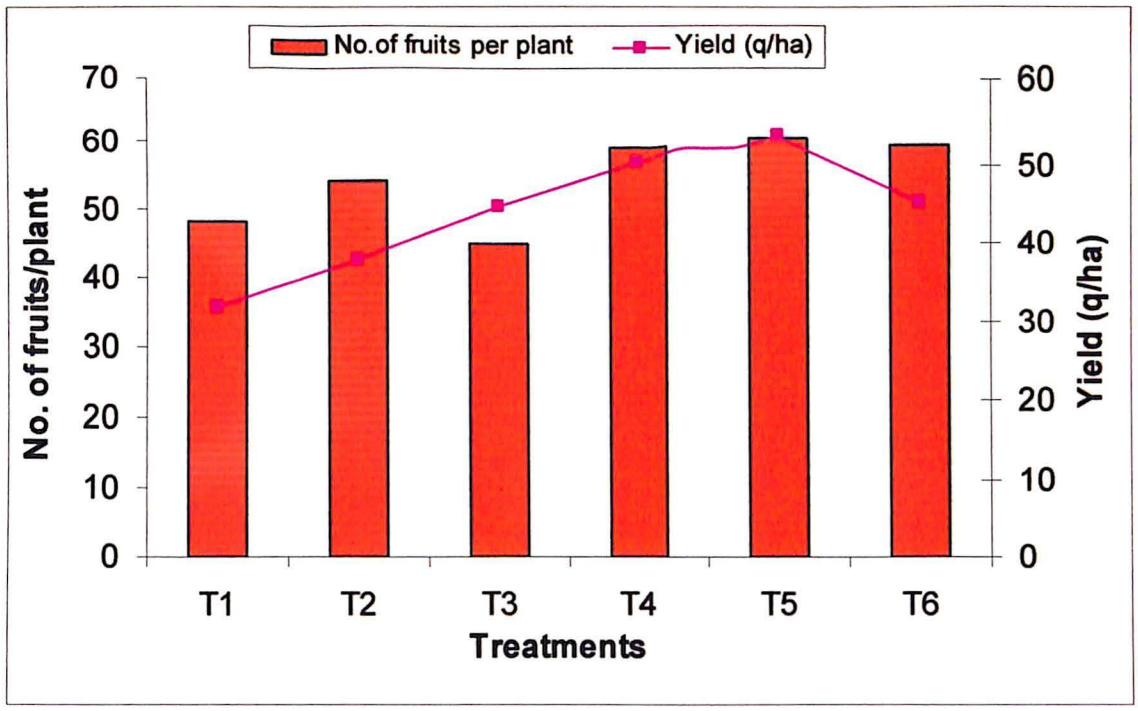


Fig 7. No.of fruits per plant and yield (q/ha) as influenced by integrated nutrient management in spine gourd

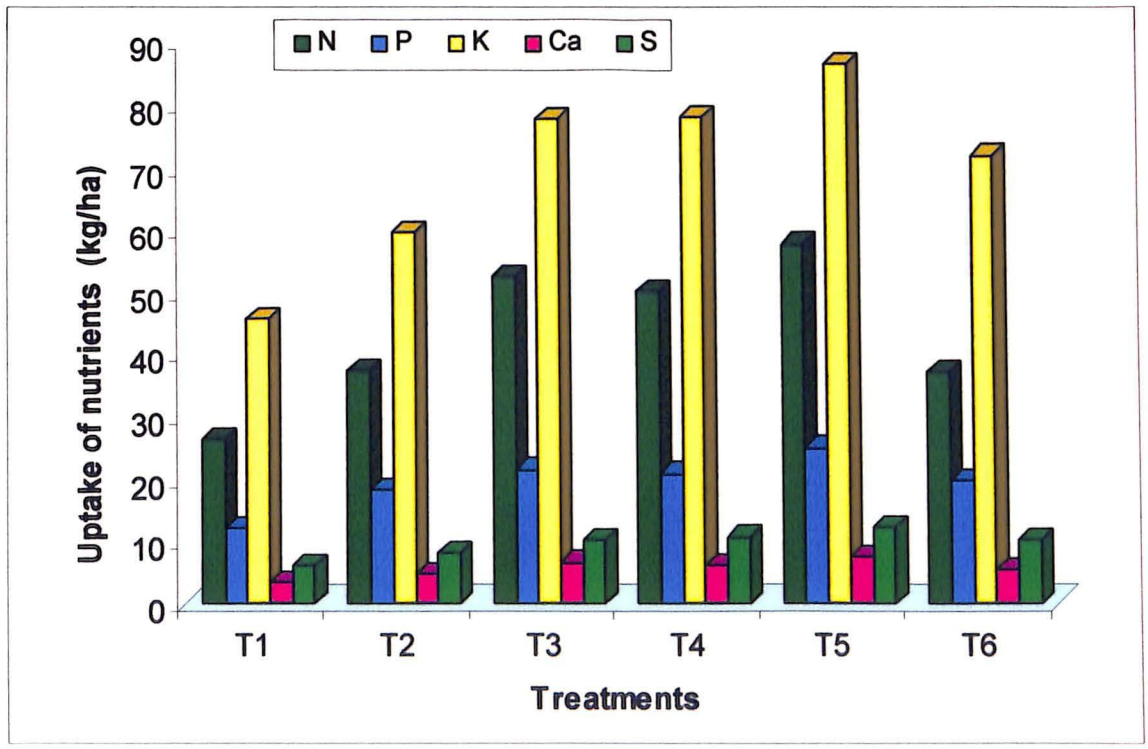


Fig 8. Total uptake of N, P, K, Ca, S as influenced by integrated nutrient management in spine gourd

NITROGEN

Removal of N was more (ranging from 18.4 to 42.6 kg ha^{-1}) through fruits than vine (ranging from 7.93 to 14.9 kg ha^{-1}) and the total amount varied between 26.3 and 57.5 kg ha^{-1}.The highest value was recorded with T_5 which was significantly superior than rest of the treatments and the lowest value was recorded in control in all the cases.

PHOSPHORUS

The amount of 'P' uptake was third in abundance amongst the other nutrients. Its uptake was more through vine than fruits. The total uptake varied between 12.1 and 24.8 kg ha^{-1}.In all the cases the highest value was observed with T_5 which was significantly higher than rest of the treatments. The lowest value was observed in T_1 which happens to be control.

POTASSIUM

Quantity wise uptake of K by the crop was highest, among the nutrients. Uptake through vine was (ranging from 28.9 to 56.4 kg/ha) higher than through fruits (ranging from 16.6 to 29.8 kg/ha). The total uptake ranged from 45.5 to 86.2 kg/ha (Table no.7 and Fig.8).Highest nutrient uptake in these cases marked with T_5 which was superior to other treatments. The lowest value was marked with T_1 which is control.

CALCIUM

Its uptake through fruit was slightly more (ranging from 1.9 to 4.0 kg/ha) than through vine (ranging from 1.3 to 3.3 kg/ha). The total uptake ranges from 3.2 to 7.3 kg/ha. The highest value was recorded with T_5 which was significantly superior than rest of the treatments and the lowest value was recorded in control in cases of both fruit and vine.

SULPHUR

The uptake of S through vine was more (ranging from 3.8 to 7.2 kg/ha) than its fruits (ranging from 2.4 to 4.8 kg/ha). The total uptake varied between 6.2 and 10.2 kg/ha which was more than calcium. In all the cases the highest value was observed with T_5 (RD+Lime+Bioinoculants) which was significantly higher than rest of the treatments and the lowest value was observed in T_1 (control).

4.18 APPARENT RECOVERY OF NUTRIENTS

The information on nutrient recovery by the spine gourd crop has been presented in Table no.8. The apparent recovery of N by the crop ranged from 19 to 45 %, P from 35 to 73 %, K from 29 to 85 per cent and S from 6 to 19 per cent. The recovery per cent of nutrients differed from nutrient to nutrient and from treatment to treatment based on the nature of the treatments. Soil amelioration for acidity and bioinoculation either alone or preferably together increased the recovery per cent of the nutrients. Reducing the recommended dose by twenty five per cent but integrating it with soil ameliorative measure and bioinoculation increased the recovery per cent 1.5 to 3 times as compared to recommended dose alone. This signifies the importance of soil ameliorative measures and bioinoculants practice in regulating the nutrient utilization by the crops.

Table no.8 Apparent recovery (%) of nutrients as influenced by Integrated Nutrient Management in Spine gourd

Treatments		Apparent recovery (%)			
		N	P	K	S
T_1	Control		-		
T_2	Recommended dose of Fertilizer (RD)	19	35	29	6
T_3	RD + Lime(0.2LR)	37	52	67	13
T_4	RD+BIOINOCULANTS (Azot.+Azs.+PSB+AM)	34	49	67	15
T_5	RD + lime + BI	45	73	85	19
T_6	75 % RD + Lime + BI	32	57	73	18

4.19 POST HARVEST SOIL PROPERTIES

The post harvest soil properties (Table no.9) show that limed soil had increased the soil pH (decreased the acidity) and unlimed soil had turned acidic (due to removal of basic cations by crops) and/or some loss through leaching.

The organic carbon and available nitrogen status in soil had increased compared to initial status but in control treatment these two parameters decreased. Biomass addition (leaf fall, root growth) under better nutrient management systems had exhibited such improvements.

As phosphorus is less used by the crop, its available, status increased where it was applied. However, it is status decreased in control treatment because no P was supplemented from external source.

Table 9 Post harvest soil properties as influenced by Integrated Nutrient Management in Spine gourd

Treatments		pH	Organic Carbon (g kg^{-1} soil)	AVAILABLE NUTRIENTS(kg ha^{-1})		
				N	P	K
T_1	Control	5.84	6.0	200	5.4	211
T_2	Recommended dose of Fertilizer (RD)	5.47	10.3	212	14.9	249
T_3	RD + Lime(0.2LR)	6.52	7.2	217	11.1	179
T_4	RD+BIOINOCULANTS (Azot.+Azs.+PSB+AM)	5.40	8.1	228	11.8	244
T_5	RD + lime + BI	6.53	6.8	232	17.8	196
T_6	75 % RD + Lime + BI	6.73	6.5	210	11.8	190
	Initial soil	5.90	6.5	280	45.8	275

The available potash status in soil after the harvest of the crop decreased invariably in all the treatments irrespective of its application indicating its use by the crop (mostly) or some loss through leaching under coarse textured soil condition.

Ameliorating the acid soil using lime had created better growing environment (physical, chemical, nutritional and biological) for the crop by neutralizing the acidity, deactivating Al, Fe ,Mn etc. the toxic elements in acid soil, improving the availability of Ca, P, K and many other desired nutrients by crop. Liming also improves the soil structure (through calcium addition) ,there by improve aeration, water holding capacity hence creating a better environment for root growth. Liming of acid soil also favours better microbial growth in soil particularly the bacterial population, there by the better microbial activity in support of plant growth.

Bioinoculation of crop in addition to N_2 fixation and phosphorus solubilization, through the enzymatic activity influencing root growth, root CEC (secreting IAA, GA, cytokinin etc.) for better nutrient absorption had helped the crop to produce higher yields with higher nutrient recovery. Combination of liming practice and bioinoculation with recommended dose of fertilizers acted like catalyst in influencing the crop performances.

The present study proposes the integration of soil ameliorative measures like lime application for acid soil with bioinocualtion of crop with *Azotobacter, Azospirilum* and phosphorus solubilizing organisms and application of recommended dose of fertilizers are very much essential for higher productivity of spine gourd crop.

PLATE 1: **COMPARISION OF PLANT GROWTH OF SPINE GOURD OBSERVED IN T_1 (CONTROL) AND T_2 (RECOMMENDED DOSE @70:40:60 Kg N,P_2O_5,K_2O PER HACTARE)**

PLATE 2: COMPARISION OF PLANT GROWTH OF SPINE GOURD OBSERVED IN T_3 (RECOMMENDED DOSE+LIME) AND T_4(RECOMMENDED DOSE+BIOINOCULANTS)

PLATE 3: COMPARISION OF PLANT GROWTH OF SPINE GOURD OBSERVED IN T_2 (RECOMMENDED DOSE) AND T_5(RECOMMENDED DOSE+LIME+BIOINOCULANTS)

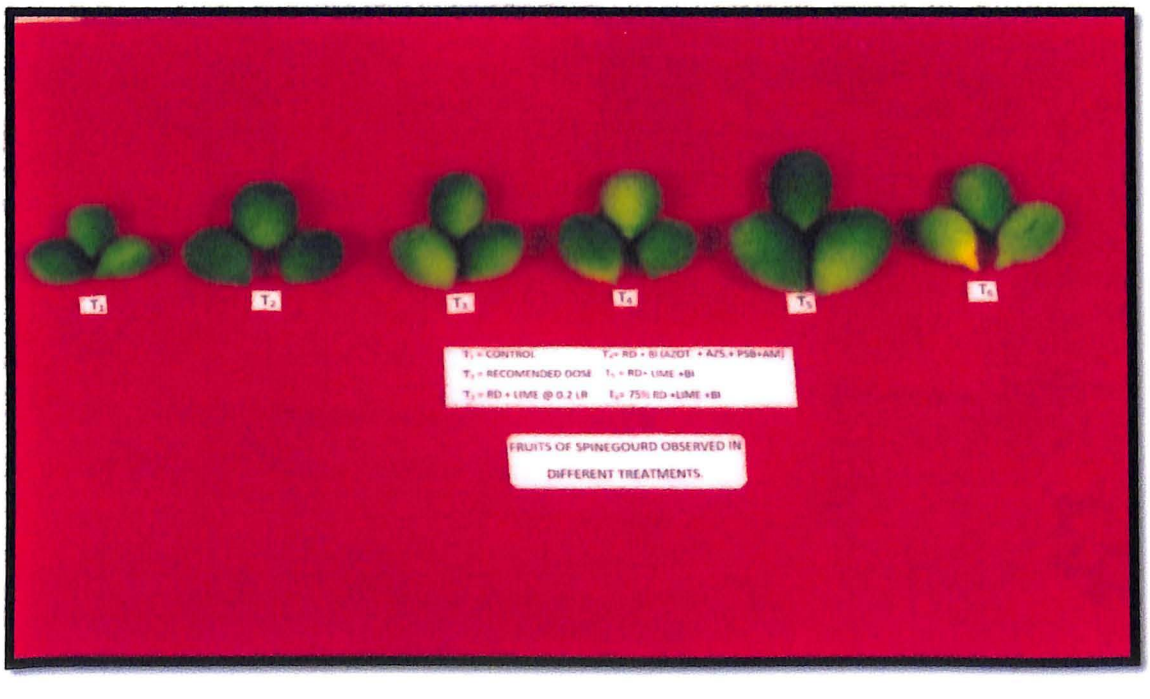


PLATE 4: FRUITS OF SPINEG OURD OBSERVED IN DIFFERENT TREATMENTS

PLATE 5 : **ROOT GROWTH OF SPINEG OURD OBSERVED IN TREATMENT T_5 (RECOMMENDED DOSE+LIME+BIOINOCULANTS)**

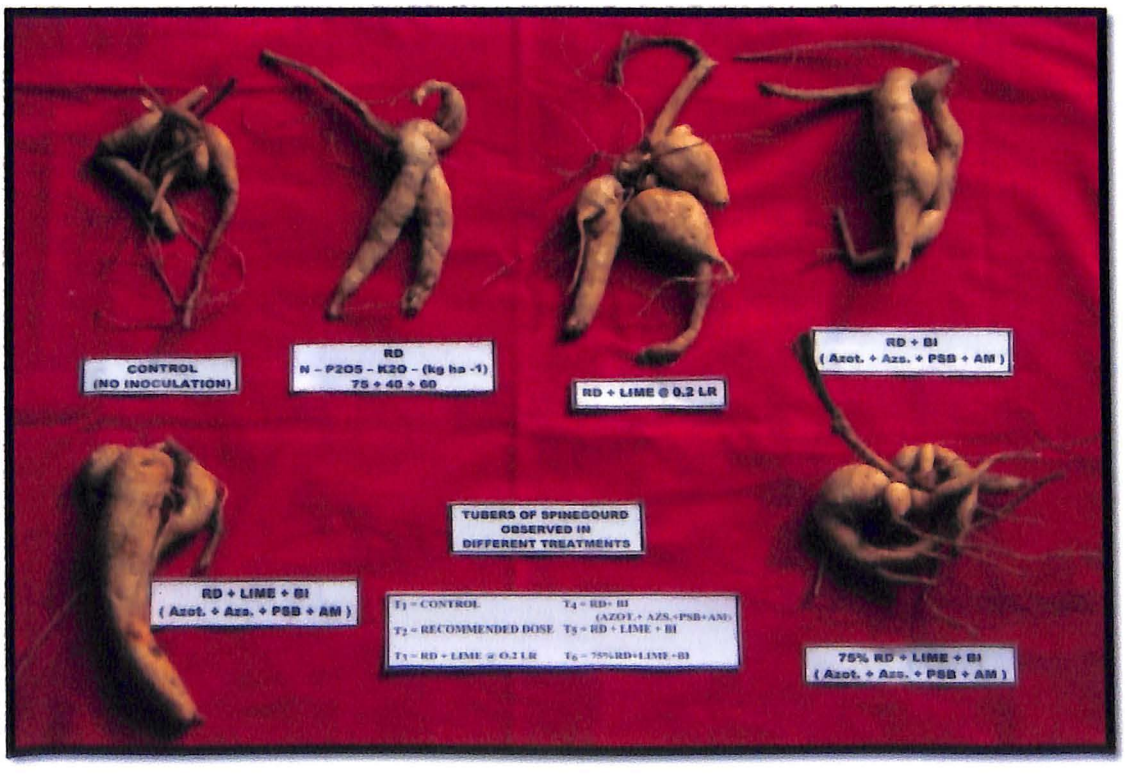


PLATE 6: ROOT GROWTH OF SPINEGOURD OBSERVED IN DIFFERENT TREATMENTS

Chapter-5

DISCUSSION

The present investigation is intended to estimate the effect of biofertilizers with graded doses of chemical fertilizers like N,P and K combine with other substances like lime and amendments on the growth, yield and quality of spine gourd (*Momordica dioica* Roxb.). Although the use of chemical fertilizer is the fastest way of counter acting the pace of nutrient depletion, the ever rising energy cost and limited input availability often create concern to the farmers for using chemical fertilizers at recommended quantities. An integrated approach to nutrient management involving judicious combinations of chemical fertilizer (Nitrogen, Phosphorous and Potash) and bioinoculants (*Azospirillum, Azotobacter, phosphorous solubilizing microbes, Arbuscular Micorrhiza*) along with lime which was evaluated on growth, yield and quality of spine gourd could be a rewarding approach in this context. The results of the present study on integrated affect of bioinoculation & chemical fertilization on growth, yield and quality of spine gourd are discussed below

5.1 PRE-HARVEST CHARACTERS

5.1.1 Plant height (cm)

The result revealed that plant height in spine gourd was greatly influenced by the combined application of N, P, K and biofertilizer along with lime and amendments. Application of only biofertilizer or 100 percent chemical fertilizers alone could not influence significantly than the combined application. However, they individually differ significantly over control. Biofertilizer might have attributed to longer amount of sustained supply of nutrient during the growth period. Significant increase in plant height might also be due to the production of different phytohormones like IAA, GA and

Cytokinin produced by biofertilizers. The increase in plant height might also be due to the action of phosphobacteria in the synthesis of growth promoting substances like vitamin B_{12}, auxin and IAA. Further, the chemical fertilizer particularly nitrogen along with lime and farm yard manure after being taken up during the growth period resulted quicker cell formation and elongation leading to increase in the height of the plant.

Similar results were also obtained by Nazeer *et al* (1991) in chilli, Paramguru *et al* (1993) in capsicum, Zeenat *et al* (1994), Terry *et al* (1995 and 2000) and Barakart and Gabr (1988) in tomato.

5.1.2 Number of branches per plant

Combined affect of 100 percent N, P, K with biofertilizer in combination with lime and amendments resulted in the production of maximum number of branches as compared to control or even application of full dose of chemical fertilizer/biofertilizer alone. This clearly indicates that biofertilizer along with amendments got a cumulative affect in association with nitrogen, thus enhancing its requirement by the crop. In the soil, the nutrient requirements of plant through fertilizers for its growth showed reduced affect on the development of number of branches per plant where it was applied alone. Further, the affect of 75 percent N, P, K with biofertilizers along with amendments could also encourage the production of more number of branches than the control. This might be attributed to the synergistic affect of biofertilizers, nitrogen & amendments that could make available the nutrients in the soil to the plants when they were applied 100 percent. By the use of 100 percent N, P, K with biofertilizers along with amendments, the use efficiency of nutrients was increased which resulted by producing more number of branches per plant. This result was in conformity with the present findings as it was reported by Subbiah (1990) in tomato & Revanappa *et al* (1998) in Chilli.

5.1.3 Vine girth (cm)

Vine girth also was influenced by the application of chemical fertilizers, bioinoculants, lime & amendments. All these influenced to increase the girth of the vine in a positive manner than the vine which was not applied with chemical fertilizers etc. Application of 75 percent N, P, K along with bioinoculants and amendments also showed increase in vine girth in a positive manner there by giving strength to the plant for trelling. The result is in conformation with Rao *et al.* (1990) in muskmelon and Shivashankar Murthy *et al.* (2006) in gherkin (*cucumis anguria* L.)

5.1.4 Number of leaves per plant

It is will known that leaves are the major site of photosynthesis and act as the major "Source" for the "Sink". The production of leaves is generally influenced both by environment as well as nutrition. The number of leaves per plant showed significant variation due to various levels of organic and inorganic fertilizers. The combined application of all i.e. 100 percent N, P, K with biofertilizers along with amendments resulted in the maximum production of leaves. Similar positive affect was also reported by Nanthakumar (1997) in brinjal and Prabhu *et al* (2003) in okra.

5.1.5 Leaf area (cm^2)

Leaf area expansion is one of the indications of response of growth factor in many of the nutritional investigation & is also a direct indication of photosynthetic potentiality of a plant. Application of 100 percent N, P, K with biofertilizers as well as amendments as seen from the investigation had significant affect on increasing the leaf area than the control. Chemical fertilizer with bioinoculant & chemical fertilizer with bioinoculant and lime remained at par. A similar result was also observed by Prabhu *et al.* (2003) in okra.

5.1.6 Height at which 1st flower appeared (cm, female)

Higher dose of N, P and K along with biofertilizers and amendments influenced flowering at a lower height as compared to control and single application of biofertilizers/chemical fertilizers/ amendments. The availability of nutrients in case of combination of all the sources appear to be more adequate, there by influencing the bud to become a female flower which ultimately appear at a lower height. The quicker the availability of nutrients to the bud sooner is the development of the flower as well as its opening. The result is in confirmation with the findings of Nair, Meena and K.V Peter (1990) in Chilli.

5.1.7 Days taken to flowering

The combined effect of 100 percent N, P, K along with biofertilizers and amendments significantly influenced the appearance of flowers at minimum days after planting than sole application of N, P, K / biofertilizers/amendments. The combined affect might have helped the plant to produce flowers which took least number of days than other treatments. The sole application of N, P, K/biofertilizer/amendments could not contribute sufficiently for the availability of required quantities of nutrients which could exhibit the production of flowers at a lesser time. The result is in confirmation with Nanthakumar (1997) in brinjal.

5.2 POST HARVEST CHARACTERS

5.2.1 Number of fruits per plant

The present investigation revealed that maximum number of fruits were obtained in the treatment combination of 100 percent N, P, K with biofertilizers and amendments than other treatments. This increase may be due to the apportioning efficiency i.e. increased allocation of photosynthates towards the economic parts that is the fruits & also the hormone balance in the plant system. Similar findings

are also reported by Terry *et al* (2000), Anguilar *et al* (1998) in tomato, Subbiah *et al* (1982) in chilli, Subramanian *et al* (1993) and Sendur *et al* (1998) in tomato.

5.2.2 Length & girth of the fruit (cm)

Both the length and the girth were found to be significant with respect to the combined effect of 100 percent N, P, K with biofertilizers and amendments over the other treatments. In both the characters 100 percent N, P, K with biofertilizers and amendments remained at par with other treatments except control. However, the higher dose of N, P and K with bio fertilizers & amendments showed increased in length & girth of the fruits which was in confirmation with Nazeer *et al* (1991) in chilli and Terran *et al* (1994) in onion.

5.2.3 Fruit Weight (g)

The weight of the fruit was found to be significant with respect to the combined effect of 100 percent N, P, K along with biofertilizers and amendments over the other treatments. However, bigger size fruits with increased weight were recorded by applying full dose of N, P and K with biofertilizer as well as amendments which might have favoured the production and accumulation of prepared food, thereby increasing the individual fruit weight. This result is in confirmation with Terry *et al* (2000), Anguilar *et al* (1998) in tomato, Subbiah *et al* (1982) in chilli, Subramanian *et al* (1993) and Sendur *et al* (1998) in tomato.

5.2.4 Fruit Yield (q/ha)

Application of different levels of N, P, K in combination with biofertilizers and amendments, increased the yield of fresh fruits per plant and ultimately the yield per hectare in an increasing order with that of increase in the dose of N, P, K combine with biofertilizers and amendments. Maximum yield (53.43 q/ha) was obtained with the use of recommended dose of chemical fertilizers with biofertilizers and amendments which was significantly higher than other treatments including control. The yield increase might have been due to the better manifestation of yield attributes on account of application of organic-inorganic combination of manures & fertilizers including biofertilizer resulting in better growth

indices due to efficient utilization of nutrients by the test crop of spine gourd. Another possible reason for the increase in yield may be the solubulization affect of nutrients as well as the chelating affect of biofertilizers on metals, thereby the availability gets increased. This is in confirmation with Sharma *et al* (2001), Anguilar *et al* (1998), Subbiah *et al* (1990) in tomato and Singh *et al* (2007) in pointed gourd.

5.2.5 Uptake of nutrients

Application of inorganic fertilizers as well as biofertilizers with amendments has increased the productivity of spine gourd crop as observed in the present investigation. Chemical fertilizers particularly nitrogen may be available to the plant in some quantity, but the major portion may leach whereas, phosphorus will remain in bound form in the soil which will be gradually available to the crop. The biofertilizers act as a chelating agent where by different nutrients except nitrogen will be made available in sufficient quantity to the plant which in turn utilize and produce maximum yield. The highest uptake value with respect N, P, K,Ca and S were recorded when 100 per cent NPK combined with biofertilizers and amendments applied to spine gourd crop.Schuphan (1974) reported that the efficiency of inorganic fertilizer was pronounced when they were combined with organic/biofertilizer. The maximum availability of N, P, K, Ca and S individually or synergistically resulted in increased vegetative growth reflected in terms of foliage production, plant height and finally increased the yield. This is in confirmation with Sharma *et al* (2001), Anguilar *et al* (1998) and Subbiah *et al* (1990) in tomato. Application of recommended dose of fertilizers had significant influence on the uptake of different nutrients as compared to no fertilizer application (control). Integrating soil amelioration with lime or bioinoculation either alone or together with recommended dose of fertilizers increased the nutrient uptake significantly. Integrating lime application and bioinoculation of crop with 25 per cent reduced dose of recommended dose of fertilizers influenced the nutrient uptake significantly higher than that due to recommended dose of fertilizers.

Chapter-6

LITERATURE CITED

SUMMARY AND CONCLUSION

An experiment entitled "Integrated Nutrient Management in Spine gourd". (*Momordica dioica* Roxb.) was carried out during *kharif* at the site allocated for "Network project on Biofertilizer" in OUAT, Bhubaneswar during 2008 with an objective to study the affect of biofertilizer, inorganic fertilizer levels and amendments on growth, yield and quality of spine gourd and the most appropriate combination for spine gourd required under Bhubaneswar agroclimatic conditions.

Application of various levels of N, P, K in combination with bio fertilizers and amendments increase the yield of fruits per plant and thereby increasing the yield/ha. Maximum yield (53.43 q/ha) was recorded by using the recommended dose of chemical fertilizers along with biofertilizers and amendments. The highest yield of this treatment was the sum total affect of yield attributing characters like number of fruits per plant, individual fruit weight, fruit length, fruit girth etc. Other biometric observations also exhibited higher value because of the fact that the growth characters also topped the list in this particular treatment. The maximum plant height, number of branches per plant, number of leaves per plant, leaf area etc. were also recorded higher value under this treatment. Yield per unit area has also been increased significantly over control, but the combined effect of biofertilizers with amendments have boosted the yield attributing characters to exhibit maximum limit which in turn produced the highest yield.

As regards the uptake of nutrients in the present investigations are concerned, when spine gourd crop was treated with biofertilizers and its soil

was amended with lime, the fruit yield increased significantly due to maximum utilization of N, P, K resulted in increased vegetative growth reflecting in terms of better foliage production, plant height and other yield attributing characters and finally the yield.

Further, investigations should be conducted with respect to the economics of crop production to arrive at a concrete conclusion on use of chemical fertilizers/biofertilizers/amendments and chemical fertilizers with biofertilizers and amendments for the benefit of the growers.

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LITERATURE CITED

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APPENDICES

APPENDICES

ANOVA TABLES

APPENDIX I: PLANT HEIGHT (cm)

Source	DF	SS	MS	F
Blocks	3	0.234	0.078	0.412
Treatments	5	2440.703	488.141	2574.808
Error	15	2.844	0.190	
Total	23			

APPENDIX II: NUMBER OF BRANCHES PER PLANT

Source	DF	SS	MS	F
Blocks	3	0.030	0.010	0.092
Treatments	5	14.466	2.893	27.190
Error	15	1.596	0.106	
Total	23			

APPENDIX III: VINE GIRTH (cm)

Source	DF	SS	MS	F
Blocks	3	0.178	0.059	0.606
Treatments	5	1.499	0.300	3.063
Error	15	1.468	0.098	
Total	23			

APPENDIX IV: NUMBER OF LEAVES PER PLANT

Source	DF	SS	MS	F
Blocks	3	1.792	0.597	3.162
Treatments	5	23486.000	4697.200	24867.530
Error	15	2.833	0.189	
Total	23			

APPENDIX V: LEAF AREA (cm^2)

Source	DF	SS	MS	F
Blocks	3	1.583	0.528	1.193
Treatments	5	1965.242	393.048	888.524
Error	15	6.635	0.442	
Total	23			

APPENDIX VI: HEIGHT AT WHICH 1ST FLOWER APPEARED (cm)

Source	DF	SS	MS	F
Blocks	3	1.325	0.442	1.959
Treatments	5	1148.662	229.732	1018.871
Error	15	3.382	0.225	
Total	23			

APPENDIX VII: DAYS TAKEN TO FLOWERING

Source	DF	SS	MS	F
Blocks	3	0.310	0.103	0.278
Treatments	5	62.552	12.510	33.712
Error	15	5.566	0.371	
Total	23			

APPENDIX VIII: TOTAL CHLOROPHYLL (mg/g)

Source	DF	SS	MS	F
Blocks	3	0.375	0.125	0.929
Treatments	5	1.222	0.244	1.818
Error	15	2.017	0.134	-
Total	23	-	-	-

APPENDIX IX: NUMBER OF FRUITS PER PLANT

Source	DF	SS	MS	F
Blocks	3	0.279	0.093	0.326
Treatments	5	989.867	197.973	695.746
Error	15	4.268	0.285	
Total	23			

APPENDIX X: LENGTH OF FRUIT (cm)

Source	DF	SS	MS	F
Blocks	3	0.147	0.049	0.614
Treatments	5	0.923	0.185	2.321
Error	15	1.194	0.080	-
Total	23	-	-	-

APPENDIX XI: FRUIT GIRTH (cm)

Source	DF	SS	MS	F
Blocks	3	0.811	0.270	3.300
Treatments	5.	0.741	0.148	1.810
Error	15	1.228	0.082	-
Total	23	-	-	-

APPENDIX XII: FRUIT WEIGHT (g)

Source	DF	SS	MS	F
Blocks	3	0.529	0.176	0.362
Treatments	5	66.432	13.286	27.278
Error	15	7.306	0.487	-
Total	23	-	-	-

APPENDIX XIII: FRUIT YIELD (q/ha)

Source	DF	SS	MS	F
Blocks	3	1.186	0.395	4.461
Treatments	5	1362.832	272.766	3077.638
Error	15	1.329	0.089	-
Total	23	-	-	-

APPENDIX XIV: PLANT DRY WEIGHT (q/ha)

Source	DF	SS	MS	F
Blocks	3	0.275	0.092	0.634
Treatments	5	30.774	6.155	42.537
Error	15	2.170	0.145	-
Total	23	-	-	-

APPENDIX XV: FRUIT DRY WEIGHT (q/ha)

Source	DF	SS	MS	F
Blocks	3	0.755	0.252	1.981
Treatments	5	26.192	5.238	41.244
Error	15	1.905	0.127	-
Total	23	-	-	-

APPENDIX XVI: TOTAL 'N' UPTAKE BY FRUIT AND VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.901	0.300	0.928
Treatments	5	2776.133	555.227	1716.182
Error	15	4.853	0.324	-
Total	23	-	-	-

APPENDIX XVII: TOTAL 'P' UPTAKE BY FRUIT AND VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.072	0.024	0.070
Treatments	5	364.301	72.860	214.174
Error	15	5.103	0.340	-
Total	23	-	-	-

APPENDIX XVIII: TOTAL 'K' UPTAKE BY FRUIT AND VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.539	0.180	1.021
Treatments	5	4420.898	884.180	5022.559
Error	15	2.641	0.176	-
Total	23	-	-	-

APPENDIX XIX: TOTAL 'Ca' UPTAKE BY FRUIT AND VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.271	0.090	0.725
Treatments	5	40.033	8.007	64.220
Error	15	1.870	0.125	-
Total	23	-	-	-

APPENDIX XX: TOTAL 'S' UPTAKE BY FRUIT AND VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.587	0.196	1.922
Treatments	5	87.493	17.499	171.854
Error	15	1.527	0.102	-
Total	23	-	-	-

APPENDIX XXI: 'N' UPTAKE BY FRUIT (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.692	0.231	1.377
Treatments	5	1801.041	360.208	2150.051
Error	15	2.513	0.168	-
Total	23	-	-	-

APPENDIX XXII: 'P' UPTAKE BY FRUIT (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.295	0.098	1.900
Treatments	5	11.068	2.214	42.737
Error	15	0.777	0.052	-
Total	23	-	-	-

APPENDIX XXIII: 'K' UPTAKE BY FRUIT (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.353	0.118	0.771
Treatments	5	478.942	95.788	628.765
Error	15	2.285	0.152	-
Total	23	-	-	-

APPENDIX XXIV: 'Ca' UPTAKE BY FRUIT (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.441	0.147	1.671
Treatments	5	11.472	2.294	26.098
Error	15	1.319	0.088	-
Total	23	-	-	-

APPENDIX XXV: 'S' UPTAKE BY FRUIT (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.770	0.257	4.378
Treatments	5	14.020	2.804	47.842
Error	15	0.879	0.059	-
Total	23	-	-	-

APPENDIX XXVI: 'N' UPTAKE BY VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.568	0.189	1.915
Treatments	5	147.830	29.566	299.166
Error	15	1.482	0.099	-
Total	23	-	-	-

APPENDIX XXVII: 'P' UPTAKE BY VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.414	0.138	1.514
Treatments	5	250.310	5.062	549.841
Error	15	1.366	0.091	-
Total	23	-	-	-

APPENDIX XXVIII: 'K' UPTAKE BY VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.316	0.105	1.025
Treatments	5	2048.641	409.728	3983.180
Error	15	1.543	0.103	-
Total	23	-	-	-

APPENDIX XXIX: 'Ca' UPTAKE BY VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.157	0.052	1.975
Treatments	5	9.064	1.813	68.494
Error	15	0.397	0.026	-
Total	23	-	-	-

APPENDIX XXX: 'S' UPTAKE BY VINE (Kg/ha.)

Source	DF	SS	MS	F
Blocks	3	0.073	0.024	0.204
Treatments	5	32.981	6.596	55.092
Error	15	1.796	0.120	-
Total	23	-	-	-

APPENDIX XXXI: N, P, K, CA AND S UPTAKE BY FRUIT (kg/ha) AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT IN SPINE GOURD

Treatments		uptake by fruit				
		N	P	K	Ca	S
T_1	Control	18.40	1.102	16.528	1.95	2.33
T_2	Recommended dose of Fertilizer (RD)	26.00	2.178	21.00	2.66	3.29
T_3	RD + lime (0.2 LR)	37.70	2.697	27.30	3.695	4.03
T_4	RD + BI (Azot + Azs + PSB + AM)	35.90	2.910	26.90	3.52	4.06
T_5	RD + Lime + BI	42.60	3.200	29.80	3.99	4.79
T_6	75 % RD + lime + BI	23.00	2.180	22.60	2.92	3.50
	SE (m) ±	0.205	0.114	0.195	0.148	0.121
	CD (0.05)	0.615	0.342	0.587	0.447	0.364

APPENDIX XXXII: N, P, K, CA AND S UPTAKE BY VINE (kg/ha) AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT IN SPINE GOURD

Treatment		uptake by vine				
		N	P	K	Ca	S
T_1	Control	7.93	10.97	28.84	1.32	3.77
T_2	Recommended dose of Fertilizer (RD)	10.88	15.97	38.24	1.97	4.74
T_3	RD + lime (0.2 LR)	14.54	18.73	50.24	2.79	6.03
T_4	RD + BI (Azot + Azs + PSB + AM)	13.91	17.79	50.82	2.50	6.50
T_5	RD + Lime + BI	14.93	21.63	56.38	3.27	7.13
T_6	75 % RD + lime + BI	13.74	17.37	49.08	2.36	6.63
SE (m) ±		0.157	0.151	0.160	0.081	0.173
CD (0.05)		0.472	0.453	0.483	0.244	0.521

APPENDIX XXXIII: TOTAL, N, P, K, CA AND S UPTAKE BY FRUIT AND VINE (kg/ha) AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT IN SPINE GOURD

Treatments		Total uptake by fruit and vine				
		N	P	K	Ca	S
T_1	Control	26.30	12.00	45.40	3.30	6.10
T_2	Recommended dose of Fertilizer (RD)	37.00	18.20	59.30	4.70	8.00
T_3	RD + lime (0.2 LR)	52.20	21.40	77.60	6.50	10.0
T_4	RD + BI (Azot. + Azs. + PSB + AM)	49.80	20.70	77.80	6.00	10.60
T_5	RD + Lime + BI	57.50	24.80	86.27	7.30	12.00
T_6	75 % RD + lime + BI	36.80	19.60	71.70	5.30	10.10
SE (m) ±		0.284	0.292	0.210	0.177	0.160
CD (0.05)		0.856	0.877	0.632	0.532	0.481