INFLUENCE OF ORGANIC MANURES AND LEVELS OF NITROGEN ON GROWTH, YIELD AND QUALITY OF PATCHOULI (*POGOSTEMON PATCHOULI* PELLET) UNDER COCONUT PLANTATION

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IN
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NAGALAND : INDIA

2007

Dedicated to
my beloved father
Late Yikhyingo Kikon

Department of Horticulture
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Prof. V.B. Singh
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CERTIFICATE

This is to certify that the work recorded in the thesis entitled, **"INFLUENCE OF ORGANIC MANURES AND LEVELS OF NITROGEN ON GROWTH, YIELD AND QUALITY OF PATCHOULI (*POGOSTEMON PATCHOULI* PELLET) UNDER COCONUT PLANTATION"** submitted by **Y. Y. KIKON** for the award of **DOCTOR OF PHILOSOPHY** Degree in **HORTICULTURE** to the Nagaland University, School of Agricultural Sciences & Rural Development, Medziphema, Nagaland, is a faithful and bonafide Research Work carried out under my supervision and guidance. The results of the investigation reported in the thesis have not so far submitted to any other degree or diploma. The assistance and help received during the course of investigation and the source of literature have been duly acknowledged.

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Dated Medziphema,
The 15-02-07

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CERTIFICATE OF VIVA-VOCE EXAMINATION OF Ph.D. (Ag.) IN HORTICULTURE
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This is to certify that the thesis entitled "*Influence of organic manures and levels of nitrogen on growth, yield and quality of patchouli under coconut plantation*" submitted by Mr. Y.Y. Kikon, s/o Mr. Yikhingo Kikon, Registration No.266/2007 dated 30th July 2005 to the Nagaland University in fulfillment of the requirements of Doctor of Philosophy (Agriculture) in the subject of Horticulture has been examined by examiners. The candidate was further examined by Power Point presentation as well as orally by us on 15.05.09. The performance on the oral examination has been found satisfactory/~~unsatisfactory~~. We recommend/~~not recommend~~ for award of the degree of Doctor of Philosophy (Agriculture) in Horticulture.

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Supervisor & Chairman

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Member

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIX

LIST OF ABBREVIATIONS

@	=	at the rate of
%	=	per cent
et al.	=	Et allia (and co-workers)
etc.	=	Et cetera
i.e.	=	that is
cv.	=	cultivar
Fig.	=	figure
g	=	gram
mg	=	milligram
kg	=	kilogram
m	=	metre
cm	=	centimeter
ha	=	hectare
t	=	tonne
q	=	quintal
viz.	=	vide list (namely)
M	=	Manure
M_1	=	Cowdung
M_2	=	Pig Manure
M_3	=	Vermicompost
FYM	=	Farm Yard Manure
N	=	Nitrogen
P_2O_5	=	Single Super Phosphate
K_2O	=	Muriate of Potash
No.	=	number
MAP	=	Months After Planting
RBD	=	Randomized Block Design
ICAR	=	Indian Council of Agricultural Research
NER	=	North Eastern Region
msl	=	mean sea level
C.D.	=	Critical Differences
MD	=	Man Day

Introduction

CHAPTER- I

INTRODUCTION

Among the essential oil bearing plants, patchouli has prime importance in the perfumery industry. Patchouli is a tropical plant which is believed to be originated from Phillipines and Indonesia, but now, it is cultivated in different tropical and sub-tropical regions in the world. The major producing countries are Indonesia, China, Brazil, Malayasia, India, Scycheeles, West Indies, etc. Patchouli (*Pogostemon cablin* syn. *P. patchouli*) is a bushy nature herb belongs to family Lamiaceae, grown under semi-shade condition of tropical plants.

The commercial oil of patchouli is obtained by steam distillation of the shaded dried leaves and is one of the most important naturally occurring essential oil used in the perfumery industry. Patchouli oil has notably strong fixative properties and helps to prevent rapid evaporation of a perfume and thereby promotes tenacity. The oil is generally blended with other essential oils, like, with those of geranium or clove oil before use. It is used in wide range of toilet soap, scents, body lotions, pre shave and after shave lotions and detergents. In very low concentrations (2.20 ppm), the oil is extensively used as a flavour ingredients in major food products, including alcoholic and non-alcoholic beverages, desserts, candy, baked products, gelatin, meat and meat products. Blended with sandalwood oil, it gives one of the finest attars, widely used in soap, cosmetics, tobacco and incense sticks (Sharan *et al.*, 1995). Dry patchouli leaves are used for scenting wardrobes. The leaves and apical buds are added in bath for their anti-rheumatic action. In Chinese medicine, decoction of the leaves is used with other drugs to treat nausea, vomiting, diarrhea, cold and headache (Leung, 1980).

Total world production of patchouli oil is estimated to be around 1000 tonnes per annum. Indonesia (Sumatra Island) alone accounts for more than 80 per cent of annual world production and the bulk of the remaining quantity comes from China (Robbins, 1983; and Tao, 1983). Currently, India is producing a very meager quantity of patchouli oil, and annually importing about 20 tonnes of pure patchouli oil and 100 tonnes of formulated oils. There is a vast gap between demand and supply which can be minimized by extension of area under patchouli cultivation in India.

Patchouli cultivation was started in north-eastern region under forest plantation by CIMAP during 1962 (Anupkumar et al., 1986). The warm and humid climatic condition along with long duration rainfall seems to be conducive for luxuriant growth of patchouli in the region. Patchouli being a shade loving plant can easily be cultivated as an intercrop among fruits and plantation crops. At least 75 per cent land goes unused in coconut plantation at a spacing of 7.5 x 7.5 m as maximum roots activity remained in the area of palm upto a radius of 2m and depth of 1.2m. (Sheeba and Nair, 2000). The high value aromatic crop like patchouli can be accommodated in such away that they fully utilized distinct layers of soil and micro-climate without competing with each other for light, nutrient and water. It is established fact that patchouli is cultivated in warmer part of north-eastern region including Nagaland without any nutrient inputs. Therefore, yield is comparatively low and also caused depiction of fertility status of the cultivable soil. This intensification and integration of land use system may be effective in strengthening the ecological base of farming in Nagaland condition.

In crop management, manuring is an important aspect which have direct impact on growth and yield of a crop. An integrated approach including the use of organic manures and inorganic fertilizers as a source of plant nutrients to obtain high yield with quality produce is of prime importance, besides maintaining soil health. Incorporation of organic manures into the soil increases the moisture holding capacity, humus content and other physical properties of soil. Therefore allows better root growth and development, assist in better uptake of nutrients by the crop plants and counter acts adverse effect of agro-chemicals (Ghose, 1984). The direct effects of organic manures relates through the uptake of humid substance as its decomposition products creating favorable growth and metabolism of plants as a result caused more yield in crops (Mathur and Guar, 1977; Singh *et al.*, 1995 and Lalramthara *et al.*, 2003).

Patchouli is grown for good herbage and to get maximum herbal yield, it requires both organic and inorganic manures. Sarwar *et al.* (1982) observed that application of a basal dose of 25 kg N, 50 kg P_2O_5 and 50 kg K_2O along with 100 kg N as top dressing in two split doses (first dose immediately after harvest and the balance about two months later) resulted in maximum herb and oil yield. Saha *et al.* (1992) found that use of 140 kg N/ha applied in four equal split doses increased the herb and oil yield significantly in Arunachal Pradesh. Defoliation and leaf reddening have been observed due to deficiency of NPK in patchouli (Vasanth kumar and Rao, 1983).

Though, the crop was introduced in north-eastern region for commercial cultivation as companion crop under forest plantation, where it was growing without any inputs. But now it is cultivated on agricultural land

or as intercrop in orchards in similar way. The nutritional requirement of the crop and its impact on soil fertility has not been standardized so far in the region. No such work has been carried out under Nagaland conditions which is also suitable for patchouli cultivation. Keeping in view of the existing technology gaps, the present work entitled "**Influence of organic manures and levels of nitrogen application on growth, yield and quality of patchouli (*Pogostemon patchouli* Pellet) cv. Johore under coconut plantation**" was carried out at Govt. Nursery, Department of Horticulture, Govt. ofNagaland, Dimapur under 6 to 9 years old coconut plantation with the following objectives:

1. To study the effect of organic manures and levels of nitrogen on growth, yield and quality of patchouli.

2. To study the effect of organic manures and levels of nitrogen on nutrient status of soil.

3. To study the economics of patchouli cultivation with different treatment combinations.

Review of Literature

CHAPTER - II

REVIEW OF LITERATURE

2:1 EFFECT OF ORGANIC AND INORGANIC NUTRITION ON GROWTH, YIELD AND QUALITY OF PATCHOULI

2:1:1 Effect of organic and inorganic nutrition on growth and yield

Patchouli is a soil exhausting crop and required liberal manuring. It responds well to both organic and inorganic manures. In a fertilizer trial on patchouli there was marked responses recorded to nitrogen and phosphorus but notto application of potassium. A response equation was formulated and used to calculate optimum fertilizer level: these were 107 kg N/ha, 38 kg P_2O_5/ha and 4 kg K_2O/ha for dry leaf of (2688 kg/ha) yield within 4 months. The oil content and quality were not effected by the fertilizer application (Adiwiganda *et al.*, 1973). For soils of poor fertility, a basal dose of 25 kg N, 50 kg.P_2O_5 and 50 kg. K_2O/ha was given in the form of urea, super phosphate and muriate of potash at the time of planting. After eight weeks, 25 kg N have again to be applied in the form of urea. After each harvest, 50 kg N has to be given in two split doses (the first dose immediately after harvest and the balance about two months later). In total, 150 kg N/ha is required to be given every year (Sarwar *et al.*, 1983). Foliar application of urea solution (0.2%) was also reported to induce better growth and higher leaf dry matter recovery.

Irulappan and Ponnuswami (1982) carried out a nutritional trial on patchouli. They applied Nat 0, 60 and 120 kg/ha along with P_2O_5 at 0, 15, 30 kg/ha and K_2O at 0, 30 and 60 kg/ha. Higher yield was recorded with application of 60 kg N, 30 kg P and 30 kg K/ha.

Munsi and Mukherjee (1982) applied various doses of nitrogen in mentha, citronella and palmarosa and observed that all the doses of nitrogen increased yield of herb and oil content in all these three crops. They further reported that quality of oil enhanced by application of nitrogenous fertilizer than control.

Bhardwaj *et al.* (1983) conducted a trial on various doses and split application of nitrogen in herb and oil yield in *Mentha citrate*. It was observed that application of 120 kg and 160 kg N/ha significantly increased herb and oil yield/ha, but application of 120 kg N/ha was found more economical than higher dose of nitrogen (160 kg/ha).

Randhawa *et al.* (1984) studied on the effect of various levels of nitrogen in *Mentha citrata* and found that the herb yield was highest with application of nitrogen at 125 kg/ha, but levels of nitrogen (0, 50, 75, 100, 125, 150, 175 and 200 kg/ha) had no effect on oil percentage.

Deficiency of N, P and K caused leaf reddening and defoliation (Vasantha kumar and Rao, 1983). Analysis of healthy and affected (reddened) leaves indicated that the sick plants were deficient of N, P and K. In such foliage, deficiency of zinc and manganese contents was also noticed. Further, in affected plants, severe toxicity of iron and copper were noticed. They also reported that iron and zinc ratio was very high in affected leaves as compared to healthy leaves. Increasing levels of soil application of P_2O_5 (from 0 to 8 g/plant) was found to increase the growth of plant and green leaf yield (Rao and Vasantha Kumar, 1989).

Munsi (1992) carried out a study on response of nitrogen and phosphorus on herb and essential oil yield in Japanese mint. He observed that application of higher doses of nitrogen (100 kg/ha) increased herb and oil yield.

Saha *et al.* (1992) found that use of 140 and 160 kg N/ha in four equal split doses increased herb yield upto (62.87 t/ha) and oil yield significantly in trials carried out in Arunachal Pradesh condition.

The patchouli plant respond well to organic and inorganic nitrogenous fertilizers and application of FYM @ 11.25 t/ha together with 228 kg each of ammonium sulphate and single super phosphate per hectare caused better yield after each harvest of leaves. Cow-dung manure and fish guano were also helped to increase the yield. Foliar application of urea solution seems to benefit growth as well as leaf production (Anon., 2002).

Vineeta *et al.* (2000) carried out an experiment on *Bacopa monniesi* to find out of response of farmyard manure and nitrogen. Shoot length, number of shoots and leaves/m^2, fresh and dry matter accumulation were increased with increasing fertility levels. The highest values of dry matters accumulation was recorded with 75 kg N + 5 t FYM/ha.

A trial on increasing doses of nitrogen was carried out by Golez *et al.* (2002) at Poland on production of herb of *Ocimum basilicum*. They reported that yield of sweet basil was increased with application of increased level of nitrogen up to 1.8 g/plant.

Singh and Rao (2005) carried out a study on nutritional trial and applied nitrogen at 0, 100, and 200 kg/ha in *Tagetes minuta*. They observed that application of nitrogen at 200 kg/ha significantly increased plant height, fresh weight, leaf/stem ratio, leaf+ flower/stem ratio, herbage (biomass) yield, oil yield and oil content. They further observed that uptake of nitrogen, phosphorus and potassium content increased as compared to control.

Singh *et al.* (2005) carried out a trial on response of organic manures on growth and yield in long pepper and applied farmyard manure, vermicompost, poultry manure, decomposed mushroom compost and wheat straw @ 5 and 10 t/ha. Application of farmyard manure at 10 t/ha significantly increased number of leaves, number of sprouts/plant and length and diameter of main branch. However, vermicompost at 10 t/ha resulted maximum leaf area and spike yield/plant followed by farmyard manure at 10 t/ha.

Singh and Karki (2005) conducted a trial on rose water and rose oil bearing variety Gruss-anTeplitz to substitute the chemical fertilizer by application of various manures and bio-fertilizer. Application of fertilizers (NPK 50: 40: 30 $g/m^{2)}$ delayed flowering, whereas early flower bud appearance and maximum flower production were noticed with FYM + VAM application treatment.

Pandey *et al.* (2005b) reported that all the sources of organic manures (FYM, vermicompost, poultry manure) had significantly effect on herb yield in *Ashwagandha* in comparison to control. Maximum plant \ height, number of branches, number of leaves and herbage yield was recorded with poultry manure (15 t/ha).

Pandey *et al.* (2005a) conducted an experiment on integrated nutrient management in *Centella asiatica and* result revealed that the number of leaves per meter row length increased significantly by NPK (100: 50: 50 kg/ha) as compared to control. Among the different doses of farmyard manure (10 t/ha) noted significantly more number of leaves as compared to the rest of the treatment. They further reported that herb yield (fresh and dry) of crop increased significantly due to application of 10 t/ha FYM as compared to 5 t/ha FYM.

Integrated nutrient management study was carried out on *Bacopa monniesi*. Singh *et al.* (2005a) revealed that application of 75 kg N and 5 t of FYM/ha on *Bacopa monniesi* recorded maximum number of leaves, branches per plant, spreading and herbage yield (fresh and dry) compared to other treatment.

Manjunatha *et al.* (2006) carried out an experiment to study the effect of bio fertilizers on growth, yield and essential oil content in patchouli cv. Johore under Bangalore condition. The results revealed that 75% NP+ 100% K + *Azotobacter* + *Azospirillum* + VAM recorded significantly superior values for plant height, number of leaves, number of branches, plant spread, leaf area, yield of essential oil followed by 50% NP + 100% K + *Azotobacter* + PSB + VAM and 50% P + NK + PSB + VAM.

2:1:2 Effect of organic and inorganic nutrition on quality of patchouli

Rao (2002) reported that farmyard manure at 15 t/ha increased total biomass yield by 10.7 per cent and essential oil yield by 10.3 per cent over control in palmarosa. He further observed that addition of higher dose of nitrogen (80 kg/ha) enhanced the total biomass yield by 57.6 per cent and total essential oil yield by 60.3 per cent. The quality of essential oil with 1.7 per cent (E)- *beta- ocimere*, 2.5 per cent *linalool*, 73.1 per cent *geraniol*, 15.8 per cent geranyl acetate and 2.0 per cent *beta- caryophyllene* was found to be good and was readily accepted in the market.

Venugopal *et al.* (2005) carried out a trial on comparative performance of patchouli under open and coconut shade condition. The result revealed significantly higher (fresh) yield under shade condition than open. Dry herbage yield was also recorded maximum in shade than open

condition. They further reported that superior quality oil and high per cent oil recovery (1.65 per cent on dry weight basis) was registered in patchouli plants under shade condition when compared to open (0.87 per cent) condition.

According to Sharma and Sharma (2003) 100 per cent oil was reverted within 3 hours in case of fresh leaf (80 - 87 per cent moisture) whereas, 80 - 90 per cent oil in semi-dried leaf (30 - 40 per cent moisture) took about 5 - 6 hours for recovery, and more than 90 per cent oil was recovered within 9 hours of distillation in case of dried leaf (10 - 20% moisture). Shade drying of leaf and storage upto 150 days seemed to be congenial condition for maximum recovery of oil.

Ramchandra *et al.* (2006) evaluated different varieties of patchouli at different spacing. They concluded that var. Johore showed better results and more oil content compared to Java (3.0% and 1.4% respectively). They recorded that maximum cumulative fresh herbage yield (7.89 t/ha) and dry herbage yield (3.15 t/ha) and essential oil (86.52 l/ha) with a spacing of 45 x 45 cm. Patchouli alcohol was also more in var. Johore (47.2%) compared to var. Java (32.50%).

Jessykutty (2005) advocated the application of organic manures at 4-5 t/ha along with 80:50:50 kg/ha, N, P and K for commercial production. However, nitrogen requires to be given in split doses. He further remarked that application of calcium and magnesium increase the oil content in patchouli.

Omidbaigi *et al.* (2006) observed that nitrogen fertilizer (150 kg N/ha) and plant density (14.3 plant/$m^{2)}$ had important role on enhancing the essential oil content and composition of *Tanacetum parthenium.*

2.2 EFFECT OF ORGANIC AND INORGANIC NUTRITION ON SOIL NUTRIENT STATUS

Application of organic manures helps in improving soil organic carbon which is crucial in sustaining of soil quality and agricultural productivity of land. Nutrient concentration and soil biological practices also enhanced by addition of organic matter. (Katyal, 2000). The soil organic matter also contributes tremendously to cation exchange capacity that enables the soil to buffer nutrient concentration in soil solution, apart from helping storage of plant nutrients (such as N, P, S and micro-nutrients etc.) in soil (Sanyal, 2001). It also increases availability of nutrients from the soil which are already present in the soil but not available to the plants. Application of FYM in the soil provided additional nutrient to the plants as well as improved the physical and biological properties of the soil (Reddy and Swamy, 2000).

Anwar *et al.* (2005) conducted a field trial to study the effect of organic manures and inorganic fertilizers on growth, herb and essential oil yield of basil crop. Various combination of farmyard manure and vermicompost as well as inorganic fertilizers (NPK) were employed. Application of vermicompost at 5 t/ha and NPK at 50, 25, 25 kg/ha exhibited maximum plant growth, herb, dry matter, oil content and oil yield. Content of principal constituents of basil oil (*methyl chavicol*) and linalool were also higher under integrated nutrient management especially when vermicompost was applied in combination with NPK. It was also noticed that organic carbon, available N, and P were higher in post harvest soils than control.

Bhaskar *et al.* (2005) conducted a field trial to study the effect of various soil amendments viz., well decomposed compost @ 30 t/ha, lime @ 2 t/ha, single super phosphate @ 600 kg/ha and gypsum @ 2 t/ha with or without recommended dose of NPK. The highest oil yield of 25.5 kg/ha was recorded when gypsum and compost were applied together with recommended NPK dose followed by 23.08 kg/ha NPK + SSP which was *at par* with treatments of NPK + lime + compost (22.61 kg/ha) and NPK + compost (20.6 kg/ha). It was also observed that saturation in terms of calcium and potassium favours the growth and yield of patchouli.

A field experiment was conducted to find out the response of organic fertilization (cattle manure) @0, 1, 2, 3 and 4 kg/m^2 on *Achillea millefolium*. All the doses of organic manure increased biomass and essential oil yield as compared to control. Level of carbon, potash, calcium and magnesium status of soil was not influenced, whereas, available phosphorus increased up to 150 per cent by application of organic manure (Schaffer *et al.*, 1993).

Sanwal et al. (2007) studied the effect of different organic manures (FYM, Poultry manure, Pig manure, Rabbit manure, Bioplus and Neem cake) and 100 % NPK on residual fertility status of soil in turmeric under Meghalaya conditions. Highest organic carbon (1.89 %), organic matter (3.26 %), available nitrogen (326.2 kg/ha) were recorded with FYM application while maximum pH (5.8), available P_2O_5 (46.70 kg/ha) and exchangeable calcium (3.28 kg/ha) and magnesium (0.74 kg/ha) were noticed with poultry manures. The pig manure caused maximum availability of potassium (243.8 kg/ha) in soil after harvest of the crop. Further, pig manure also enhanced residual fertility status of soil in comparison to other organic manures viz; rabbit manure and bio plus and full doses of chemical

fertilizers. Application of FYM, poultry manure and pig manure considerably reduced the soil acidity and significantly increased the accumulation of organic matter.

2.3 EFFECT OF ORGANIC AND INORGANIC NUTRITION ON ECONOMICS OF PATCHOULI

Adopting of any cropping system by farming community will ultimately be decided by its economic and advantages. The mono cropping of coconut generated employment opportunity of only around 150 man days per hectare per year, whereas, various cropping system could generate additional employment of 130-606 man days per hectare per year with a net return of Rs.50,000/- to Rs.1,00,000/- per hectare in coconut based farming (Sivarama, 2002). From along term fertilizer studies in coconut on Alfisols, it was observed that the fertilizer treatment 1000g N - 437g P - 1667g K per palm per year recorded significantly higher nut yield (136 nuts/palm) than the treatment 500g N- 218g P – 833g K/ palm/ year (104 nuts/ palm) and no fertilizer (58 nuts/ palm) (Reddy et al., 2002).

Production from 2 hectares of land can support 2 distillation units of one quintal capacity (60 kg dry leaf/batch) at a time. Running of two units of smaller size will be more economical as compared to large size one in respect of labour utilization and distillation efficiency. He further remarked that this venture will provide employment generation of 1255, 1285, 1285 and 1275 man days in first, second, third and fourth year respectively. It was also concluded that these units gave a net return of Rs.95,450/- Rs.2,34,120/- and Rs.1,58,120/- in first, second and third year respectively (Ahmed, 2002).

Materials and Methods

CHAPTER- III

MATERIALS AND METHODS

The present investigation entitled "**Influence of organic manures and levels of nitrogen application on growth, yield and quality of patchouli (*Pogostemon patchouli* Pellet) cv. Johore under coconut plantation**" was conducted at Govt. Nursery, Department of Horticulture, Govt. of Nagaland at 4th mile Dimapur, Nagaland during the year 2005 and 2006. The details of materials used and procedure followed during investigation regarding various parameters and analysis are represented below.

3:t GENERAL

3:1:1 Location

Experimental site was located at 4th mile between Dimapur and Chumukedima under the District of Dimapur at an altitude of 210 meters above m. s. l. at 25° 45' 43" N latitude and 93° 53' 04" E longitude.

3:1:2 Climate

The experimental site has sub-tropical type of climate, predominantly humid, moderate to warm temperature with an average rainfall ranges between 2000 mm - 2500 mm occurring about 6 months from April to October. Though, few light showers are also observed in other months, however, remaining period from November to March is comparatively dry. The summer temperature ranges between 22°C to 35°C,

while during winter it remains at an average between 10°C to 22°C. The relative humidity varies between 85 and 95 per cent during summer/rainy season while during winter it ranges between 50 and 60 per cent. The detailed weather condition during the period of experimentation has been presented as recorded at Meteorological Observatory Station located at District Soil Conservation Office, Dimapur, Govt. of Nagaland (Table 1 and fig. 1).

3:1:3 Soil

The soil of research field was characterized as deep sandy loam and well drained with mild undulating topography. The soil fertility status of the experimental field was classified as medium in available nitrogen, high in potash and low in available phosphorus content. The result of the soil analysis are presented below:

Para meter	Value	Status	Method employed
pH	5.40	Acidic	Digital pH meter (Single electorate meter)
Organic carbon (%)	2.90	High	Walkly & Black method. Rapid Titration method (Piper 1966)
Available Nitrogen (kg/ha)	315.50	Medium	Micro- kjeldahle method (Jones 1984)
Available Phosphorus (kg/ha)	19.32	Low	Spectrophotometer Vanadao molybdate yellow color method (Jackson 1969)
Available Potash (kg/ha)	298.70	High	Flamephotometer (Chapman and Pratt 1961)

3:1:4 Composition of organic manures

Locally available FYM, pig manure and vermicompost which were used in the present investigation were actually intended by the authority of the University, SASRD, Medziphema from a recognized dealer and analyzed the same for available Nitrogen, Phosphorous and Potash and data are given below:

Source	Nitrogen (%)	Phosphorous (%)	Potash(%)
FYM	0.50	0.20	0.35
Pig manure	1.00	0.50	0.60
Vermicompost	3.00	1.00	1.50

Nitrogen was estimated by Kjeldahle method (A.O.A.C., 1970), Phosphorous by Jackson, (1969) and Potash by Flame Photometer (Champanand Pratt, 1961).

3:2 EXPERIMENTAL DETAILS

The experiment was laid out (fig. 2) with two main factors – organic manure (M) and chemical fertilizer (N) and with four sub-factors viz., organic manure (M_0 - control), farmyard manure (M_1- 20 t/ha), pig manure (M_2- 10 t/ha), vermicompost (M_3 - 5 t/ha) and nitrogen with four levels (N_0- control, N_1- 60 kg/ha, N_2 - 80 kg/ha and N_3- 100 kg/ha). Full dose of organic manures were applied 15 days before planting in respective plot as per treatment along with the basal dose of phosphorus and potash @ 50 kg/ ha each. Nitrogen was applied in four split doses after each cutting of the leaves. The coconut plantation were pre-bearing stage hence the coconut plants were given NPK dose in two split application (first dose in the beginning of monsoon i.e., April and the second in the month of September) @ 400:200:800 g per tree per year along with 20 kg FYM.

Table : 1 : METEROLOGICAE DATA OF EXPERIMENTAL AREA FOR THE YEAR 2005 AND 2006 (JANUARY 2005 TO AUGUST 2006)

MONTHS	MAXIMUM TEMPERATURE(0C)	TURE(0C) TEMPERUATUE (0C)	RAINFALL(mm)	RELATIVE HUMIDITY (%)
JANUARY'05	24	11	15.2	66.6
FEBRUARY'05	24.5	14	12.4	62.1
MARCH'05	25	16	69.2	76.2
APRIL'05	27.5	20	59.8	78.4
MAY'05	32	20	79.2	80
JUNE'05	34	25	113.4	84.6
JULY'05	34	24	169.4	86.4
AUGUST'05	32.8	23	288.1	88.8
SEPTEMBER'05	33	22	89.6	76.3
OCTOBER'05	30	10	143	74
NOVEMBER'05	27	17	0	56.24
DECEMBER'05	21	14	2.6	58.4
JANUARY'06	23	12	0	56.4
FEBRUARY'06	26	15	0	58.2
MARCH'06	27	18.4	26.4	68.8
APRIL'06	29	18	58.4	68.4
MAY'06	33	22	345.9	86.4
JUNE'06	33	23.4	176.2	88.6
JULY'06	33	24	185.8	86.7
AUGUST'06	36.5	25	104.8	84.2

Souroa : Department of Soil & Water Conservation, Dimapur.

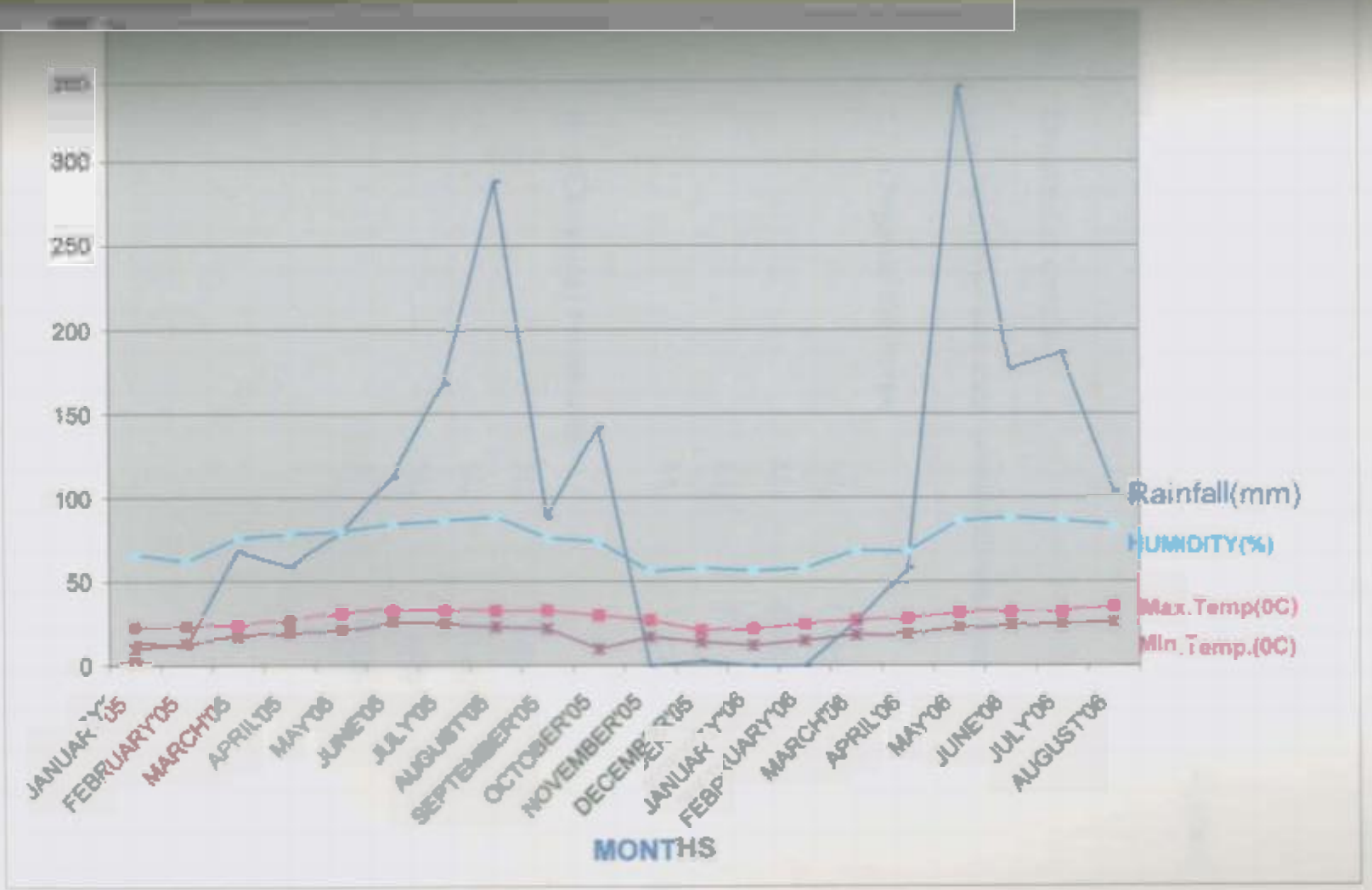


Fig. 1 : Meteorological data of experimental site during Jan '2005 to Aug '2006

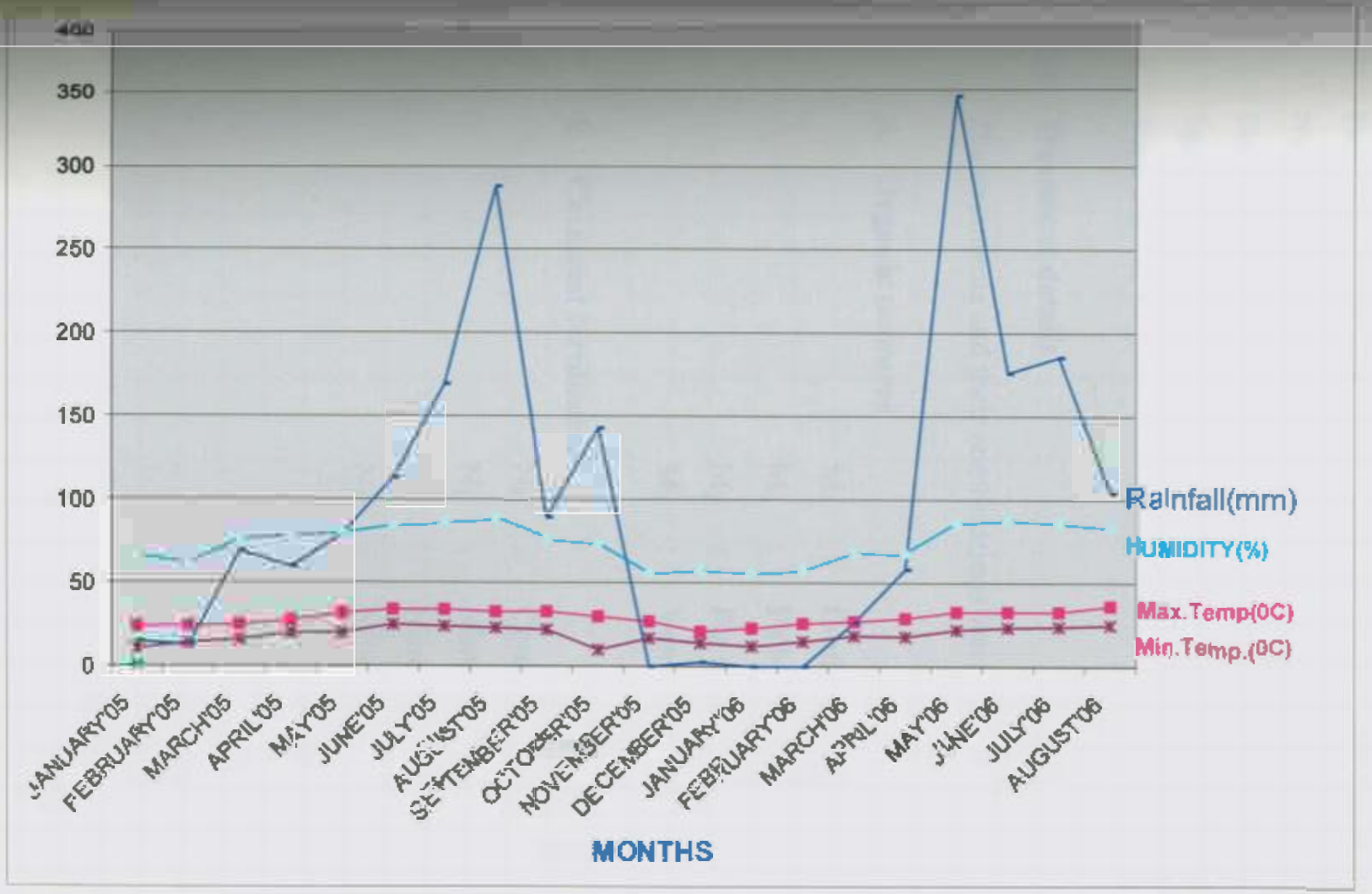


Fig. 1 : Meteorological data of experimental site during Jan '2005 to Aug '2006

3:2:1 Design of expefiment

Experimental design	:	Randomized Block Design
Factors	:	2
Number of replication	:	3
Plot size	:	2.25 m x 3.0 m.
Spacing	:	60 cm x 45 cm plant to plant.
Total number of plot	:	48

3:2:2 Treatment details

The treatments and their combinations were as follows:

A. Organic manures

M_0	:	Control (0 t/ha)
M_1	:	FYM (20 t/ha)
M_2	:	Pigmanure(10t/ha)
M_3	:	Vermicompost (5 t/ha)

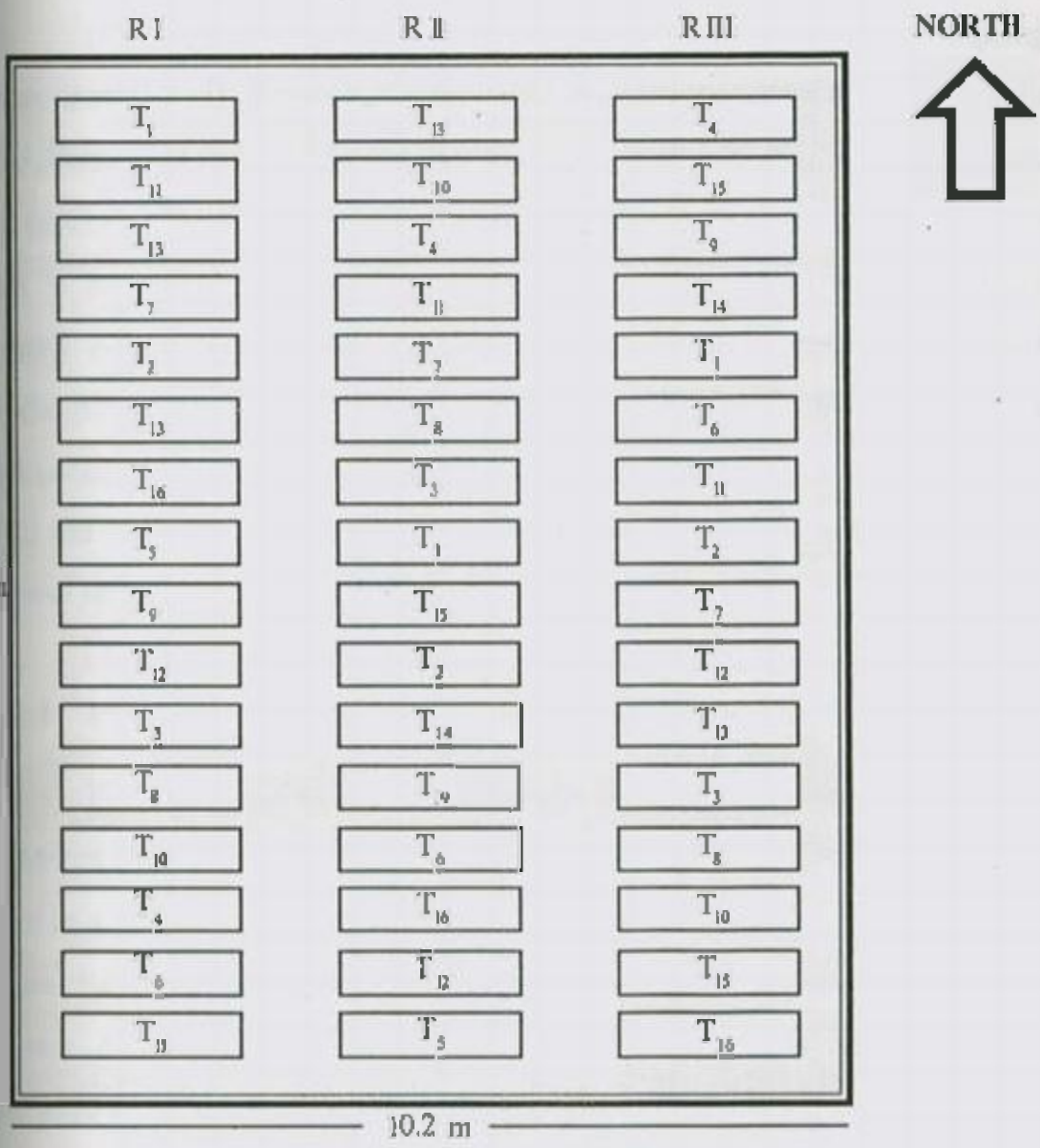
B. Chemical fertilizers

N_0	:	Control	0 kg/ha
N_1	:	Nitrogen	60 kg/ha
N_2	:	Nitrogen	80 kg/ha
N_3	:	Nitrogen	100 kg/ha

C. **Treatment combinations: 16**

Total amount of nutrients (kg/ha) imposed to different treatments combination through organic and inorganic sources:

Treatment	(Organic+ Inorganic)			P_2O_5	K_2O
T_1- M_0N_0	- 0	+	0	0	0
T_2- M_0N_1	- 0	+	60	0	0
T_3-M_0N_2	- 0	+	80	0	0
T_4- M_0N_3	- 0	+	100	0	0
T_5- M_1N_0	- 100	+	0	40	70
T_6- M_1N_1	- 100	+	60	40	70
T_7-M_1N_2	- 100	+	80	40	70
T_8-M_1N_3	- 100	+	100	40	70
T_9- M_2N_0	- 100	+	0	50	60
T_{10}-M_2N_1	- 100	+	60	50	60
T_{11}-M_2N_2	- 100	+	80	50	60
T_{12}-M_2N_3	- 100	+	100	50	60
T_{13}- M_3N_0	- 150	+	0	50	75
T_{14}- M_3N_1	- 150	+	60	50	75
T_{15}- M_3N_2	- 150	+	80	50	75
T_{16}- M_3N_3	- 150	+	100	50	75



Design: Randomised Block Design			Spacing of planting: 60 cm x 45 cm		
No. of replications	:	3	Space between replication	:	2 m
No. of treatments	:	16	Space between plots	:	0.75 m
Individual plot size	:	2.25m x 3m	Area of the experimental plot	:	108 m^2

FIG. 2: PLAN AND LAYOUT OF THE EXPERIMENTAL PLOT

3:2:3 Land preparation

The experimental field was thoroughly prepared by ploughing 3 times breaking all the clods along with elimination of all weeds and stubbles. The Plots were then made on flat land with a size of 2.25 m x 3.0 m under the coconut plantation. The plots were prepared at the spacing of 30 cm apart and 75 cm space was provided in between the blocks. The requirement of organic manure as per treatment was then applied in the plots and mixed thoroughly with the soil before 3 weeks of planting. Full dose of phosphorus and potash and $^{1}/_{4}^{th}$ of nitrogen were applied in respective plots and mixed with the soil one day before planting and plot were slightly raised from ground level in order to avoid water accumulation.

3:2:4 Planting

For raising the planting materials, cuttings were made in first week of March 2005 with a length of 10 cm and cuttings were planted in polythene bags in a size of 15 x 10 cm filled with FYM and soil and kept in shade net house. Regular watering was done with the help of watering can in absence of rain. About eight weeks old established planting materials were planted and used as experimental materials.

3:2:5 After care

The area of each plot was kept clean by regular manual weeding. After each cutting, weeding and hoeing were done with application of fertilizer in respective plots as per the treatment followed by earthing up of soil. Plants were irrigated regularly during the entire growing period in absence of rain.

3:2:6 Plant protection measure

Though, the crop does not suffered due to the attack of disease and pests. However, in certain plots, termites were observed and to check the incidence chloropyriphos chemicals were applied.

3:3 OBSERVATION RECORDED

For recording various morphological growth parameter, four (4) representative plants were tagged at random in each plot. The growth parameter of tagged plants were recorded at the time of harvesting (each leaf curing) starting from 3 month after planting (MAP) till the fifth cutting.

3:3:1 Growth parameters

3:3:1:2 Plant height

The average height of plant was based on the observation recorded in 4 tagged plants with a metre scale at 3 months interval till the last harvesting (fifth cutting) *i.e.*, up to August 2006. The height of plants was recorded from ground level to the tip portion of the plant and the mean values were represented in terms of centimeters (cm).

3:3:1:3 Number of leaves per plant

Fully opened leaves of patchouli plants of four tagged plants for each replication and their mean values were estimated at 3, 6, 9, 12, and 15 months after planting (MAP).

3:3:1:4 Number of branches

The number of branches were counted at each harvesting time on tagged plants in each replication and their mean values were recorded.

3:3:1:5 Plant canopy

The plant canopy has been recorded by multiplying the height and width of each tagged plants of each plot and the mean values were calculated and represented in terms of square cm.

3:3:2 Yield attributes

3:3:2:1 Fresh weight of leaves per plant

Leaves of the tagged plants were cut from 25 cm above the ground level including the tender branches and weight was taken with the help of weighing balance and an average was recorded in each treatment and the fresh weight of leaves per plant was expressed in grams (g).

3:3:2:2 Fresh yield of leaves per plot

Average yield weight of fresh leaves per tagged plant were multiplied with the total number of plants per plot and obtained the fresh weight of leaves per plot and mean values were expressed in terms of kilogram (kg) per plot.

3:3:2:3 Projected yield of fresh leaves per hectare

The fresh leaves yield per hectare in respect of each treatment in each replication was calculated from the basis of plot yield recorded for each treatment using the following formula.

$$Y = \frac{A \times 10000}{S}$$

Where, Y = Yield per hectare (MT)

A = Yield per plot (kg)

S = Plot area (m^2)

The values were expressed in terms of metric tonnes per hectare.

3:3:2:4 Dry weight of leaves

The harvest was made in dry weather when the sun has drunk up the dew from the leaves. The top leaves of the plants were cut by sickles rejecting all yellow or decayed leaves including tender stems. Selected parts were then dried under the shade (as the sun light would draw out the perfume). Further, to ensure evenness in drying, the leaves were spread on bamboo rakes and floor with proper aeration. During this process, they were frequently turn over to have the smooth drying of the whole mass. The materials for each treatment and tagged plants were dried separately and after drying weight was recorded per plant as well as per plot of each treatment and express in gram.

3:3:2:5 Projected yield of dry leaves per hectare

Projected yield of the dry leaves per hectare in respect of each treatment in each replication was calculated from the basis of plot yield (dry) recorded for each treatment by using the same formula adopted for fresh yield/ha and the recorded data were expressed in terms of tonnes per hectare (MT/ha).

3:3:2:6 Oil content

The volatile oil was obtained by stem distillation method using modified Clevenger's Apparatus by using semi-dried at 25 per cent to 30 per cent moisture for 5 hours of distillation and presented in terms of percentage. (Anonymous, 1976 and Sharma and Sharma, 2003).

3:3:2:7 G.C. Analysis of Oil

Quantitative and qualitative estimation of the oil sample was carried out by Gas Chromatographic Method on a Chemito Model 8510 GC equipped with PC based Data Processor, using a BP-20 GC analytical column (28m x 0.53 mm) with hydrogen as carrier gas. The column temperature was programmed from 80°C to 225°C@ 30 C min Injector and Detector (FID) temperature were maintained at 230°C each. Patchouli alcohol, the major and active constituent of the patchouli oil was identified with the help of standard authentic reference compound and confirmed by GC-MS.

3:3:2:8 Oil yield per hectare

The percentage of oil recorded in each and every treatment were multiplied by dry weight of the leaves and is projected in terms of litre/ha.

3:3:2:9 Observation on coconut plantation

The girth of plant was taken at the height of one meter from the ground level and the average of it were presented in terms of centimeter (cm).

3:3:2:10 Yield of coconut per plant

The number of fruits from entire plants from the experimental area were counted and average of the number of fruits per plant was calculated as yield per plant.

3:3:3 Fertility status of experimental plants

Soil samples were collected from respective plots after final harvest of crop within the area of soil depth of 0-20cm. Collected soil samples were air dried, ground and passed through 2 mm sieve and subjected to analysis of pH (1:2) soil: INKCL mixture, organic carbon titrametically using wet oxidation method (Walkley and Black 1934), available nitrogen using alkaline $KMn0_4$ steam distillation (Subbiah and Asiza,1956), Bray- P using ammonium fluoride extraction by shaking 1g of soil in 20ml of 0.03NNH_4F in o.25 NHCL for 30 minutes and extractable in 1N neutral NH_40AC in 1:2 soil: extraction ratio after shaking for 30 minutes (Laynon and Heald, 1982).

3:3:4 Eeonomics

Effect of different treatment combinations was worked out according to prevailing market prices of input and output cost of cultivation. The cost of eultivation of patchouli leaf oil was calculated as per the cost elements viz., land preparation, manuring, plant protection measures, planting materials cost, labour involved in various operations from land preparation to harvesting and drying of leaves as prevalent rate at Govt. Nursery Farm.

Gross return : Gross return was calculated for each treatment combination of different dose of nitrogen and types of organic manures by multiplying the value of economics produces and the prevailing market prices of output.

Net return: Net return for each treatment eombination of organic manures and levels of nitrogen was estimated by subtracting the total cost of cultivation from the gross return.

Cost benefit ratio: Cost benefit ratio was calculated by the formula,

$$CBR = \frac{\text{Total output (Rs)}}{\text{Total input (Rs)}}$$

3.3.5 Statistical analysis

The data obtained during the period of investigation were analyzed by factorial randomized block design (Panse and Sukhatme 1978). The significance of difference sources of variation were tested by error mean square using Fisher Schedecurf – test of probability at 0.05 per cent.

Experimental Findings

CHAPTER- IV

EXPERIMENTAL FINDINGS

In this chapter an attempt has been made to present the entire findings during the experimentation, which have been derived after subjecting the data to statistical analysis and the interpretation. The data presented with the help of tables and illustrations so as to make them clear and easily understandable.

4:1 EFFECT OF ORGANIC MANURES AND LEVELS OF NITROGEN ON GROWTH, YIELD AND QUALITY

4:1:1 Growth characters

4:1:1:1 Height of plant (cm)

Data pertaining to the height of plants was influenced by various treatments and their combinations are presented in Table 2. From the perusal of the data, it clearly indicates that various sources of organic manures were found to increase the height of plants at different stages of observation. Among the different sources of organic manures, vermicompost proved its superiority with regard to enhancement of growth of plant in all the stages of harvesting, however significant impact was recorded only at first and third harvesting. Pig manure was found to be second best source of nutrition but impact was significant only at first and third stage. Similarly, FYM also caused significant increase in height of plant over control.

Application of nitrogen was found to have much appreciable impact in increasing the height of the plant at each stages of cutting with

Table-2: Effect of organic manures and levels of nitrogen on height of plants (cm) at different stages of cuttings.

Treatment	1st (3 MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	69.09	64.95	50.30	44.50	32.66
FYM(M_1)	74.42	67.54	59.00	48.16	37.66
PigManure(M_2)	76.34	66.89	59.01	53.83	40.25
Vermicompost (M_3)	79.60	70.16	62.50	59.16	43.25
C.D. at 5 %	**2.84**	**N.S.**	**8.44**	**N.S.**	**N.S.**
Nitrogen (N)					
Control (N_0)	69.74	60.91	51.30	45.46	33.33
60kg N/ha (N_1)	73.28	68.62	55.95	49.67	37.83
80kg N/ha(N_2)	76.22	69.18	59.15	53.50	39.92
100kg N/ha (N_3)	80.20	70.83	64.41	57.04	42.75
C.D. at 5%	**2.84**	**N.S.**	**8.44**	**N.S.**	**N.S.**
Interaction (M x N)					
M_0N_0	62.83	60.33	46.50	39.17	26.67
M_0N_1	68.16	65.00	50.86	43.33	32.00
M_0N_2	70.60	66.25	51.00	45.83	35.67
M_0N_3	74.76	68.25	52.83	49.67	36.33
M_1N_0	70.66	58.58	50.20	43.67	34.00
M_1N_1	71.63	68.66	57.33	47.83	37.33
M_1N_2	75.16	70.25	60.33	48.17	38.67
M_1N_3	80.23	72.66	68.16	53.00	40.67
M_2N_0	70.65	62.58	51.36	47.83	35.00
M_2N_1	75.50	70.41	56.76	51.33	39.67
M_2N_2	77.40	67.00	60.60	55.67	41.33
M_2N_3	81.83	67.58	67.33	60.50	45.00
M_3N_0	74.83	62.16	57.16	51.17	37.67
M_3N_1	77.83	70.41	58.86	56.17	42.33
M_3N_2	81.73	73.25	64.66	64.33	44.00
M_3N_3	84.00	74.83	69.33	65.00	49.00
C.D. at5%	**5. 68**	**N.S.**	**16.89**	**N.S.**	**N.S.**

increasing level of nitrogen. The maximum height of plant (80.20 cm, 70.83cm, 64.41cm, 57.04 cm, and 42.75 cm.) at first, second, third, fourth and fifth cutting, respectively was recorded at the highest level of nitrogen @ 100 kg/ha followed by 80 kg/ha, and 60 kg/ha and the control recorded lowest height of plant (69.74 cm, 60.91 cm, 51.30 cm, 45.46 cm and 33.33 cm.) in various stages of cuttings. All doses of nitrogen were found to be significantly superior to control in increasing the height of plant at each stages of leaf cuttings.

Among the different treatment combinations, T_{16} (M_3N_3) i.e., vermicompost @ 5 t/ha + nitrogen 100 kg/ha has recorded maximum height (84.00 cm at 3 MAP and 74.83 cm at 6 MAP). Findings revealed that other treatment combinations were also found better to enhancing the height of the plant. Minimum height of plant was noticed in control plots at all stages of harvesting over to other treatment combinations. It was also recorded that, there was no significant effects on height of the plant at second, fourth and fifth stages of cuttings within the treatment combinations

4:1:1:2 Number of leaves per plant

Application of organic manures, various doses of nitrogen and their combinations showed appreciable impact on enhancing the number of leaves per plant at different stages of harvesting (Table 3).

Among the various sources of organic manures, number of leaves were observed to be highly influenced due to treatment of M_3 (vermicompost @ 5 t/ha). Vermicompost @ 5 t/ha had produced the maximum number of leaves at all stages of leaf harvesting i.e., 648.81, 514.91, 491.83 and 289.16 at3 MAP, 6 MAP, 12 MAP and 15 MAP, respectively. The result was

Table-3 : **Effect of organic manures and levels of nitrogen on number of leaves per plant at different stages of cuttings.**

Treatment	1st (3MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manure (M)					
Control(M_0)	495.16	404.58	388.10	389.58	204.00
FYM (M_1)	562.25	462.08	412.77	413.75	225.16
Pig Manure (M_2)	603.68	503.54	430.04	444.41	256.25
Vermicompost (M_3)	648.81	514.91	414.00	491.83	289.16
C.D. at 5%	**22.75**	**7.70**	**N.S.**	**20.11**	**N.S.**
Nitrogen (N)					
Control (N_0)	512.66	419.58	379.20	367.66	206.25
60 kg N/ha(N_1)	555.52	453.41	379.41	430.41	242.58
80kg N/ha (N_2)	603.41	492.54	439.41	446.91	253.58
100 kg N/ha (N_3)	638.31	519.54	447.81	494.58	272.16
C.D. at 5%	**22.75**	**7.70**	**N.S.**	**20.22**	**N.S.**
Interaction (M x N)					
M_0N_0	475.16	343.33	322.83	288.33	175.00
M_0N_1	471.25	360.00	381.33	368.33	213.33
M_0N_2	524.75	451.66	429.83	421.66	207.66
M_0N_3	509.50	466.33	418.41	480.00	220.00
M_1N_0	488.75	420.00	439.83	348.33	205.00
M_1N_1	558.75	436.66	291.25	441.66	212.00
M_1N_2	587.50	486.66	456.25	408.33	238.33
M_1N_3	614.00	505.00	463.75	456.66	245.33
M_2N_0	525.75	473.33	381.91	390.00	206.66
M_2N_1	573.41	497.00	428.83	445.00	266.66
M_2N_2	643.58	510.16	436.08	457.66	271.66
M_2N_3	672.00	533.50	473.33	485.00	280.00
M_3N_0	561.00	441.66	372.25	444.00	238.33
M_3N_1	618.66	520.00	416.25	466.66	278.33
M_3N_2	657.83	521.66	435.50	500.00	296.66
M_3N_3	757.75	576.33	435.75	556.66	343.33
C.D. at 5%	**45.51**	**15.41**	**N.S.**	**40.22**	**N.S.**

significantly better with vermicompost over other source of organic manures and control to increasing the number of leaves, except at third and fifth harvesting stage.(Table- 3) Pig manure @ 10 t/ha was observed to be the second best source of organic manure at most of the stages of harvesting and even it recorded highest number of leaves (430.04) at 9 MAP. The FYM @ 20 t/ha was also showed positive impact in increasing the number of leaves at all stages of cutting compared to control.

Application of various doses of nitrogen showed significantly superior impact in increasing the number of leaves with increasing level of nitrogen. The maximum number of leaves per plant was observed (638.31, 519.54, 447.81, 494.58 and 272.16) during first, second, third, fourth and fifth cuttings, respectively at the highest dose of nitrogen i.e., 100 kg N/ha and compared to lower doses in most of the harvesting stages except in third and fifth cuttings. The number of leaves were influenced by increasing the levels of nitrogen significantly. The application of nitrogen @ 80 kg N/ha produced higher number of leaves followed by 60 kg N/ha and lowest number of leaves was recorded with control.

The number of leaves due to application of vermicompost @ 5 t/ha + nitrogen @ 100 kg /ha recorded maximum at all stages of cuttings except the third stage, where maximum number of leaves (473.33) was recorded with the treatment of pig manure @ 10 t/ha + nitrogen @ 100 Kg /ha (M_2N_3). In general, maximum number of leaves per plant was observed at first stage of harvesting (3 MAP) followed by second, fourth, and fifth cuttings. However, significant effect was observed at first, second and fourth stage of cuttings.

4:1:1:3 Number of branches per plant

Data presented in Table 4 showed that organic manures and levels of nitrogen application singly or in combinations were found effective in altering the number of branches per plant at different stages of observation however, impact was not significant.

Vermicompost (M_3) caused maximum number of branches at second, fourth and fifth stages of harvesting whereas, pig manure caused maximum number of branches (52.2 and 38.27) at first and third stage respectively. FYM@ 20 t/ha also showed its effect in increasing the number ofbranches compared to control.

Different levels of nitrogen showed positive impact in increasing the number of branches per plant with increasing level of nitrogen. Maximum number of branches were recorded by application of 100 kg/ha followed by 80 kg/ha and 60 kg/ha, whereas, less number of branches per plant was observed in control at different stages of harvesting.

Among interaction, the maximum number of branches were recorded by treatment combination of M_3N_3 (vermicompost @ 5 t/ha + nitrogen @ 100 kg/ha) during entire cropping period followed by M_2N_3, which exhibited second best combination at first, second and fourth stages.

4:1:1:4 Plant canopy (cm^2)

There was a marked increase in the plant canopy due to various treatments and their treatment combinations and significantly influenced at different stages of leaf cuttings (Table 5 and fig. 3 a and b).

Table-4 : Effect of organic manures and levels on nitrogen on number of branches pef plant at different stages of cuttings.

Treatment	1st (3 MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	41.06	40.66	35.01	33.00	30.58
FYM (M_1)	49.66	44.50	35.89	40.08	35.66
Pig Manure (M_2)	52.20	49.16	38.27	46.66	42.08
Vermicompost (M_3)	51.08	51.00	37.95	48.83	44.41
C.D. at 5%	N.S.	N.S.	N.S.	N.S	N.S.
Nitrogen (N)					
Control (N_0)	45.85	43.66	34.47	37.91	34.00
50kg N/ha (N_1)	48.12	44.25	36.49	41.25	36.83
80 kg N/ha (N_2)	47.25	47.83	36.81	43.33	39.66
100kg N/ha (N_3)	52.79	49.58	39.35	46.08	42.25
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction(M x N)					
M_0N_0	36.91	37.33	32.41	30.00	24.66
M_0N_1	39.16	39.66	33.71	32.00	29.00
M_0N_2	39.58	42.00	35.24	33.00	32.66
M_0N_3	48.58	43.66	38.67	37.00	36.00
M_1N_0	50.83	41.00	37.00	33.66	30.33
M_1N_1	51.75	43.66	37.41	39.00	34.33
M_1N_2	45.75	46.66	35.83	40.66	38.00
M_1N_3	50.33	46.66	33.33	47.00	40.00
M_2N_0	49.91	46.66	35.41	44.00	39.00
M_2N_1	51.16	44.66	37.50	47.00	40.66
M_2N_2	52.66	52.00	40.41	48.66	43.33
M_2N_3	55.08	53.33	39.75	47.00	45.33
M_3N_0	45.75	49.66	33.08	44.00	42.00
M_3N_1	50.41	49.00	37.33	47.00	43.33
M_3N_2	51.00	50.66	35.75	51.00	44.66
M_3N_3	57.16	54.66	45.66	53.33	47.66
C.D.at 5%	N.S.	N.S.	N.S.	N.S.	N.S

Table-5: **Effect of organic manures and levels of nitrogen on plant canopy (cm^2) at different stages of cuttings.**

Treatment	1st (3MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	4775.25	2538.67	1010.41	715.83	1022.50
FYM (M_1)	5161.03	2878.33	1253.58	851.66	1086.66
Pig Manure (M_2)	5307.26	2949.92	1484.16	1116.25	1567.75
Vermicompost (M_3)	5486.41	3102.75	1517.33	1349.16	1841.25
CD at 5%	138.75	144.07	163.95	109.53	194.94
Nitrogen (N)					
Control (N_0)	4548.80	2243.75	989.00	691.67	803.75
40 kg N/ha (N_1)	5163.92	2727.25	1153.92	976.25	1439.58
80 kg N/ha (N_2)	5476.39	3117.83	1293.67	1112.08	1471.67
120 kg N/ha (N_3)	5540.83	3380.83	1828.92	1252.92	1803.17
CD at 5%	138.75	144.07	163.95	109.53	194.94
Interaction (M x N)					
M_0N_0	3997.04	1516.33	676.67	510.00	653.33
M_0N_1	4715.89	2430.00	830.00	748.33	1016.67
M_0N_2	5079.33	2851.00	1141.67	800.00	1210.00
M_0N_3	5308.73	3357.33	1393.33	805.00	1210.00
M_1N_0	4884.08	2368.67	997.67	686.67	750.00
M_1N_1	4935.25	2859.33	1192.67	733.33	866.67
M_1N_2	5490.87	3100.00	1318.00	1040.00	1180.00
M_1N_3	5333.92	318533	1506.00	946.67	1550.00
M_2N_0	4744.83	2476.67	1149.00	770.00	848.33
M_2N_1	5423.70	2573.33	1079.33	1103.33	1816.67
M_2N_2	5548.06	3355.00	1550.00	1108.33	1753.33
M_2N_3	5512.44	3394.67	2158.33	1483.33	1852.67
M_3N_0	4569.27	2613.33	1132.67	800.00	963.33
M_3N_1	5580.83	3046.33	1513.67	1320.00	2058.33
M_3N_2	5787.31	3165.33	1165.00	1500.00	1743.33
M_3N_3	6008.23	3586.00	2258.00	1776.67	2600.00
CD at 5%	277.51	288.14	327.90	219.05	389.89

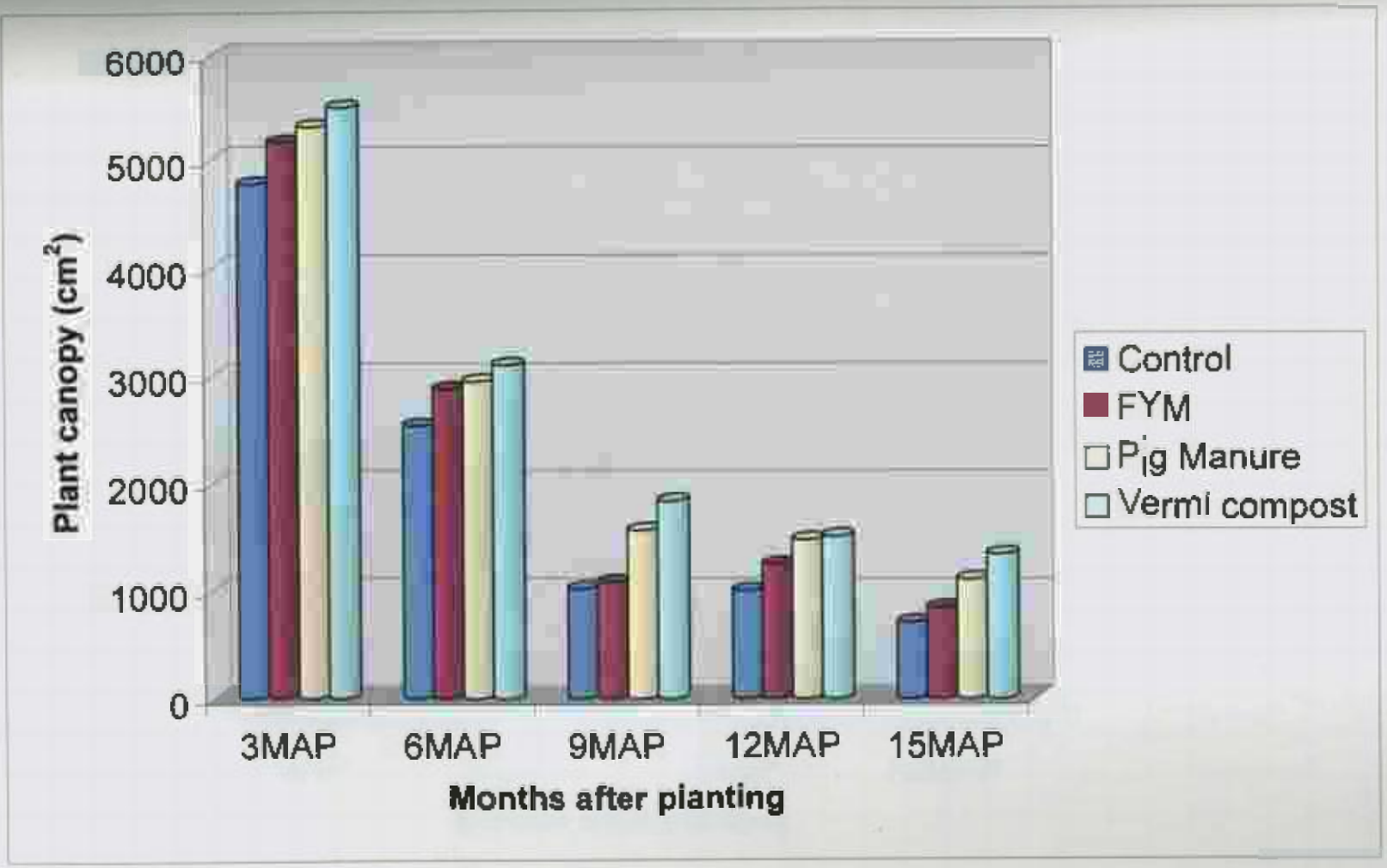


Fig. 3 (a) : Effect of organic manures on plant canopy (cm^2)

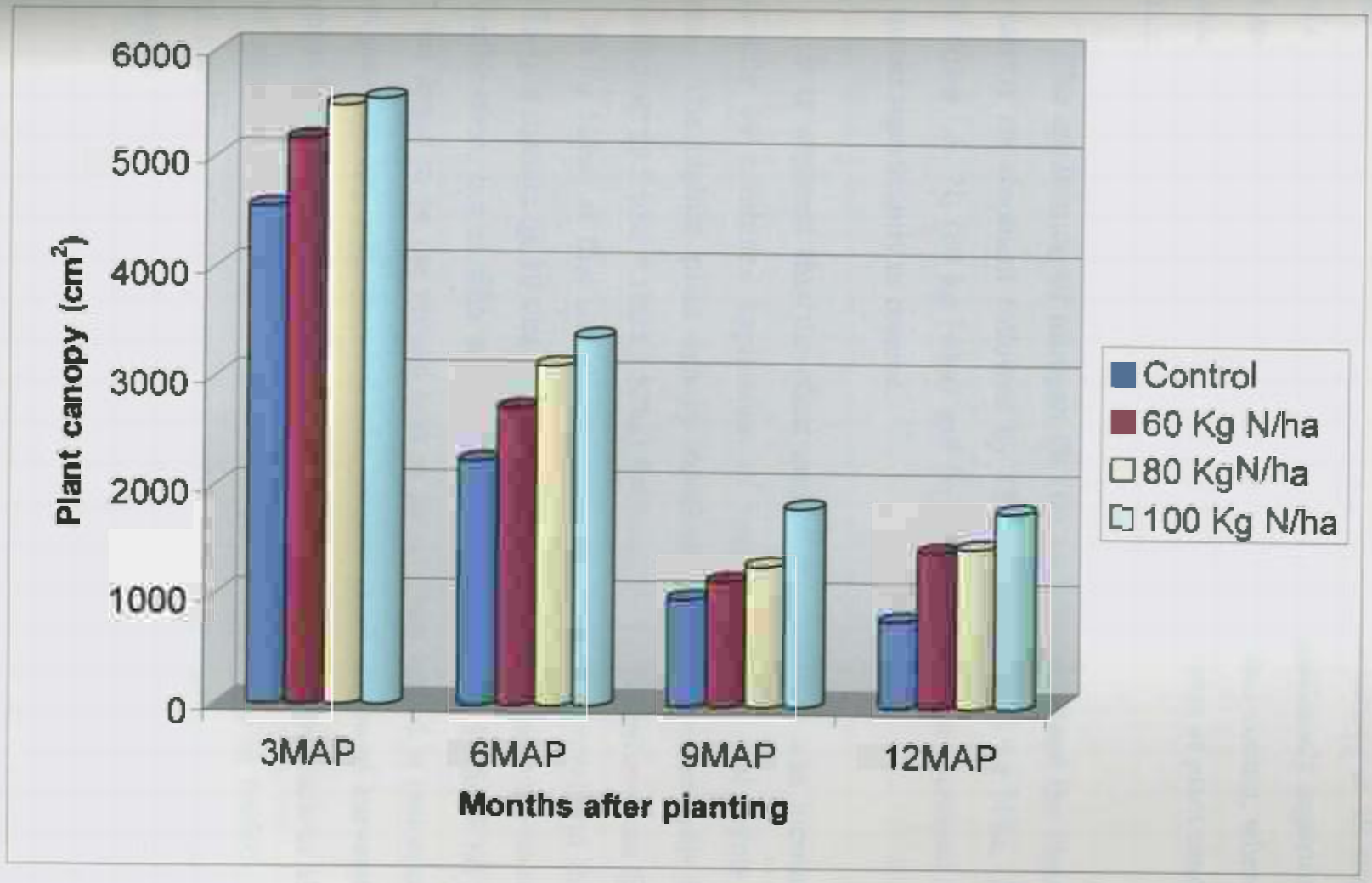


Fig. 3 (b) : Effect of leveis of nitrogen on piant canopy (cm^2)

Among the different sources of organic manures, vermicompost proved to be better source of manure to influence plant canopy at all stages of leaf cuttings followed by pig manure which was significantly superior to FYM and control at all stages of cuttings except at second cutting, where it remained *at par* with FYM. FYM also influence the increase of plant canopy significantly better over control at all stages of cuttings.

The application of nitrogen@ 100 kg N/ha provided the highest plant canopy development followed by 80 kg N/ha and 60 kg N/ha. The middle doses i.e., N_2 (80 kg N/ha) and N_1 (60 kg N/ha) also increased the plant spread significantly to control.

It is apparent that the plant canopy development was increased significantly by combined application of various manures and levels of nitrogen. The highest plant canopy development was noticed with T_{16} (vermicompost@ 5 t/ha + 100 kg N/ha) followed by T_{15} (vermicompost@ 5 t/ha + 80 kg N/ha) at first and fourth stage, whereas, at second and third stage T_{12}(pig manure@ 10 t/ha + 100 kg N/ha) was found to be the second best combination, but at fifth stage T_{14} (vermicompost@ 5 t/ha + 60 kg N/ha) was found to be the second best as far as plant spread is concerned. Lowest plant canopy was recorded with control at all stages of harvesting throughout the period of investigation. Several treatment combinations also showed significant influence on plant canopy development to control. In general maximum plant canopy was noticed at first cutting followed by second cutting and comparatively lower in third, fourth and fifth cuttings.

4:1:2 Yield characters

4:1:2:1 Fresh weight of leaves per plant (g)

The data presented in Table 6 shows that different organic manures and various levels of nitrogen and their treatment combinations had increased the yield of patchouli leaves per plant. Among the various sources of organic manures, vermicompost proved to be better source of manuring as it provided maximum fresh weight of leaves at all stages of harvesting and the highest yield (473.45 g, 469.83 g, 271.67 g, 217.12 g and 235.83g) was recorded. Moreover, significant impact was noticed in first and second cuttings only. FYM and pig manure also showed significant effect in increasing fresh yield of leaves as compared to control at first and second stage of observation, however, it remained *at par* with vermicompost.

There was considerable increase in yield of fresh leaves per plant with increasing doses of nitrogen. Highest level of nitrogen i.e., 100 kg N/ha recorded maximum yield of leaves per plant at all stages of harvesting (486.41g, 503.20g, 288.66g, 219.62g, and 231.08 g) followed by 80 kg N/ha and 60 kg N/ha. The N_3, N_2 and N_1 remained at par with each other and found significantly superior to control at first and second stage of harvesting.

Highest yield was recorded with treatment M_3N_3 (Vermicompost @ 5t/ha + 100 kg N/ha) at most of the stages of harvesting, however, significant impact was noticed only in first and second stage of harvesting. Several other combinations were also found significantly superior with regard to increasing the fresh weight of leaves per plant during first and second harvesting stage.

Table-6 : Effect of organic manures and levels of nitrogen on fresh weight of leaves per plant (g) at different stages of cuttings.

Treatment	1st (3MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	394.10	321.81	223.41	167.50	177.50
FYM (M_1)	460.87	444.41	251.79	181.25	200.00
Pig Manure (M_2)	443.83	453.06	241.16	194.25	211.50
Vermicompost (M_3)	473.45	469.83	271.67	217.12	235.83
C.D.at5%	**56.08**	**113.25**	**N.S.**	**N. S.**	**N.S.**
Nitrogen (N)					
Control (N_0)	381.33	332.08	211.91	162.91	185.83
60kgN/ha(N_1)	443.06	396.77	234.16	178.00	196.91
80kgN/ha(N_2)	461.45	457.06	253.30	199.58	211.50
100kg N/ha (N_3)	486.41	503.20	288.66	219.62	231.08
C.D. at 5%	**56.08**	**113.25**	**N.S.**	**N.S.**	**N.S.**
Interaction (M x N)					
M_0N_0	331.16	243.75	186.66	136.66	163.33
M_0N_1	379.66	272.91	211.00	158.33	171.66
M_0N_2	417.91	325.83	235.00	175.00	181.66
M_0N_3	447.66	444.75	261.00	200.00	193.33
M_1N_0	435.41	350.00	226.66	156.66	185.00
M_1N_1	455.58	387.50	235.00	171.66	194.33
M_1N_2	458.75	506.25	250.33	190.00	205.00
M_1N_3	493.75	533.91	295.16	206.66	217.66
M_2N_0	370.83	360.00	196.66	180.00	195.00
M_2N_1	454.50	447.91	227.00	173.66	136.66
M_2N_2	479.16	483.50	252.66	206.66	219.33
M_2N_3	470.83	520.83	288.33	216.66	235.00
M_3N_0	387.91	374.58	237.66	178.33	200.00
M_3N_1	482.50	478.75	263.66	208.33	225.00
M_3N_2	490.00	512.66	275.20	226.66	240.00
M_3N_3	533.41	513.33	310.16	255.16	278.33
C.D. at 5%	**112.15**	**226.51**	**N.S.**	**N.S.**	**N.S**

4.2.2 Dry weight of leaves per plant (g)

It is evident from the data presented in Table 7 that, there was appreciable impact of various sources of organic manures and levels of nitrogen fertilizers on increasing the recovery of dry weight of leaves per plant at different stages of harvesting. However, results wefe significant only atfirst, second, and fourth stage of harvesting.

Maximum dry weight of leaves per plant was recorded with the application of vermicompost (140.58 g, 120.66 g, 59.33 g, 52.2 g, and 50.58g) at various intervals of cuttings from the experimental field. However, it remained statistically non significant with FYM during first and second cutting and with pig manure at first cutting, whereas, data recorded at fourth cutting was higher in all the treatment combinations. FYM and pig manure were found to be better for higher dry weight recovery than control, at second and fourth harvesting stage of leaves.

Application of nitrogen has resulted favourable impact on recovery of dry matter of leaves with increasing levels of nitrogen. The maximum dry weight of leaves per plant was recorded by application of 100 kg N/ha at all stages of harvesting. Though, impact was found significantly superior to lower doses of nitrogen and control at first, second and fourth stage of leaf cuttings. Similarly, 80 kg N/ha also caused to increase the dry weight of leaves at second and fourth stage, while it remained at par with higher and lower doses of nitrogen at first harvesting. The lower dose of nitrogen (60 kg N/ha) also recorded to increase in the yield of dry weight of leaves in comparison to control.

Table -7: Effect of organic manures and levels of nitrogen on dry weight of leaves per plant (g) at different stages of cuttings.

Treatment	1st (3MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	123.37	79.06	52.50	42.25	37.70
FYM (M_1)	135.47	120.18	56.50	46.25	44.50
Leaf Manure (M_2)	125.27	112.41	52.37	49.08	46.75
Vermicompost (M_3)	140.58	120.66	59.33	52.20	50.58
C.D. at 5%	**16.39**	**4.27**	**N.S.**	**1.61**	**N.S.**
Nitrogen (N)					
Control (N_0)	110.85	85.18	46.41	41.91	38.08
50 kg N/ha (N_1)	124.37	104.91	52.00	46.25	43.58
100 kg N/ha (N_2)	139.52	115.45	57.66	49.45	48.20
150 kg N/ha (N_3)	149.95	126.77	64.62	52.50	49.66
C.D. at 5%	**16.39**	**4.27**	**N.S.**	**1.61**	**N.S.**
Interaction (M x N)					
M_0N_0	100.83	48.33	40.66	35.00	27.33
M_0N_1	118.75	65.83	47.33	39.33	39.33
M_0N_2	132.25	89.16	58.00	45.00	39.16
M_0N_3	141.66	112.91	64.00	49.66	46.00
M_1N_0	111.91	104.41	47.33	40.33	36.33
M_1N_1	132.50	122.41	55.00	48.00	42.33
M_1N_2	146.66	125.00	58.00	49.66	50.66
M_1N_3	150.83	128.91	65.66	48.33	48.66
M_2N_0	115.00	96.33	45.83	45.00	42.66
M_2N_1	109.58	113.91	48.33	48.00	45.33
M_2N_2	130.41	115.41	54.66	50.33	50.33
M_2N_3	146.08	124.00	60.66	53.00	48.66
M_3N_0	115.66	91.66	51.83	47.33	46.00
M_3N_1	136.66	117.50	57.33	49.66	48.33
M_3N_2	148.75	132.25	60.00	52.83	52.66
M_3N_3	161.25	141.25	68.16	59.00	55.33
C.D. at 5%	**32.78**	**8.55**	**N.S.**	**3.22**	**N.S.**

The combination of M_3N_3 (vermicompost@5 t/ha + nitrogen 100 kg/ha) showed superiority in recovery of dry leaves per plant at most stages of harvesting but significant effect was noticed only at first, second and fourth stage over control. Treatment combinations like M_3N_2, M_2N_3, M_1N_3, etc., were found better with regard to higher recovery of dry weight of leaves per plant (Table 7).

4.2.3 Fresh weight of leaves per plot (kg)

Application of organic manures, nitrogen and their combination significantly influenced the fresh weight of the leaves per plot. The data have been recorded at all the 5 stages of cuttings at three months interval and is presented in Table 8. The favourable response to these treatment sources was maintained upto last harvesting stage (fifth cutting).

The maximum fresh weight (25 kg/plot at 3 MAP) was obtained with vermicompost@ 5 t/ha, whereas, minimum with control (8.58 kg/plot a 15 MAP). Further, vermicompost application showed its superiority over other source of organic manures at most of the harvesting stages except first cutting where it remained statistically at par with FYM and pig manure. Pig manure was found to be second best with regard to increasing fresh weight of the leaves per plot at most stages of harvesting but remained statistically at par with farm yard manure. Individual effect of nitrogen showed positive impact on increasing the fresh yield of leaves per plot with increasing level of nitrogen. The application of 100 kg N/ha was found significantly superior at all stages of harvesting over all the treatments of nitrogen and control. The middle dose (80 kg N/ha) was also found significantly effective in enhancing the yield over control. However, fresh yield of leaves per plot remained *at par* with lower and higher doses of nitrogen.

Table-8: Effect of organic manures and levels of nitrogen on fresh weight of leaves per plot (Kg) at different stages of cuttings.

Treatment	1st (3MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	15.53	12.44	12.06	10.33	8.58
FYM (M_1)	19.70	14.43	13.16	11.40	9.47
PigManure (M_2)	21.86	16.07	14.55	12.58	10.50
Vermicompost (M_3)	25.46	19.51	17.63	15.46	13.22
C.D. at 5%	**6.38**	**3.46**	**2.23**	**2.6**	**3.00**
Nitrogen (N)					
Control (N_0)	14.92	12.20	11.25	9.66	7.91
60 kg N/ha (N_1)	22.68	14.12	12.76	11.15	9.35
120kg N/ha (N_2)	22.26	16.93	15.60	13.25	11.16
180kg N/ha (N_3)	23.00	19.20	17.79	15.70	13.35
C.D. at 5%	**6.38**	**3.46**	**2.23**	**2.67**	**3.00**
Interaction (M x N)					
M_0N_0	10.97	8.56	8.63	7.48	6.40
M_0N_1	14.48	10.40	9.80	1.77	7.59
M_0N_2	15.92	15.68	14.42	12.14	9.59
M_0N_3	18.29	15.13	15.40	12.92	10.75
M_1N_0	18.14	12.30	10.92	9.16	7.34
M_1N_1	21.30	13.98	12.30	11.09	9.11
M_1N_2	24.32	14.97	13.80	11.67	9.90
M_1N_3	26.98	16.49	15.61	13.67	11.55
M_2N_0	19.09	13.36	11.86	10.00	7.86
M_2N_1	20.37	15.36	13.80	11.55	9.56
M_2N_2	22.18	16.26	15.33	13.41	11.37
M_2N_3	27.41	19.32	17.22	15.36	13.20
M_3N_0	15.12	14.60	13.59	11.99	10.05
M_3N_1	22.66	16.76	15.13	13.20	11.15
M_3N_2	25.04	20.83	18.86	15.79	13.79
M_3N_3	29.18	25.86	22.95	20.86	17.91
C.D. at 5%	**12.76**	**6.92**	**4.47**	**5.34**	**6.01**

The various combinations of manures and nitrogen were found superior to control at all stages of harvesting. The maximum yield of fresh leaves per plot was recorded with M_3N_3 (29.18 kg) followed by M_2N_3 (27.41 kg), M_1N_3 (26.98 kg) M_3N_2 (25.04 kg) etc.

4:1:2:4 **Dry weight of leaves per plot (kg)**

The data presented in Table 9 showed that there was a good impact of different treatments and their combinations in recovery of dry weight of leaves per plot in patchouli crop. It is observed from the data that vermicompost had significant influence in increasing the dry weight of leaves at different stages of leaf cuttings (5.53 kg, 4.67 kg, 4.09 kg, 3.31 kg and 2.98 kg), respectively, and significantly better than pig manure and FYM. Minimum dry weight of leaves per plot (3.74 kg, 2.78 kg, 2.36 kg and 1.91 kg), was noticed with control at various stages of cuttings. Pig manure was found significantly superior in comparison to FYM in enhancing the dry weight of the leaves. Application of FYM also proved statistically better than control to influence the dry weight of leaves of patchouli per plot at all stages of observation.

Dry weight of leaves per plot had been significantly increased by application of various levels of nitrogen. The maximum dry weight per plot was recorded by application of 100 kg N/ha, (5.53 kg) followed by 80 kg N/ha (5.19 kg) and 60 kg N/ha (4.71 kg) and minimum with control. The middle doses were also found significantly superior over control to enhance the dry weight of leaves per plot.

As in the case of fresh weight of leaves per plot, the dry yield of leaves were also found to be highest at different stages (6.52, 6.28, 5.29, 4.70

Table-9 : Effect of organic manures and levels of nitrogen on dry weight of leaves per plot (Kg) at different stages of cuttings.

Treatment	1st (3MAP)	2nd (6MAP)	3rd (9MAP)	4th (12MAP)	5th (15MAP)
Organic manures (M)					
Control (M_0)	3.74	2.97	2.78	2.36	1.91
FYM (M_1)	4.87	3.41	2.97	2.58	1.96
Leaf Manure (M_2)	5.23	3.82	3.39	2.78	2.35
Vermicompost (M_3)	5.53	4.67	4.09	3.31	2.98
C.D. at 5%	**0.04**	**0.29**	**0.11**	**0.18**	**0.17**
Nitrogen (N)					
Control (N_0)	3.92	2.93	2.56	2.02	1.75
40 kg N/ha (N_1)	4.71	3.36	2.87	2.44	1.97
80 kg N/ha (N_2)	5.19	4.01	3.64	2.96	2.45
120 kg N/ha (N_3)	5.53	4.58	4.14	3.60	3.03
C.D. at 5%	**0.04**	**0.29**	**0.11**	**0.18**	**0.17**
Interaction (M x N)					
M_0N_0	2.90	2.20	1.98	1.70	1.39
M_0N_1	3.60	2.60	2.20	2.02	1.70
M_0N_2	4.06	3.45	3.33	2.69	2.17
M_0N_3	4.40	3.64	3.60	3.06	2.39
M_1N_0	3.90	2.99	2.35	2.02	1.61
M_1N_1	4.92	3.24	2.72	2.47	1.61
M_1N_2	5.23	3.62	3.26	2.68	2.14
M_1N_3	5.42	3.88	3.60	3.14	2.45
M_2N_0	4.63	3.17	2.79	2.16	1.84
M_2N_1	4.97	3.74	3.17	2.46	2.02
M_2N_2	5.56	3.83	3.51	2.96	2.50
M_2N_3	5.78	4.59	4.07	3.52	3.07
M_3N_0	4.27	3.38	3.13	2.22	2.17
M_3N_1	5.36	3.85	3.49	2.82	2.55
M_3N_2	5.52	5.16	4.47	3.52	3.00
M_3N_3	6.92	6.28	5.29	4.70	4.18
C.D. at 5%	**0.08**	**0.59**	**0.23**	**0.36**	**0.35**

and 4.18 kg/plot,) respectively by application of M_3N_3 (vermicompost@ 5 t/ha + 100 kg N/ha) and closely followed by M_2N_3 (pig manure @10 t/ha + 100 kg N/ha) and M_3N_2 (vermicompost@ 5 t/ha + 80 kg N/ha) and lowest was in control. Various other treatment combinations were also found significantly effective in increasing the dry weight ofleaves per plot.

5.1.2.5 Projected yield of fresh weight of leaves per hectare (MT)

The data obtained with regard to projected yield of fresh weight of leaves is presented in Table 10 and fig.4 (a) and (b).The maximum fresh yield of leaf was recorded with vermicompost i.e., 62.98 and 68.76 t/ha in 2005 and 2006, respectively. Pig manure was found to be the second best source of manure in enhancing the projected fresh yield of patchouli leaf followed by FYM. However, they remained at par with each other and significantly superior to control during first year of observation.

Among the individual effect of various levels of nitrogen, 100 kg N/ha caused maximum fresh yield of leaves per hectare followed by 80 kg N and 60 kg N/ha in both year during cropping. However, significant impact ofnitrogen application at all levels was noticed only during 2005 while in second year significant impact was observed in the application of 100 kg N/ha and control only.

Among the interaction, vermicompost with higher levels of nitrogen (M_3N_3) was found to be the best treatment combination for increasing the yield of fresh leaves (81.54 and 91.98 t/ha during the year 2005 and 2006, respectively followed by M_2N_3, (pig manure @ 10 t/ha + 100 kg N/ha), M_3N_2 (vermicompost @ 5 t/ha + 80 kg N/ha) and M_1N_3 (FYM @ 20 t/ha + 100 kg N/ha) during both the year of investigation. Several other

combinations of organic manures and nitrogen were also found superior in enhancing the projected fresh yield of leaves in comparison to control (7.545 t/ha).

4:1:2:6 Projected yield of dry leaves per hectare (MT)

The influence of organic manures and nitrogen application and their combinations have been recorded in Table 10 and fig. 4 (a) and (b). As like the fresh weight of leaves, vermicompost also caused maximum production of dry leaves during the both years of investigation (15.09 and 15.32 MT., respectively) followed by pig manure and FYM and minimum was noticed with control during both year of investigation. But significant impact was noticed only between vermicompost and control.

Projected dry weight yield of leaves was found highest at the maximum level of nitrogen application i.e., 100 kg N/ha (14.98 and 15.80 t/ha during 2005 and 2006, respectively) and impact was significantly superior to control. Though N_2 and N_1 also caused better dry yield of leaves but they remained statistically *at par* with control.

The perusal of data in Table 10 reveals that the dry weight of the leaves was also recorded maximum with M_3N_3 (18.95 and 21.0 t/ha during the year 2005 and 2006 respectively, followed by M_3N_2, (vermicompost @ 5 t/ha + 80 kg N/ha), M_2N_3 (pig manure @ 10 t/ha + 100 kg N/ha), M_2N_2 (pig manure @10 t/ha + 80 kg N/ha) and M_1N_3 (FYM @20 t/ha + 100 kg N/ha). The lowest dry yield of leaves per hectare was recorded with M_0N_0 i.e., control (7.55 and 7.54 t/ha during 2005 and 2006, respectively).

Table-10: **Effect of organic manures and levels of nitrogen on projected yield of leaves per hectare (MT).**

Treatment	2005		2006	
Organic manures (M)	**Fresh**	**Dry**	**Fresh**	**Dry**
Control (M_0)	40.18	9.95	45.90	10.44
FYM (M_1)	54.96	12.30	50.42	11.18
PigManure (M_2)	56.82	13.41	55.75	12.63
Vermicompost (M_3)	62.98	15.09	68.76	15.32
C.D. at 5%	**2.14**	**4.16**	**22.41.**	**4.17**
Nitrogen (N)				
Control (N_0)	41.61	10.16	42.71	9.41
60kg N/ha(N_1)	50.36	11.16	49.29	10.94
80 kg N/ha (N_2)	57.40	13.64	59.29	13.43
100kg N/ha (N_3)	65.57	14.98	69.55	15.8
C.D.at 5%	**2.14**	**4.16**	**22.41**	**4.17**
Interaction (M x N)				
M_0N_0	28.94	7.55	33.36	7.54
M_0N_1	37.85	9.20	38.78	8.73
M_0N_2	46.82	11.14	53.57	12.14
M_0N_3	47.11	11.90	57.89	13.36
M_1N_0	45.09	10.21	40.63	8.87
M_1N_1	52.27	12.10	48.16	10.58
M_1N_2	58.10	13.10	52.41	12.00
M_1N_3	64.39	13.79	60.50	13.27
M_2N_0	48.37	11.55	44.40	10.09
M_2N_1	52.94	12.90	51.72	11.34
M_2N_2	56.73	13.91	59.42	13.30
M_2N_3	69.23	15.30	67.83	15.80
M_3N_0	44.03	11.34	52.79	11.15
M_3N_1	58.41	13.66	58.51	13.13
M_3N_2	67.96	16.43	71.77	16.29
M_3N_3	81.54	18.95	91.98	21.00
C.D. at 5%	**4.28**	**8.32**	**44.83**	**8.35**

Fig. 4 (a) : Effect of organic manures on projected yield of leaves / ha. (MT)

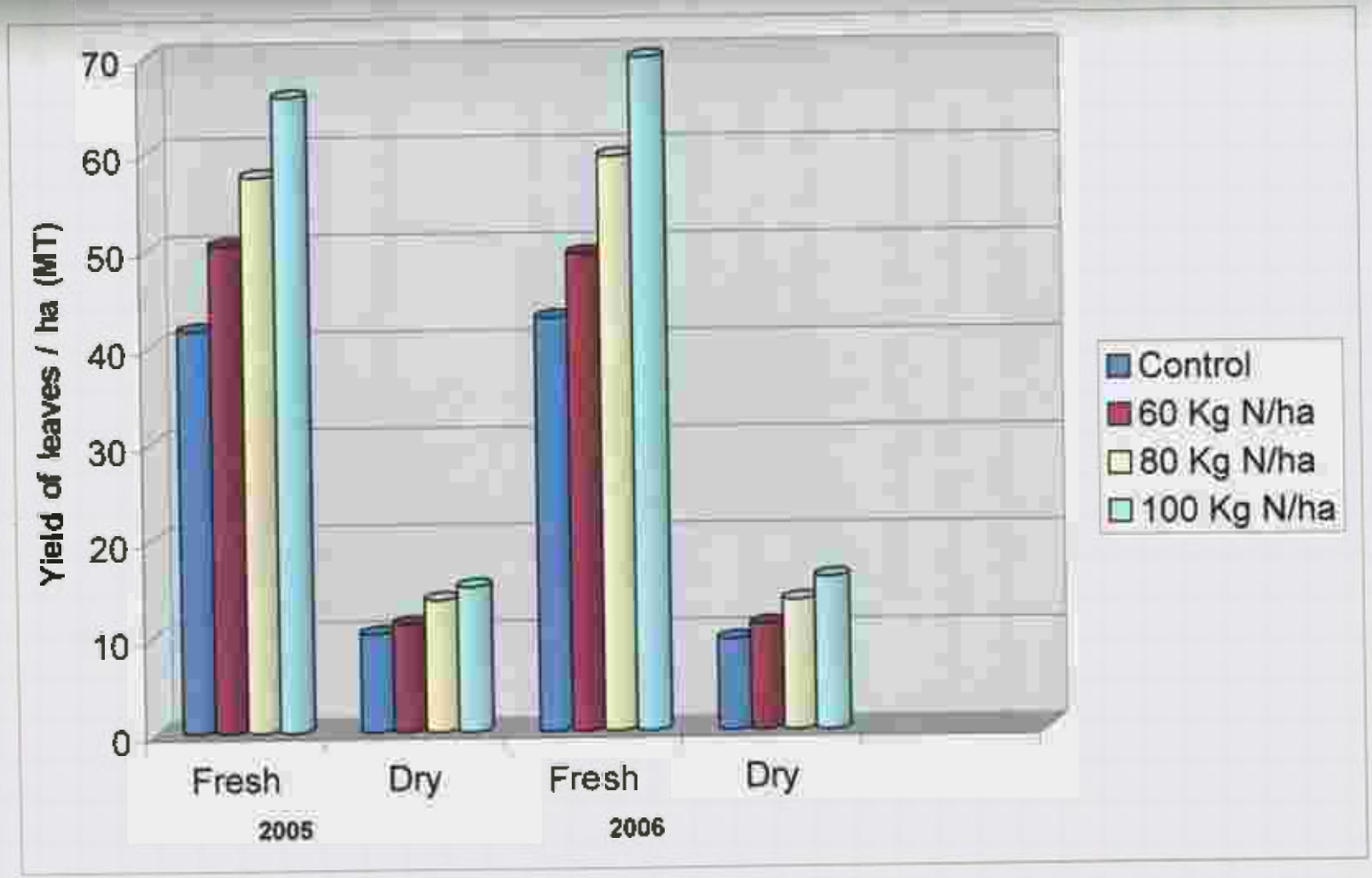


Fig. 4 (b) : Effect of levels of nitrogen on projected yield of leaves / ha. (MT)

4:1:3 Quality attributes

4:1:3:1 Oil content (%)

The data pertaining to oil content of dried leaves, which has been influenced by different sources of organic manures and level of nitrogen (Table 11). As far as oil content was concerned, vermicompost also influence maximum recovery of oil percentage in dry leaves during different stages of harvesting (2.60 to 2.63%). Though FYM responded as the second best dose for oil content (2.61%) during the first cutting of leaves, while it remained *at par* with pig manure during the second cutting of leaves. Lowest oil content was recorded (2.52 to 2.56%) in control.

Among the various doses of nitrogen, the N_3 (100 kg/ha) and N_2 (80 kg/ha) doses of nitrogen produced maximum oil percentage and were significantly superior to lower dose of nitrogen N_1 (60 kg N/ha) and N_0 (control) during first and second cuttings. Among the interaction, maximum oil recovery was recorded with M_3N_3 (2.7%) combination followed by M_3N_2 (2.63%). Lowest oil percentage was noticed in control at all stages of observations.

4:1:3:2 Projected oil yield per hectare (litre)

It is evident from the Table 12 and fig. 5 (a) and (b) that various sources of organic manures and levels of nitrogen caused appreciable impact on production of oil yield per hectare. The application of vermicompost @ 5 t/ha caused significantly maximum production of oil during both the year 2005 and 2006 (380.03 l/ha and 392.70 l/ha, respectively), followed by pig manure and FYM. The pig manure and FYM were also found significantly superior to control and at par with each other.

Table-11: **Effect of organic manures and levels of nitrogen on oil (%) and alcohol content (%) at different stages of cuttings.**

	Oil content (%)			Alcohol content (%)		
Treatment	1st	2nd	3rd	1st	2nd	3rd
Organic manures (M)	(3MAP)	(6MAP)	(9MAP)	(3MAP)	(6MAP)	(9MAP)
Control (M_0)	2.56	2.52	2.52	45.56	45.90	45.94
FYM (M_1)	2.61	2.59	2.58	45.69	46.24	46.17
Pig Manure (M_2)	2.59	2.59	2.59	45.51	46.10	46.16
Vermicompost (M_3)	2.63	2.60	2.60	45.63	46.26	46.18
C.D. at 5%	0.01	0.01	0.01	N.S.	0.17	0.16
Nitrogen (N)						
Control (N_0)	2.58	2.55	2.56	45.50	45.78	46.00
40 kg N/ha (N_1)	2.57	2.58	2.58	45.07	46.11	46.18
80 kg N/ha (N_2)	2.62	2.59	2.57	45.62	46.35	46.05
120 kg N/ha (N_3)	2.62	2.59	2.58	45.56	46.25	46.23
C.D. at 5%	0.01	0.01	0.01	N.S.	0.17	0.16
Interaction (M x N)						
M_0N_0	2.53	2.50	2.46	45.66	45.40	45.50
M_0N_1	2.56	2.53	2.53	45.56	45.73	46.23
M_0N_2	2.60	2.53	2.46	45.53	46.16	45.70
M_0N_3	2.56	2.56	2.53	45.50	46.33	46.33
M_1N_0	2.60	2.60	2.56	45.60	46.10	46.23
M_1N_1	2.60	2.60	2.60	45.66	46.30	46.03
M_1N_2	2.63	2.60	2.56	45.66	46.30	46.23
M_1N_3	2.63	2.60	2.60	45.80	46.26	46.20
M_2N_0	2.60	2.60	2.60	45.36	45.76	46.13
M_2N_1	2.53	2.60	2.60	45.63	46.10	46.23
M_2N_2	2.63	2.60	2.56	45.78	46.13	46.10
M_2N_3	2.60	2.56	2.60	45.30	46.40	46.20
M_3N_0	2.60	2.53	2.63	45.40	45.86	46.13
M_3N_1	2.60	2.60	2.60	45.93	46.33	46.23
M_3N_2	2.63	2.63	2.60	45.53	46.83	46.16
M_3N_3	2.70	2.66	2.60	45.66	46.03	46.20
C.D. at 5%	0.03	0.02	0.03	N.S.	0.35	0.32

Table-12: **Effect of organic manures and levels of nitrogen on projected oil yield per hectare (Litre).**

Treatment	Year 2005	2006
Organic manures (M)		
Control (M_0)	254.88	268.02
FYM(M_1)	313.85	283.55
Pigmanure(M_2)	342.25	314.51
Vermicompost (M_3)	380.03	392.70
C.D. at 5%	**53.16.**	**43.15**
Nitrogen (N)		
Control (N_0)	259.30	239.08
60 kgN/ha (N_1)	306.36	279.27
80 kgN/ha (N_2)	348.06	341.95
100 kgN/ha (N_3)	377.29	398.48
C.D. at 5%	**53.16**	**43.15**
Interaction (M x N)		
M_0N_0	192.68	198.46
M_0N_1	238.94	222.87
M_0N_2	284.17	309.85
M_0N_3	303.75	340.89
M_1N_0	260.45	220.23
M_1N_1	308.75	269.92
M_1N_2	334.34	305.45
M_1N_3	351.86	338.60
M_2N_0	294.81	253.04
M_2N_1	329.28	289.43
M_2N_2	354.53	336.93
M_2N_3	390.38	378.65
M_3N_0	289.28	284.60
M_3N_1	348.46	334.86
M_3N_2	419.20	415.56
M_3N_3	463.17	535.78
C.D. at 5%.	**106.32**	**87.30**

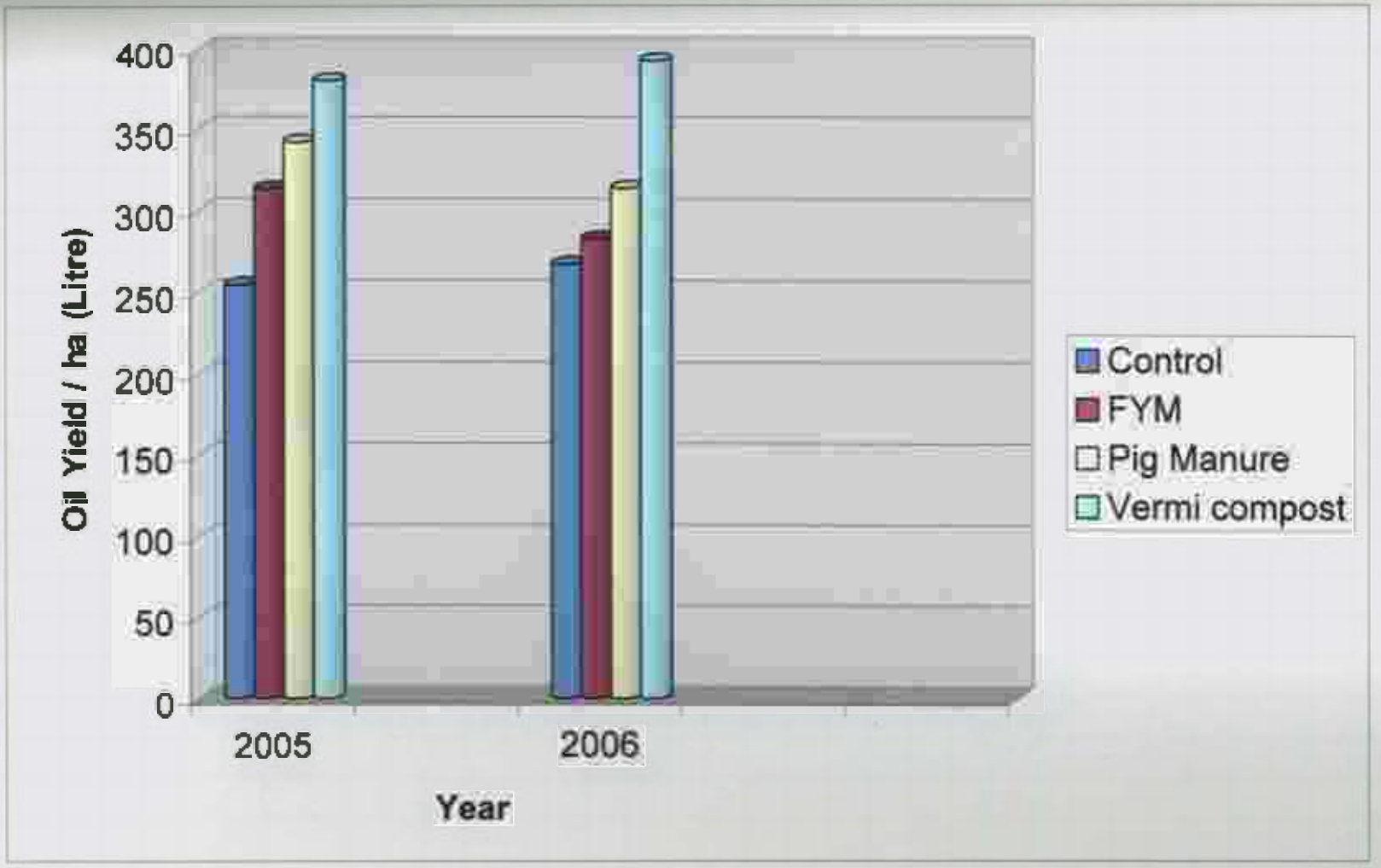


Fig. 5 (a) : Effect of organic manures on projected oil yield / ha (Litre).

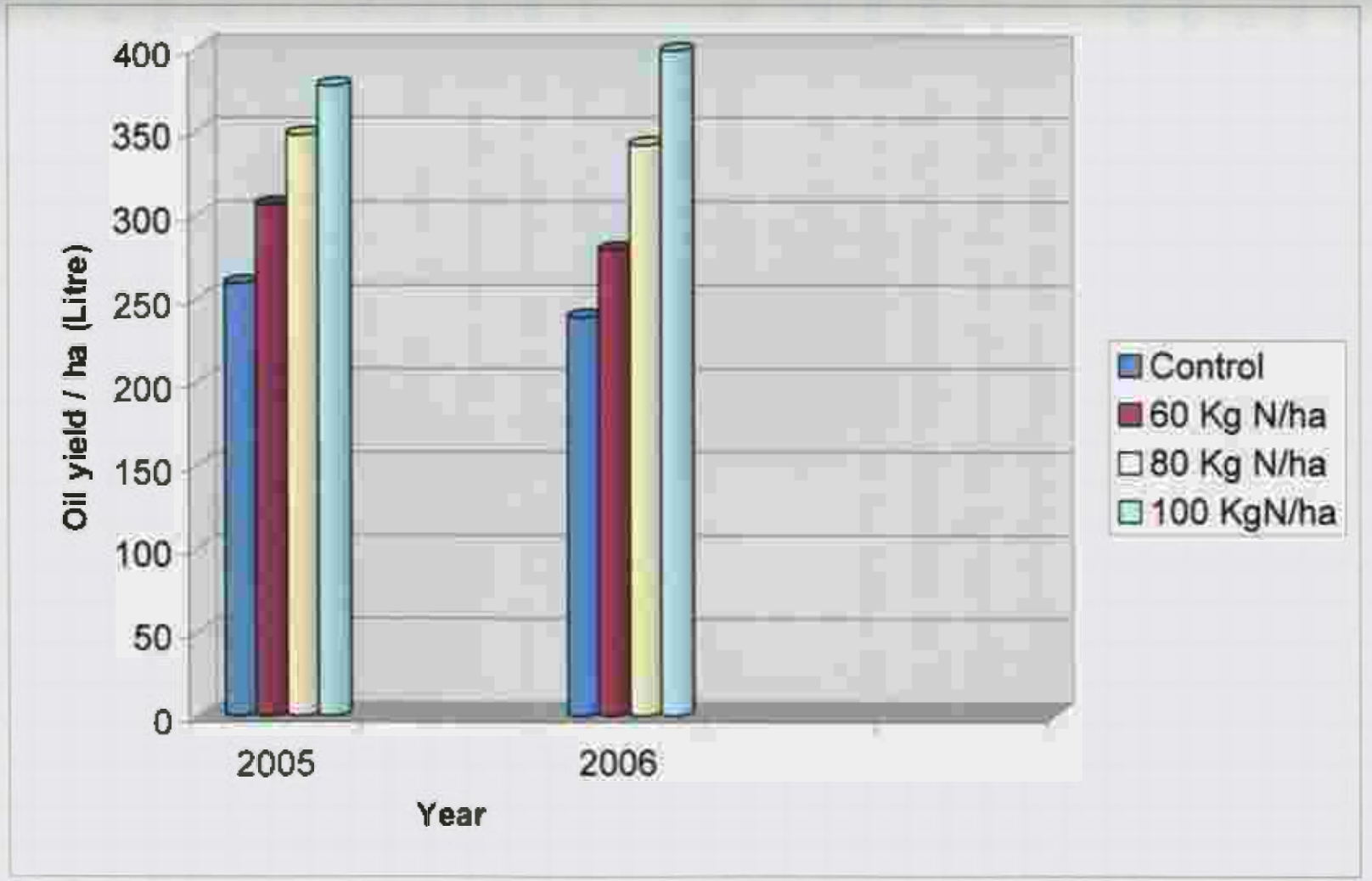


Fig. 5 (b) : Effect of levels of nitrogen on projected oil yield / ha (Litre).

Application of various doses of nitrogen led to increase projected oilyield per hectare in comparison to 100 kg N/ha (377.29l/ha and 398.48 l/ha) during 2005 and 2006, respectively, followed by 80 kg N/ha and 60 kg N/ha. N_2 and N_1 also had significant impact on increasing oil yield during the year 2005 and 2006 except N_1 as it remained at par with control during the year 2006.

As in the case of oil percentage, the projected yield of patchouli oil (463.17 and 535.78 t/ha) was also recorded highest by M_3N_3 (vermicompost @ 5 t/ha + 100 kg N/ha) combination during both the years. Several other combinations were also exhibited significant impact in increasing the oil yield per hectare in comparison to control.

4.1.3.3 Patchouli alcohol content (%)

It is apparent from the Table 11 that various organic manures and levels of nitrogen have also influenced positively in increasing the alcohol percentage in patchouli oil. The maximum alcohol percentage was obtained by treatment with vermicompost @ 5 t/ha (45.63 – 46.18%) followed by FYM and pig manure. The minimum alcohol content was recorded in control.

Application of various doses of nitrogen also caused to increase alcohol percentage in patchouli oil. The maximum alcohol percentage was recorded in the treatment of 80 kg N/ha from the first and second cuttings, while it was highest when applied with 100 kg N/ha during third stage of cutting. Several combinations like M_3N_3, M_2N_3, M_3N_2, etc., also exhibited positive trend of influence with regard to alcohol percentage in patchouli oil.

4:2 EFFECT OF ORGANIC MANURES AND LEVELS OF NITROGEN ON FERTILITY STATUS OF SOIL

4:2:1 Status of major nutrients in the soil after harvest

Supply level of available nutrients (N, P and K) have been significantly effected by different sources of organic manures, inorganic- N and their interactions (Table 13 and fig. 6a and b). The available nitrogen status improved substantially from 155.66 kg/ha with M_0 to 214.66 kg/ha with M_3 (vermicompost 5 t/ha) which was significantly superior to M_1 (FYM 20 t/ha and at par with M_2 (Pig manure 10 t/ha). Among different levels of inorganic nitrogen, 100 kg/ha has given the highest availability of nitrogen (207.58 kg/ha). The middle (80 kg N/ha) and lower (60 kg N/ha) doses of applied nitrogen were also found to improved available nitrogen in the soil significantly to control. In general, response of organic manures $M_0 - M_3$ (155.66– 214.66 kg/ha) was better than inorganic nitrogen $N_0 - N_3$ (156.66 - 207 kg/ha) with regard to nitrogen availability.

Among the interaction M_3N_3 was found more effective in improving available nitrogen (239.66 kg/ha) followed by M_3N_2 (231.66 kg/ha) and M_2N_3 (229.33 kg/ha). However, these interaction remained at par with each other but they were found significantly superior to most of the combinations and control (142.33 kg/ha).

Phosphorus availability in the experimental soil was not influenced statistically by organic manures, inorganic nitrogen and their interaction. However, application ofvermicompost has resulted maximum availability of phosphorus in the experimental plot after harvest (17.58 kg/ha) followed by pig manure (16.83 kg/ha) and FYM (16.75 kg/ha).

Maximum availability of phosphorous was recorded with highest level of nitrogen (N_3) i.e. 17.50 kg/ha followed by N_2 and N_1 and lowest in control (15.66 kg/ha).

With regard to interaction effect on availability of phosphorous, the highest amount was noticed with M_3N_3 (19 kg/ha and lowest was with M_0N_0 (15 kg/ha).

The application of organic manures, nitrogen and their combinations had favourable effect in sustaining the availability of potassium in the soil after harvest of patchouli (Table 13 and figure 6a and b). Maximum availability of potassium (177.41 kg/ha) was recorded with vermicompost (M_3) and closely followed by pig manure (177.0 kg/ha). Both were significantly found better in enhancing the available potassium in comparison to FYM (M_1) and lowest available potassium was recorded in control (143.58 kg/ha).

As like available nitrogen in soil, available potassium in soil has been significantly increased by application of various levels of nitrogen. Maximum availability of potassium (188 kg/ha) was recorded at highest level of nitrogen (100 kg/ha) which was significantly superior to middle and lower doses of nitrogen application. Though N_2 (80 kg/ha) and N_1 (60 kg/ha) remained at par with each other but their effect was statistically better to control with regard to the enhancing the availability of potassium in the soil. Among the interaction, M_3N_3, M_2N_3, M_2N_2, M_3N_2, etc., were also led to make more availability of potassium (203.33 – 198.33 kg/ha) in the soil after harvest, which were far better than individual as well as combined application of organic manures and nitrogen. Minimum available potassium (119 kg/ha) was observed with M_0N_0.

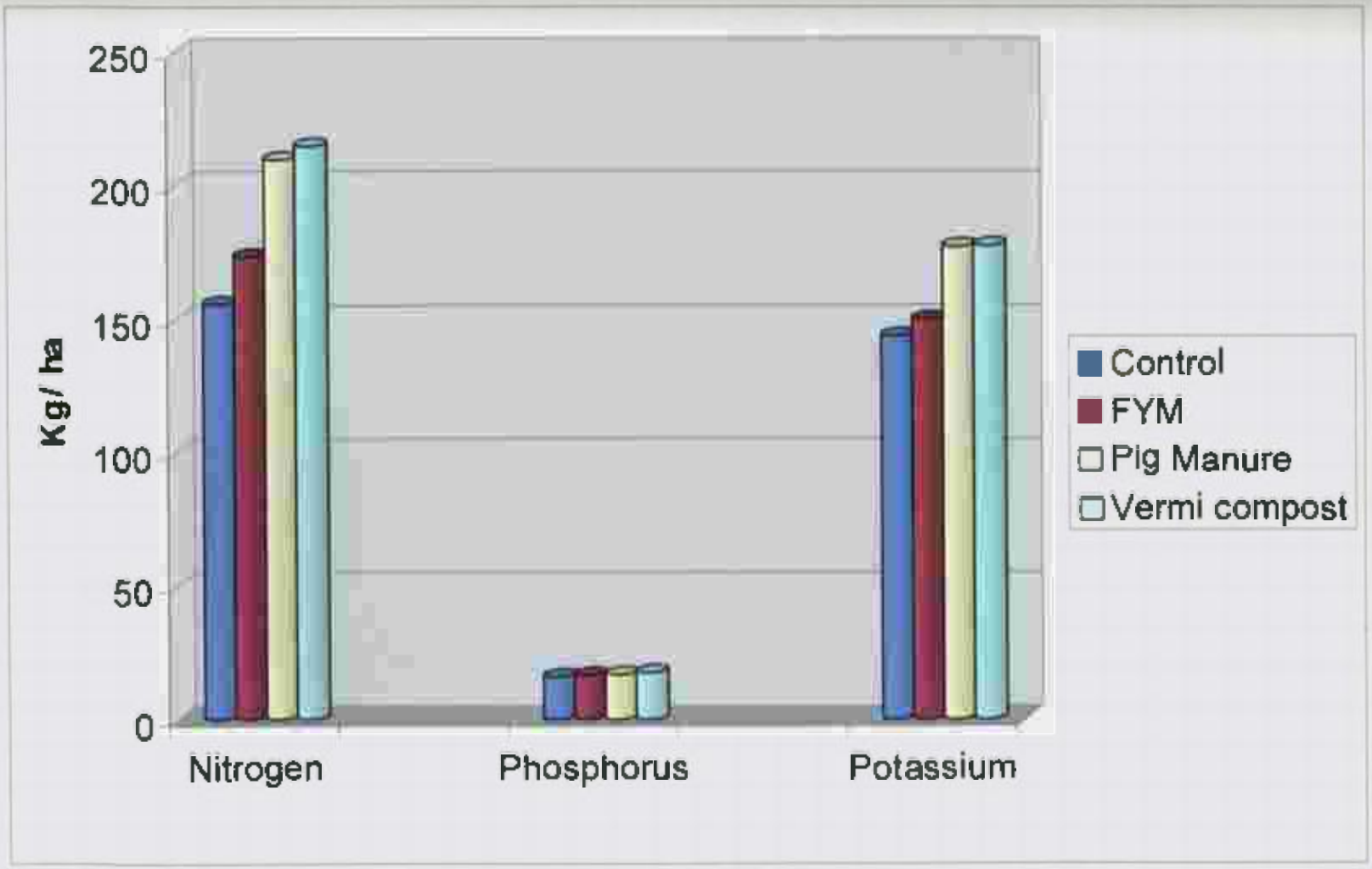


Fig. 6 (a) : Effect of organic manures on N, P and K content in the soil after harvest.

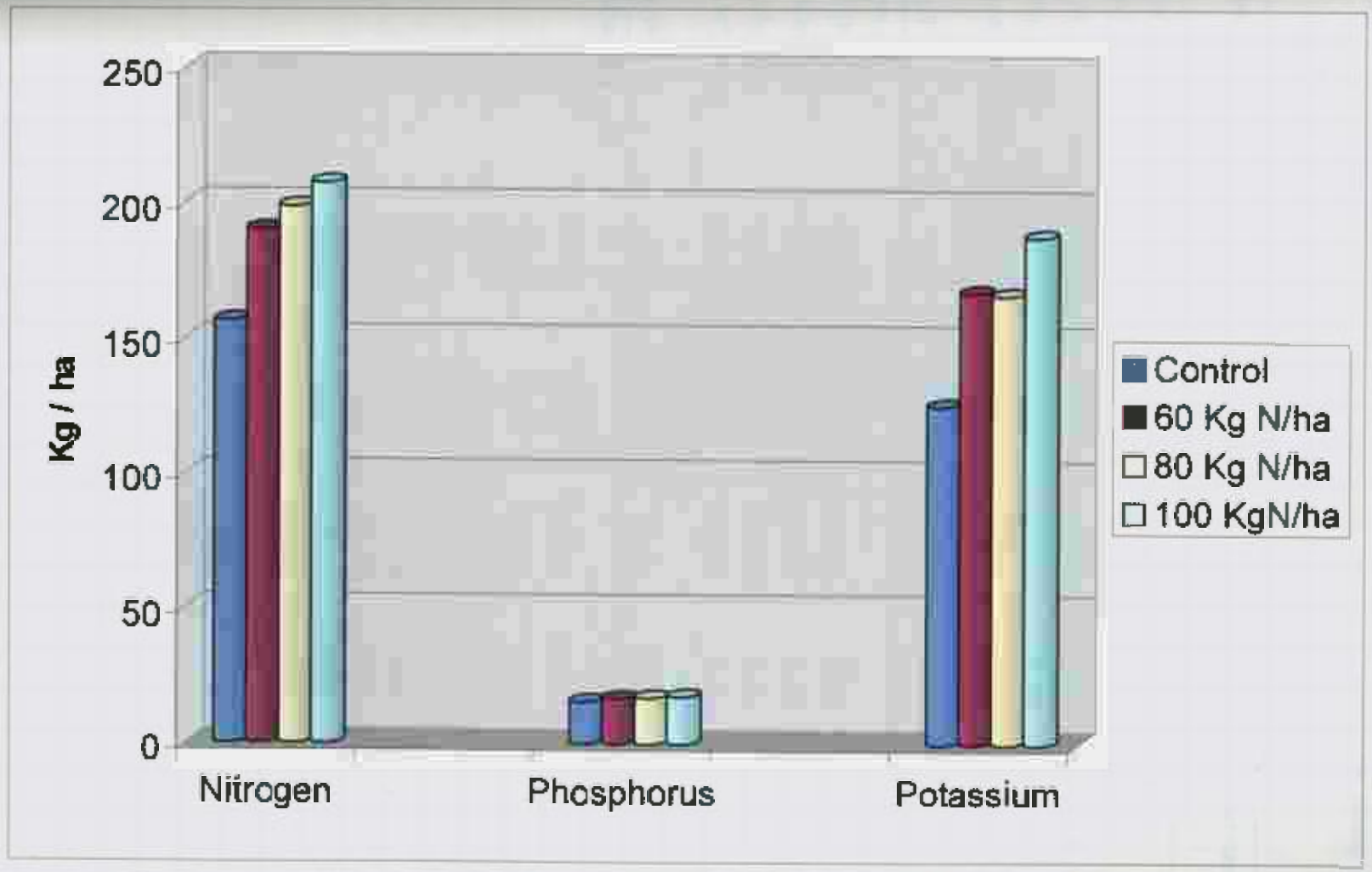


Fig. 6 (b) : Effect of levels of nitrogen on N, P and K content in the soil after harvest.

Table-13 : **Effect of organic manures and levels of nitrogen on nitrogen, phosphorus, potassium, pH and organic carbon of the soil after harvest.**

Treatment	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	pH	organic carbon (%)
Organic manures (M)					
Control (M_0)	155.66	16.00	143.58	5.30	2.69
FYM (M_1)	173.41	16.58	149.83	5.40	3.03
Pig Manure (M_2)	209.66	16.83	177.00	5.40	2.96
Vermicompost (M_3)	214.66	17.58	177.41	5.40	2.90
CD at 5%	**8.52**	**N.S.**	**14.11**	**N.S.**	**0.20**
Nitrogen (N)					
Control (N_0)	156.66	15.66	125.50	5.40	2.81
60 kg N/ha (N_1)	190.33	16.75	167.58	5.40	2.90
120 kg N/ha (N_2)	198.83	17.08	166.58	5.40	2.91
180 kg N/ha (N_3)	207.58	17.50	188.16	5.40	2.95
CD at 5%	**8.52**	**N.S.**	**14.11**	**N.S.**	**N.S.**
Interaction (M x N)					
M_0N_0	142.33	15.00	119.00	5.30	2.63
M_0N_1	151.33	16.00	132.66	5.30	2.70
M_0N_2	161.00	16.00	154.66	5.40	2.70
M_0N_3	168.00	17.00	168.00	5.40	2.73
M_1N_0	151.00	16.00	130.00	5.40	2.90
M_1N_1	170.00	16.66	169.33	5.40	3.01
M_1N_2	179.33	17.01	20.66	5.40	3.06
M_1N_3	193.33	16.66	179.33	5.40	3.06
M_2N_0	166.00	15.66	124.66	5.40	2.93
M_2N_1	220.00	17.00	183.33	5.40	2.96
M_2N_2	223.33	17.33	198.00	5.40	2.96
M_2N_3	229.33	17.33	202.00	5.40	3.00
M_3N_0	167.33	16.00	128.00	5.40	2.80
M_3N_1	220.00	17.33	185.00	5.40	2.83
M_3N_2	231.66	18.00	193.00	5.40	2.93
M_3N_3	239.66	19.00	203.33	5.40	3.03
CD at 5%	**17.05**	**N.S.**	**28.23**	**N.S.**	**0.40**

4.2.2 Effect on soil pH and organic carbon

Application of various organic manures and levels of nitrogen did not alter the pH of the experimental field. However, pH 5.4 was noticed in most of the treatments and their combinations and lowest was recorded with control and M_0N_0 plots (5.3).

Application of organic manures had appreciable impact in sustaining the organic carbon alone as well as with nitrogen. The net increase in organic carbon was much higher with organic manures $M_0 - M_3$ (2.69–3.02 %) over inorganic fertilizer $N_0 - N_3$ (2.81 – 2.95 %). All sources of organic manures were significantly found to enhance the availability of organic carbon in soil after harvest of crop. Though maximum carbon content was noticed with M_1 (FYM), but it remained at par with M_2 and M_3. Inorganic nitrogen application did not alter the organic carbon content of the soil significantly after the experimentation. However, it was found to increase the organic carbon with increasing level of nitrogen.

Among the treatment combinations, FYM with nitrogen @ both 100 kg/ha and 80 kg/ha showed highest content of organic carbon (3.06) in the soil after harvest followed by M_3N_3, M_1N_1, M_2N_3, M_2N_2 and M_2N_1 (3.03 – 2.96 %) and lowest with M_0N_0 (2.63 %) (Table -13).

4.3 ECONOMICS OF PATCHOULI CULTIVATION AS INTERCROP IN COCONUT PLANTATION

4.3.1 Economics of patchouli cultivation

It is visible from the data presented in Table 14 (a) and (b) that most of the treatment combinations have favourable impact on enhancing economic return of patchouli. Though treatment combination with

Table-14 (a): Cost of inputs and sale price of produce.

S.No.	Items			Cost (Rs.)
1.	**Ploughing 3 times by Tractor @ Rs.1200/ha.**			3,600.00
2.	**Manuring-FYM, 20t/ha @ Rs.500/-ton**			10,000.00
3.	**Cost of Fertilizers:**			
	(i) 60 Kg N/ha	=	130 Kg Urea @ Rs. 8/ per kg	1,040.00
	(ii) 80 Kg N/ha	=	174 Kg Urea @ Rs. 8/ per kg	1,392.00
	(iii) 100 Kg N/ha	=	218 Kg Urea @ Rs. 8/ per kg	1,744.00
	(iv) 50 Kg P_2O_5/ha	=	312.5 Kg S.S.P. @ Rs. 8/- per kg	2,500.00
	(v) 50 Kg K_2O/ha	=	90 Kg MOP @ Rs. 10/- per kg	900.00
	(vi) Pig manure	=	10 t/ha. @ Rs. 500/ton	5,000.00
	(v) Vermicompost	=	5 t/ha @ Rs. 12,000/ ton	60,000.00
4.	**Plant protection measures:** Chloropyriphos chemicals applied to check fungal attack and Malathion to check termites, red ants etc.			280.00
5.	**Cost of seedlings for one hectare** - 30,000 nos @ Rs. 5/-			1,50,000.00
6.	**Cost of labour @ Rs.80/- per head per day:**			

	Particulars	Mandays	Cost (Rs.)
1.	Filling of 30,000 poly bags @ Rs.100 per 1000 nos.	37.5 nos.	3000.00
2.	Bed preparation	25 nos.	2000.00
3.	Application of manures & Fertilizers	10 nos.	800.00
4.	Lay out of plots (48) of 3 m. x 2.25 m	40 nos.	3200.00
5.	Basal dressing	15 nos.	1200.00
6.	Planting of seedlings	25 nos.	2000.00
7.	Staking and taggings of plants	25 nos.	2000.00
8.	Top dressing	8 nos.	640.00
9.	Application of P/P chemicals	6.5 nos.	320.00
10.	Weeding, hoeing & earthing up for 4 times 20 x 4	80 nos.	6400.00
11.	Cost of irrigation/watering during dry period	15 nos.	1200.00
12.	Harvesting	60 nos.	4800.00
13.	Drying and packing etc.	20 nos.	1800.00
	Total	367 man days	Rs. 29,360.00

7. **Sale price of produce (dry)-@ Rs. 22/- per Kg.**

Table-14 (b) : **Economics of patchouli cultivation at treatment combination of organic manures and nitrogen fertilizer.**

Treatment combination	Dry yield (t/ha)	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs./ha)	Cost benefit ratio.
M_0N_0	15.09	1,83,240/-	3,31,980/-	1,48,740/-	1: 1.80
M_0N_1	17.93	1,84,280/-	3,94,460/-	2,00,180/-	1: 2.13
M_0N_2	23.28	1,84,632/-	5,12,160/-	3,27,528/-	1: 2.77
M_0N_3	25.26	1,84,984/-	5,55,720/-	3,70,736/-	1: 3.00
M_1N_0	19.08	1,93,240/-	4,19,760/-	2,26,520/-	1: 2.17
M_1N_1	22.68	1,94,280/-	4,98,960/-	3,04,600/-	1: 2.56
M_1N_2	25.10	1,94,632/-	5,52,200/-	3,57,568/-	1: 2.83
M_1N_3	27.06	1,94,984/-	5,95,320/-	4,00,336/-	1: 3.05
M_2N_0	21.64	1,88,240/-	4,76,080/-	2,87,840/-	1: 2.52
M_2N_1	24.24	1,89,280/-	5,33,280/-	3,44,000/-	1: 2.81
M_2N_2	27.21	1,89,632/-	5,98,620/-	4,08,988/-	1: 3.16
M_2N_3	31.10	1,89,984/-	6,84,200/-	4,94,216/-	1: 3.60
M_3N_0	22.49	2,43,240/-	4,94,780/-	2,51,540/-	1: 2.03
M_3N_1	26.79	2,44,280/-	5,89,380/-	3,45,100/-	1: 2.41
M_3N_2	32.72	2,44,632/-	7,19,840/-	4,75,208/-	1: 2.94
M_3N_3	39.95	2,44,984/-	8,78,900/-	6,33,916/-	1: 3.58

vermicompost @ 5 t/ha and highest level of nitrogen i.e., 100 kg N/ha caused the maximum cost of production (Rs.2,44,984.00) in comparison to other treatment combinations, but it also gave maximum gross and net return because of the increase biomass yield of patchouli. The maximum gross return (Rs.8,78,900.00) was recorded with M_3N_3 followed by M_3N_2, M_2N_3, M_2N_2, M_1N_3 etc., and net return (Rs.6,33,916.00) was also recorded highest with the treatment combination of M_3N_3. The treatment combination M_2N_3 was found second best with regard to gross return Rs. 6,84,200) and net return (Rs.4,94,216) with highest cost benefit ratio of 1:3.60 followed by M_0N_3, (1: 3.58), M_2N_2, (1 :3.16), M_1N_3 (1:3.05) etc. Treatment combinations with pig manure and FYM at lower doses were also found better in increasing the net return and cost benefit ratio in comparison to control. Lowest net return (Rs. 1,48,740/-) with cost benefit ratio of 1:1.80 was noticed with control. Among the organic manures, M_2 produced maximum net return of Rs.2,87,840 with CBR of 1:2.52 followed by M_3 and M_1 and lowest in M_0N_0, with regard to influence of various doses of nitrogen on gross and net return as well as CBR, it was found to increase with increasing levels of nitrogen application.

4.3.2 Effect of intercropping with patchouli on productivity of coconut

In general, the vigor of the palm of plantation area was enhanced along with the productivity due to intercropping of patchouli and also due to manuring of individual coconut trees. The average increase in girth size of coconut plants was recorded from 76.76 cm to 93.81 cm at the end of experimentation after intercropping with patchouli. The productivity of fruits per palm was also increased from 18 nuts per palm (2812 nuts/ha) to 65 nuts per palm (8125 nuts/ha).

Discussion

CHAPTER-V

DISCUSSION

Restoring soil fertility with inorganic fertilizers and maintaining soil productivity has been though successful but continued decline in soil fertility especially on Alfisols/Utisols of tropical/sub-tropical region is a common feature (Lal, 1993). Organic manures and inorganic fertilizers are two major sources of plant nutrients, if used judiciously that promises to improve the biomass of green leaves and oil yield in addition to improving to rhizosphere of both intercrop as well as main crop nutritionally and microbiologically which also led in sustaining the soil fertility. The experimental approach to the present study was therefore, intended to evaluate the effect of organic manures and levels of nitrogen on growth, yield and quality, changes in soil fertility and cost benefit ratio of patchouli cv. Johore. Result thus obtained in this regard which have been presented in the previous chapters are discussed as under, in the light of available literature and evidence.

5:1 EFFECT ON GROWTH, YIELD AND QUALITY OF PATCHOULI

5:1:1 Growth characteristics

Among various sources of organic manures, application of vermicompost @ 5 t/ha was found more effective in enhancing the growth parameters viz., height of plant, number of leaves and plant canopy significantly at different stages of leaf cutting. This is because of higher content of all the major nutrients (NPK) with compared to pig manure and FYM. Incorporation of vermicompost into the soil increased the moisture

ding capacity and other physical properties of soil which led to better root growth and development of better plant canopy due to better nutrient availability and uptake of nutrients. Anwar *et al.* (2005) also recorded maximum plant growth by application of vermicompost @ 5 t/ha in Basil (*Ocimum basilicum* L. cv. *Kushal Chavisol*), whereas, Singh *et al.* (2005) reported maximum leaf area of long pepper by application of vermicompost at 10 t/ha. The favourable effect on growth parameters by application of vermicompost has been observed by Singh (2006) in onion and Khate (2006) in cucumber under polyhouse condition. Pig manure also found effective in increasing the plant height, number of leaves per plant and plant canopy at most of the harvesting stages in comparison to FYM and control. In the present experimentation, increased in the vigor of the plant by application of pig manure @ 10 t/ha was due to its beneficial effect as it increased the organic matter and humus content of the soil, water holding capacity of soil and enhances activity of plant nutrients into available form in more amount in comparison to FYM. Therefore, growth of plant was better with pig manure than FYM.

The beneficial impact of FYM application @ 20 t/ha has been recorded in increasing the growth attributes of patchouli to control. The favourable impact of FYM was also reported in aromatic and spices crops by various workers like Vineeta *et al.* (2005) in *Bacopa monniesi;* Singh *et al.* (2005) in long pepper; Singh and Karki (2005) in rose; Pandey *et al.* (2005 a) in Ashwagandha; Pandey *et al.* (2005 a) in *Centella asiatica.*

In general, application of various doses of nitrogen increased the plant growth significantly over control except the number of branches. Maximum plant height, number of leaves and plant canopy was recorded with 100 kg N/ha, which was significantly superior at most stages of harvesting over lower doses. It seems that higher dose was able to enhanced

vegetative growth because of more availability of nitrogen. Nitrogen a constituent of protein, amino acid, nucleic acid, etc. helps in ...sing the size and vigor of leaves, which caused more vegetative ...th at 100 kg/ha during the present investigation followed by 80 kg N/ha ...d 60 kg N/ha). The increase vigor of plant following the application of ...ganic nitrogen may have also attributed to favourable effect on increased chlorophyll production with greater foliar area for higher photosynthesis, ...ited more number of leaves along with the increase in size and height of ..., thus has better growth in terms of height of plant, number of leaves ... spread of plant. The present finding is in close conformity with the work ... Adiwiganda *et al.* (1973) who observed better plant growth in patchouli ... application of 107 kg N/ha. Whereas, Servan *et al.*(1983) advocated the ...lication of 150 kg N/ha per year in patchouli. Saha *et al.* (1992) found ...ter growth with application of 160 kg N/ha in Arunachal Pradesh in ...chouli, whereas, better result was obtained with 60 kg N/ha application by ...lappan and Ponnuswami (1982) in patchouli under Bangalore condition. ...vourable impact with nitrogen application has also been reported by the ...ious workers in other aromatic crops viz., Bhardwaj *et al.* (1983) in ...ntha, Rao (2001) in palmarosa, Munsi *etal.* (1982) in mentha, citronella ... palmarosa. Singh and Rao (2005) in *Tagetes minuta* .

In general, interaction effect of organic manures and nitrogen were found better than the individuals. The highest amount i.e. 100 kg N/ha application in association with organic manures resulted in better plant growth. However, vermicompost with 100 kg N/ha caused maximum plant growth in terms of number of leaves, plant height and plant canopy at different stages of observations followed by M_3N_2 (vermicompost @ 5 t/ha + 80 kg N/ha), M_2N_3 (pig manure@ 10 t/ha + 100 kg N/ha) and M_1N_3 (FYM @20 t/ha + 100 kg N/ha) in most of the growth characters.

This is probably due to favourable effect of organic manures along with nitrogen application which has provided more availability of nutrients in the soil as well as further translocation to the plant parts resulted better growth of plant in terms of number of leaves, height of plant and further plant spread. Similar observation was made by Anwar *et al.* (2005) who obtained maximum plant growth of basil by application of vermicompost and nitrogen and Pandey *et al.* (2005) in Ashwagandha by vermicompost along with NPK. Whereas, Vineeta *et al.*(2005) observed a favourable impact of nitrogen and FYM in *Bacopa monniesi* and Pandey *et al.* (2005) obtained better plant growth of *Centella asiatica* with application of 10 t/ha FYM along with NPK (50:50:50) which is close conformity with the present investigation. Several other workers have also found beneficial effect of organic manures and nitrogen application in increasing the growth of various aromatic crops (Baskar *et al.*, 2005, Manjuntha *et al.*, 2006, Jessykutty, 2005).

5:1:2 Yield attributes

The result of present experimentation showed beneficial effect of organic manures and levels of nitrogen application on fresh and dry leaves yield of patchouli. Application of vermicompost @ 5 t/ha produced maximum yield per plant, per plot and per hectare, however, it remained *at par* with pig manure and FYM with regard to increasing the dry weight of leaves per hectare. The projected yield of fresh leaves per hectare was found to increased by application of vermicompost over pig manure, FYM and control by 14.5 per cent, 20 per cent and 34.6 percent, respectively.

The increase in yield by the application of vermicompost might be associated with liberation of nutrients in more amount which caused better growth and yield in comparison to pig manure and FYM. Results of present

investigation are also in close conformity with the findings of earlier workers, who also reported that vermicompost had beneficial effect in enhancing the yield of different aromatic crops by application of increased levels of soil fertility (Anwar *et al.* 2005, Singh *et al.*, 2005 and Pandey *et al.*, 2005 a).

Application of pig manure and FYM also significantly increased the biomass yield of patchouli per plot at different stages of harvesting to control. Beneficial effect of FYM in increasing the productivity of aromatic and spices crops had been reported by Schaffer *et al.* (1993) in *Achillea millefolium*. Rao (2001) in palmarosa, Vineeta *et al.* (2000) in *Bacopa monniesi*, Singh and Karki (2005) in rose water, Pandey *et al.* (2005a) in Centella asiatica.

The present finding is in agreement with several workers who recorded favourable effect of organic manures in promoting the yield of the crops, Nowak *et al.* (1985) obtained with better yield with organic manures in crops like garlic, turmeric, raddish and carrot. Lalramthara *et al.* (2001) had observed that application of FYM@ 25 t/ha and pig manure@ 15 t/ha were most effective dose for enhancing growth, yield and quality of ginger under foot hill conditions of Nagaland. Whereas, the pig manure was found to be better source of manuring in comparison to FYM and poultry manure under Nagaland conditions. (Chingkhong, 1994). Favourable effect of organic manures viz; FYM, vermicompost and poultry manures have been reported by Pandey et al., (2005) in Ashwagandha.

Different levels of inorganic nitrogen application exhibited appreciable impact in increasing the fresh as well as dry weight of leaves per plant, per plot and per hectare. However, the effect was only significant at first and second cutting with regard to both fresh and dry weight of leaves

per plant basis. In general, application of nitrogen at 100 kg/ha was found significantly better in enhancing the biomass yield (fresh and dry) of patchouli per plot as well as per hectare at different stage of harvesting. Adequate amount of nitrogen plays an important role in chlorophyll synthesis and chlorophyll plays biological role in harvesting the solar energy and photosynthetic compound in energy transformation which lead to optimum growth of the plant. Present result is in close conformity with the findings of Adiwigandha *et al.* (1973) and Munsi, 1992 who also observed increased in yield of fresh and dry weight of patchouli by application of 100 kg N/ha, whereas Sarwar *et al.* (1983) advocated application of 150 kg N/ha every year for good yield of patchouli. Several other workers also reported favourable impact of nitrogen application@ 100– 260 kg/ha in production of biomass of different aromatic crops viz., *mentha citrate* (Bhardwaj *et al.*, 1983), *Centella asiatica* (Pandey *et al.*, 2005a) and *Tagetes minuta* (Singh and Rao, 2005).

Application of 80 kg and 60 kg N/ha were also found to increase the fresh and dry weight of patchouli leaves per plot to control. Though, rate of increase was better in 80 kg N/ha but remained at par with the lower dose of nitrogen at most stages of observations. There was significant difference between these two doses with regard to the projected yield of fresh leaves per hectare only during 2005. The middle doses had significant influenced on dry leaves production per plot to control and they also vary to each other. Irulappan and Ponnuswami (1982) also observed higher herbage yield of patchouli by application of 60 kg N/ha which is in credence with the present findings.

Combined application of vermicompost (M_3) along with N_3 level of nitrogen produced the highest level of biomass, suggesting the improved agronomic efficiency of both the organic manures and inorganic nitrogen.

Likewise combination of M_3N_2, M_2N_3 and M_1N_3 gave better yield than other treatments and their combinations. The biomass yield per plot in both fresh and dry were significantly influenced at all stages of harvestings. These observations suggested that slow nutrients release behaviour of all three manures has direct co-relation with the yield improvement. Favourable impact of organic manures and nitrogen fertilization has been reported in enhancing the biomass yield in several aromatic crops. Application of vermicompost @ 5 t/ha and NPK at 50:25:25 kg/ha executed maximum herbage and dry matter in basil crop in comparison to FYM. Similar results have been observed by Anwar *et al.* (2000). Whereas, Vineeta *et al.* (2000) and Singh *et al.* (2005a) observed the highest values of herbage yield (fresh and dry) accumulation at 75 Kg + 5 t FYM/ha in *Bacopa monniesi*. Jessykutty (2005) advocated the application of FYM at 5 t/ha along with 80:50:50 kg/ha of NPK for commercial production of patchouli.

5:1:3 Quality attributes

As like the yield attributes, oil recovery from dry leaves of patchouli as well as alcohol content was highest with the application of vermicompost along with the projected yield of patchouli oil per hectare. Vermicompost impact was found significantly superior to pig manure and FYM with regard to oil and alcohol content at most stages of harvesting. Pig manure and FYM were also significantly influenced in increasing the oil and alcohol content than control. The projected oil yield per hectare was also increased during both the years of experimentation by application of pig manure and FYM than control but the impact was not significant. Rao (2001) reported that FYM at 50 t/ha increased the essential oil yield by 10.3% over control in *Palmarosa*. Similarly, Schaffer *et al.* (1993) also reported favourable impact of organic manures (cattle manure) application in increasing the essential oil yield as compared to control in *Achillea*

mellifolium, Lalramthara *et al.* (2001) observed that both FYM and pig manure were found significantly effective in increasing the volatile oil percentage in ginger under Nagaland conditions.

Application of various levels of nitrogen showed the favourable effect on increasing the oil and alcohol content as well as projected yield of oil per hectare with increasing level of nitrogen. Munsi (1982) observed that application of higher dose of nitrogen i.e. 100 kg/ha increase the oil yield of Japanese mint than lower doses of nitrogen which is in close conformity with the present findings, whereas, Randhawa *et al.* (1984) remarked that levels of nitrogen had no effect on oil percentage in *Mentha citrate*. Bhardwaj *et al.* (1983) also obtained the increased oil yield in *Mentha citrata* by application of 120 kg/ha, while Singh and Rao, (2005) found highest oil yield in *Tagetes minuta* by application of 200 kg N/ha.

Among the interactions M_3N_3 (vermicompost + 100 kg N/ha) showed highest concentration of oil in leaves and alcohol content in oil as well as projected oil yield per hectare followed by M_3N_2 and M_2N_3 and minimum was recorded in control. In integrated nutrient management system Manjunatha *et al.* (2006) recorded significantly superior oil yield of patchouli in cv. Johore by application of 75% NP + 100% K + *Azotobacter* + *Azospirilum* + VAM under Bangalore condition. Ramchandra *et al.* (2006) evaluated different varieties of patchouli revealed that Johore variety resulted more oil content compared to Java and they further remarked that patchouli alcohol was more in variety Johore. It seems that oil content and patchouli alcohol varies with the varieties of patchouli. However, it is also influenced by proper management of the crop. Whereas, Omidbaigi *et al.* (2006) observed that nitrogen fertilization along with the plant density (14.3 plant/m^2) had an important role in enhancing the oil content and composition of *Tanacetum parthenium*. Baskar *et al.* (2005) observed the highest oil yield

of patchouli when field was given with compost @ 30 t/ha along with the gypsum together with recommended doses of NPK. The yield and quality of oil also influenced under the condition in which patchouli is cultivated i.e. open and shade. It is observed that superior quality of oil and higher percentage of oil recovery had been reported under shade condition (Vineeta *et al.*, 2005). Whereas Sharma and Sharma (2005) observed that shade drying of leaves and keeping the dry leaves upto 150 days seemed to be congenial condition for maximum recovery of oil.

5.2 NUTRIENT STATUS INTHE SOIL AFTER HARVEST

Sustainability of a cropping system besides being evaluated on the basis of response, a serious consideration is to be given to soil health. It is evident from the data analysis that supply level of available NPK, organic carbon and pH of the soil has appreciably affected by different sources of organic manure and inorganic nitrogen and their interactions after harvest of crop in the soil. Among organic manures, application of vermicompost caused the maximum content of these major nutrients (NPK). It was significantly superior to other sources of organic manures and control with regard to available nitrogen in soil. M_3 and M_2 were found equally effective inenhancing the available potassium in soil and their impact were significant to FYM and control. Though M_3 caused maximum available phosphorous followed by M_2 and M_1 but impact was not significant.

The application of organic manures did not altered the pH of the soil of the experimental plots as all treatments exhibited sustainable effect with regard to this parameters of soil except control where decreased of soil pH level was noticed. These organic manures produced many hydroxyl organic acid as decomposition product, which are very helpful in sustaining soil pH.

Organic carbon stock of soil acts as a source of nutrients for microbial population which regulates the availability of different nutrients through microbial transformation. The organic carbon was much higher with organic manures over inorganic fertilizer due to supply of carbon rich manures. In these studies, it is more interesting to observe the improvement in organic carbon status with inorganic nitrogen fertilization supporting the biotic principal of carbon sequestration through improved biomass production.

Nutrient concentration and soil biological practices can be enhanced by addition of organic matter besides improving soil organic carbon, which is essential in sustaining soil quality (Katayl, 2000). FYM was found much effective in increasing the organic carbon of the soil and was significantly superior to control and remained statistically at par with pig manure and vermicompost. Whereas, Scheffer *et al.* (1993) observed that cattle manure did not influence the level of carbon, potash, calcium, magnesium, status of soil, whereas, available phosphorus in the soil was increased upto 150 per cent. Anwar *et al.* (2005) reported that various combinations of FYM and vermicompost were found to increased organic carbon, availability of nitrogen and phosphorus in post harvest soil than control.

The NPK and organic carbon content of the soil was found to be increased with increasing levels of nitrogen. Though, maximum level of soil fertility was noticed with 100 kg N/ha but it remained statistically at par with lower dose with regard to potash and organic carbon content, while there was significantly increased of nitrogen content with increasing level of nitrogen application. All doses of nitrogen caused significant increased of nitrogen, potassium and organic carbon of the soil.

Further effectiveness of organic manures and inorganic N in supply of N, P and K was improved through their combined application which was better than their individual effects. Maximum accumulation of these nutrients (N, P and K) were also recorded with vermicompost in combination with 100 kg N/ha, however, it was at par with M_3N_2, M_2N_3 and M_2N_2. Whereas, the FYM along with 100 kg /ha as well as with 80 kg /ha of nitrogen caused maximum presence of organic carbon in the soil after harvest of the crop followed by M_3N_3 and M_2N_3 interactions. It seems, that the crop required high amount of manuring in order to sustain the fertility level of the soil as there was more depletion of these major nutrients, due to uptake by the crop, as in the beginning of the experimentation, there was high content of these major nutrients especially nitrogen and potash.

Present finding is in close conformity with the findings of Sanwal et al.,(2007) who recorded highest organic carbon, organic matter and available nitrogen with FYM application, while maximum availability of potassium with pig manure in soil after harvest of turmeric under Meghalaya condition. They further remarked that application of FYM, poultry manure and pig manure considerably reduced the soil acidity and increased the accumulation of organic matter. Favourable effect of organic manures in improving soil organic carbon, organic matter, which constitutes tremendously to cation exchange capacity that enables the soil to buffer nutrients concentration in soil solution (viz; N, P, S and micronutrients) has been described by Sanyal, (2001).

5:3 ECONOMICS OF PATCHOULI CULTIVATION AS INTERCROP WITH COCONUT PLANTATION

5:3: 1 Economics of patchouli cultivation

The utility of nutritional response is dictated by economics of returns from produce in ultimate term. The economic analysis of the data

from the present investigation in coconut cum patchouli plantation indicates an encouraging results.

The net return was invariably higher with combined application of organic manures and inorganic nitrogen. The combined application of M_3 with N_3 produced highest net return followed by M_2N_3, M_3N_2, M_2N_2 and M_1N_3. Though pig manure caused lesser yield as well as net return in comparison to vermicompost treatment combination, but the cost of cultivation in case of pig manure was lesser than vermicompost as well as FYM too. Therefore, cost benefit ratio was highest with pig manure @ 10 t/ha along with nitrogen-100 kg/ha combination. It shows that pig manure may also be considered a better source of manuring for patchouli cum coconut combination.

The difference of best treatment M_3N_3 versus control was still wider and more prominent, which signified that, the importance of integration of two divergent nutrient sources are vital, in order to harness the mutual benefit from each other. Sivaraman *et al.* (2002) made a similar observation that adopting of any cropping system by a farming community will ultimately be decided by its economic advantage, while mono-cropping of coconut generates employment opportunities of only around 150 man days per hectare with a net income of Rs.10,400/- per hectare per year, whereas, various cropping systems generate the additional employment of 130 – 606 man days per hectare per year with a net return of Rs. 50,000/- to 1,00,000/-per hectare in coconut based mixed farming.

The studies revealed that the integrated use of manures and inorganic fertilizer, provide an additional employment opportunity (367 man days) and net return (Rs.1,48,740 – Rs.6,33,916) with coconut based patchouli intercropping. Ahmed (2002) also reported employment generation

of 1255, 1285, 1285 and 1275 man days in first, second and third year along with a net return of Rs.95,450/-, Rs.2,38,120/- and Rs.1,58,120/- respectively from 2 hectares area of patchouli. Earlier studies under similar agro system, Munsi and Mukherjee (1982) observed favourable impact of fertilizer application on the performance of crops like mentha, citronella and palmarosa as subsidiary crops in inter spaces of perennial plantation.

5:3:2 Effect on Coconut plantation

A synergistic effect of rhizosphere changes in intercrop influenced the performance of main crop was as evident from increase in size of the coconut from 75.21cm to 93.81 cm with simultaneously increase in yield from 18 nuts per palm (2812 nuts/ha) to 52 nuts per palm (8125 nuts/ha). The observation supplement the fact that monoculture of coconut is less sustainable in terms of yield of main crop, besides, an additional yield obtained through raising intercrop with patchouli. Long term fertilizer response studies in coconut (Reddy et al., 2002) on Alfisols showed that fertilizer treatment 1000g N – 437g P – 166g K per palm per year recorded significantly higher nut yield (136 nuts/palm) than treatment with 500g N 218g P – 833g K per palm per year (104 nuts/palm) and no fertilizer application (58 nuts/palm).

Summary and Conclusion

CHAPTER–VI

SUMMARY AND CONCLUSION

Coconut-based farming system is the tradition of tropical and sub-tropical regions. But using patchouli (Pogostemon cablin (Blanco) as an intercrop under coconut plantation is of comparatively recent adoption and no information is absolutely available on possibility of improving the quality of patchouli through better nutrient supply. Hence, present investigation entitled **"effect of organic manures, levels of nitrogen and their combinations on patchouli was carried out within the inter-space of coconut plantation"** during the year 2005 and 2006. The salient findings obtained from the present investigation are summarized below:

Among various sources of organic manures, application of vermicompost @ 5 t/ha was found more effective in enhancing growth parameters viz.; height of plant, number of leaves and plant canopy significantly at different stages of leaf cutting.

Maximum plant height, number of leaves and plant canopy was recorded with 100 kg N/ha which was significantly superior at most stages of harvesting over lower doses. The highest amount of nitrogen (100 kg/ha) application in association with organic manures resulted in better plant growth.

Application of vermicompost @ 5 t/ha produced maximum biomass yield per plant, plot and per hectare, however, it remained at par with pig manure and FYM with regard to increasing the dry weight of leaves per hectare.

Application of nitrogen @ 100 kg N/ha was found significantly better in enhancing the biomass yield both fresh and dry of patchouli per plot as well as per hectare.

Combined application of M_3 along with N_3 level of nitrogen produced highest level of biomass. Likewise, combination of M_3N_2, M_2N_3 and M_1N_3 gave better yield than other treatments and their combinations.

Oil recovery from dry leaves of patchouli as well as alcohol content was highest with M_3 along with projected yield of patchouli oil per hectare and was significantly superior to M_2 and M_1. The quality attributes were found to be increased with increasing level of nitrogen.

As like biomass yield of patchouli, highest concentration of oil in leaves and alcohol content in oil as well as projected oil yield per hectare was recorded with M_3N_3 followed by M_3N_2 and M_2N_3.

Supply level of available nutrients (N, P and K) and organic carbon have been significantly effected by different sources of organic manures, inorganic N and their interactions. Vermicompost caused the maximum content of these major nutrients (NPK). It was significantly superior to other sources of organic manures with regard to available nitrogen in soil.

With regard to potassium content of soil, M_3 (vermicompost) and M_2 (pig manure) were found equally effective and they were statistically superior to M_1 (FYM) and M_0(control).

Available nitrogen in soil was found to increase with increasing levels of nitrogen significantly. Highest level of nitrogen caused maximum concentration of potassium in soil followed by N_2 and N_1. Though N_2 and

N_1 remained at par but significantly superior to control (N_0) with regard to enhancing available potassium in soil.

Among the interactions, highest level of nitrogen (N_3) along with vermicompost (M_3) and pig manure (M_2) caused better accumulation of these nutrients, however they remained at par with each other.

Among organic manures, the highest organic carbon content in soil was observed with M_1 application followed by M_2 and M_3. They remained at par with each other and significantly superior to control. Maximum organic carbon was observed with M_1 (FYM) along with N_3 and N_2 followed by M_3N_3 and M_2N_3 which were significantly superior to several other combinations.

The application of organic manures, inorganic nitrogen and their combination did not altered the pH of soil as well as available phosphorous in soil of experimental plots significantly. Similarly inorganic nitrogen also did not influence the organic carbon in soil statistically.

The net return was invariably higher with combined application of organic manures and inorganic nitrogen. The interaction M_3N_3 produced highest net return followed by M_2N_3, M_3N_2, M_2N_2 and M_1N_3.

The cost of cultivation in case of pig manure was lesser than vermicompost as well as FYM. Whereas, cost benefit ratio was highest with pig manure @ 10 t/ha along with nitrogen 100 kg/ha.

The intercrop influenced the performance of main crop was as evident by increase in size of palm with simultaneously increase in yield per palm as well as projected yield of nuts/ha from coconut-cum- patchouli cultivation.

CONCLUSION

Based on the experimental findings, it is concluded that combined application of vermicompost @ 5 t/ha along with 100 kg N/ha may be considered as better source of manuring in terms of optimum plant growth, biomass yield and oil quality of patchouli followed by pig manure@ 10 t/ha with 100 kg N/ha.

Supply level of available nutrients (NPK) and organic carbon in the soil after harvest has been favourably affected by combined application of organic manures and highest level of nitrogen.

This studies revealed that the integrated use of manures and inorganic fertilizer provided additional employment opportunity and the income with coconut based patchouli intercropping.

These data base also suggest that raising patchouli as an intercrop also sustain the additional nutrient requirement of intercrop in biomass production besides any potential depletion in soil fertility. The studies also offer a possibility of exploiting the residual effect of mineralized nutrients into the soil solution so that the fertilizer inputs can be further reduced, the research on which such similar crops are currently in progress.

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Plates

Plate 1 : Experimental site at initial stage of plantation.

Plate 2 : General view of experimental site at harvesting stage.

Plate 3 : Comparative view of control (M_0N_0) and pig manure with nitrogen@ 80 kg/ha (M_2N_2)experimental plots.

Plate 4 : Treatment combination of farm yard manure and nitrogen@ 60 kg/ha (M_1N_1) plot.

Plate 5 : Effect of farm yard manure and nitrogen @ 80 kg/ha (M_1N_2) plot.

Plate 6 : Effect of vermicompost and nitrogen @ 100 kg/ha (M_3N_3) plot.

Plate 7 : Recording of plant canopy.

Plate 8 : Recording of observations of harvested samples.

Plate 9 : Samples under the process of shed drying.

Plate 10 : Dry samples of patchouli ready for oil extraction

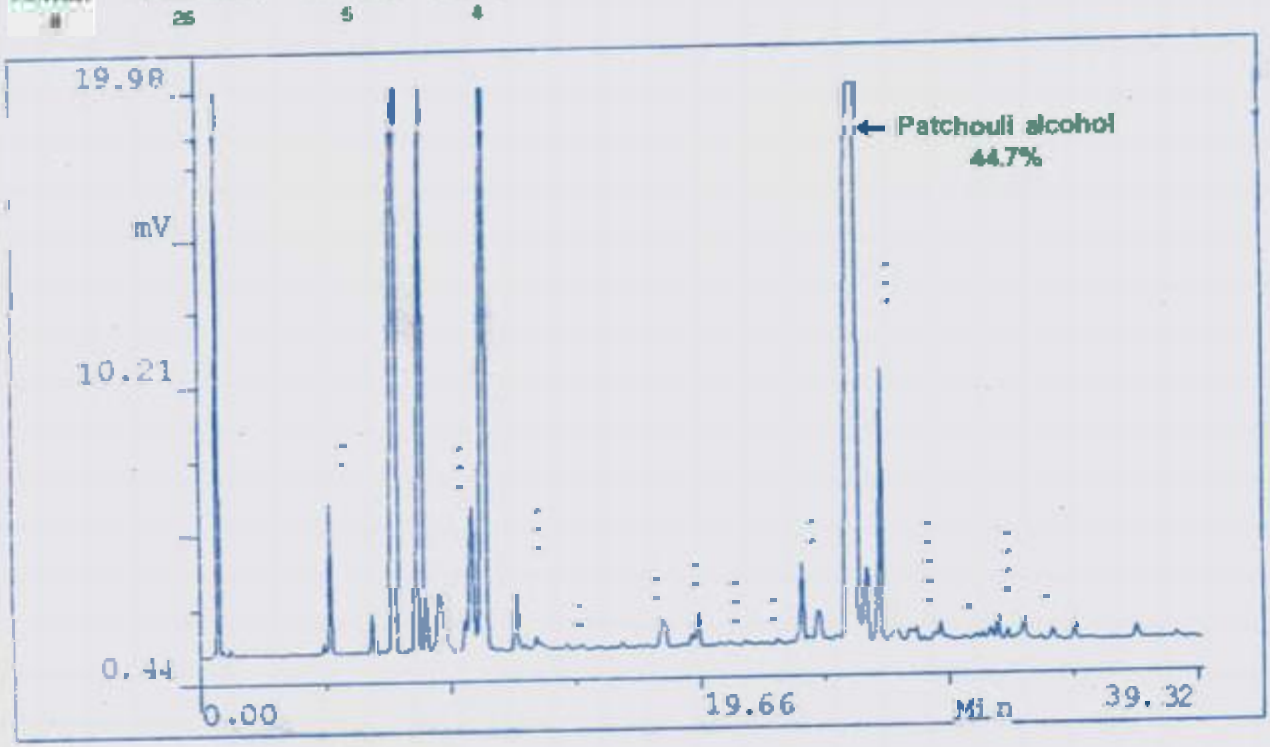
Appendices

APPENDIX - 1 (a)

Sample Name: patch oil (s-2)
Method File: PATHAKMET
Detector: FID
Date: 11 Nov 2005
Run: ch2 1
Type of Analysis : Percent On Area
Report printed on : 11/11/2005 at 10:59:28

Date File: ch2dat00.dat
System: GC
Time: 10:56:52

Pk Width	Peak Thrsh	Area Rej	Ht Rej
8	25	5	4



Typical chromatogram of Patchouli oil

APPENDIX - 1 (b)

Sample Name : Patch Oil (S-2)
Data : 11 Nov 2005

Data File : ch20s002dat
Time : 10 : 55 : 52

Retn. Time	Area	Area %	Pk Ty	Component Name
4.62	4081	0.01 45	BP	
4.83	27874	0.0098	PV	
5.09	414788	1.4623	VB	
6.71	13849	0.4883	BV	
7.66	3715952	13.2932	VV	
8.72	2858456	10.0351	VV	
9.04	1933358	6.8809	TTP	
9.51	1227812	4.3706	TPV	
9.88	170887	0.6310	TVP	
10.38	41481	0.1480	TPT	
10.64	601132	2.1399	VV	
11.19	3898529	13.8857	VV	
11.19	3825	0.0137	S	
12.31	241371	0.8594	BV	
12.70	18482	0.0658	S	
13.15	94585	0.3365	VV	
13.38	25805	0.0922	S	
14.33	16020	0.0572	BV	
14.72	3942	0.0141	VV	
14.95	14391	0.0514	VB	
16.53	17695	0.0631	BB	
17.17	2829	0.0101	BB	
18.30	97194	0.3229	BV	
18.16	68120	0.2327	VB	
19.91	4205	0.0150	BV	
19.25	40869	0.1453	VV	
19.19	127993	0.4574	VP	
20.76	23105	0.0826	S	
21.20	14135	0.0505	PB	
21.91	3415	0.0122	S	
22.18	4528	0.0161	PP	
22.81	21236	0.0759	PB	
23.57	291409	1.0414	BV	
23.85	8614	0.0315	TTT	
24.85	108878	0.3134	VB	
24.24	12864	0.0460	BP	
25.67	12488103	44.6322	PV	← Patchouli Alcohol
26.12	304146	1.0869	TTT	
19.70	9603[illegible]	34.330	VP	
27.10	11483	0.0411	S	
27.31	40805	0.1458	VV	
27.76	29044	0.1038	VV	
27.90	34424	1.123	VV	
28.07	36227	0.1295	VP	
28.40	4508	0.0163	PP	
18.91	27999	0.1001	PV	
29.01	76620	0.2738	VB	
30.01	10336	0.0369	BV	
30.80	14671	0.0524	VV	
24.82	21536	0.0772	VV	
30.85	50794	0.1815	VV	
31.22	86524	0.3095	VP	
31.20	36400	0.1301	PV	
32.01	19867	0.0575	S	
32.27	93586	0.3345	BB	
35.39	46739	0.167	BB	
34.27	51172	0.1829	BB	
36.71	53123	0.1898	BB	
	27983853			

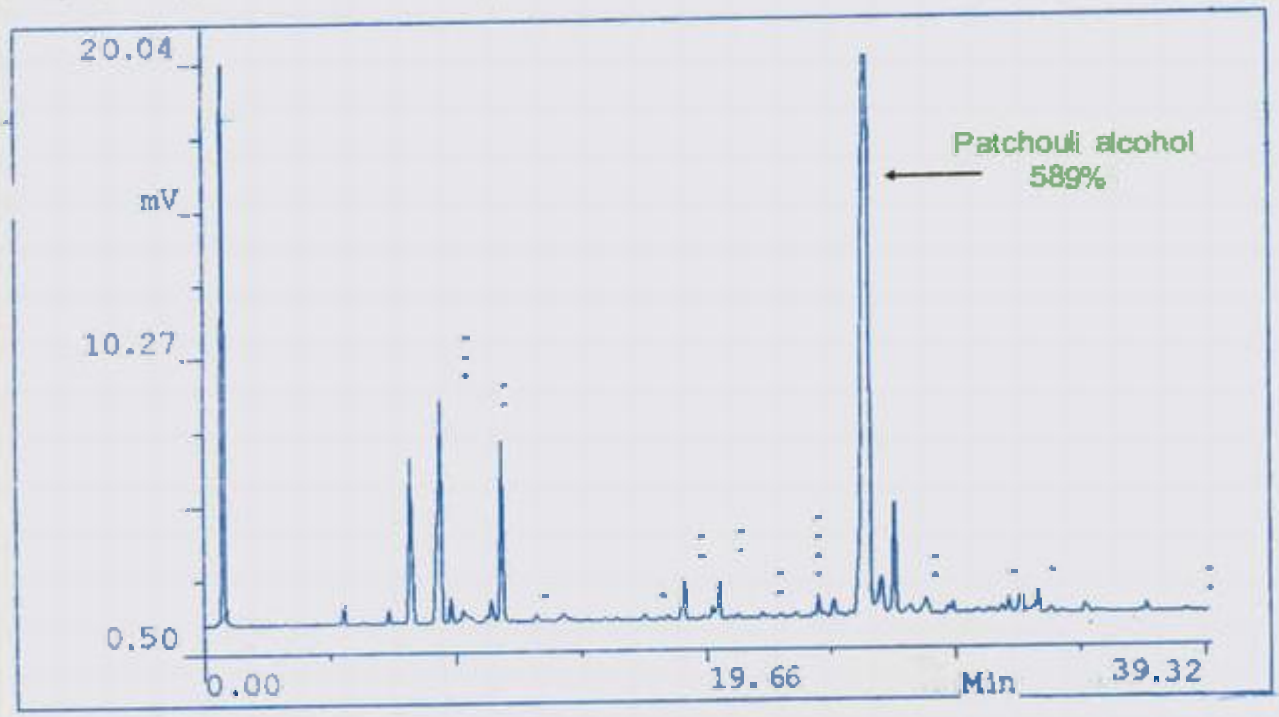
SUMMARY

TOTAL PEAKS	40
MUL. FACTOR	1.0000
SAMPLE AMT	1000000
DILUTION	1.0000

APPENDIX- 2 (a)

Sample Name: patch oil (S-7) Data File: ch2de00.dat
Method File: PATHAKME1
Detector: FID System: GC
Date: 11 Nov 2005 Time: 1612:50
Run: ch2 8
Type of Analysis : Percent On Area
Report printed on : 11/11/2005 at : 18:17:32

Pk Width	Peak Thrsh	Area Rej	Ht Rej
8	25	5	4



Typical chromatogram of Patchouli oil

APPENDIX - 2 (b)

SampleName : patch oil (S-7) DataFile : ch2del00.dat
Date: 11 Nov 2005 Time : 16:12:50

Ret. Time	Area	Area %	Pk Ty	Component Name
5.42	84586	0.8048	BB	
7.17	40389	0.3786	BB	
8.01	662674	6.1956	BB	
9.19	922188	8.6451	BP	
9.80	81814	0.7621	PV	
9.89	7528	0.0708	S	
10.08	78844	0.7390	BV	
10.97	16024	0.1502	S	
11.16	83728	0.7847	BV	
11.80	618887	5.7998	VB	
12.91	24076	0.2257	BB	
13.74	7289	0.0683	S	
17.14	17125	0.1605	BV	
18.11	10605	0.0994	BP	
18.63	165421	1.5507	PB	
19.49	9900	0.0928	BP	
19.77	39829	0.3733	PV	
20.00	161604	1.5150	VP	
20.49	5582	0.0523	S	
20.79	13544	0.1269	VB	
21.78	21508	0.2016	BV	
22.08	13891	0.1302	VV	
22.58	9382	0.0879	VP	
23.08	19001	0.1781	PP	
23.49	2952	0.0277	S	
23.73	9127	0.0855	S	
23.98	70443	0.6602	BV	
24.16	14652	0.1373	S	
24.53	73070	0.6849	BV	
24.86	15689	0.1470	VV	
25.18	15011	0.1407	VP	
25.95	6281681	58.8745	PV	← Patchouli Alcohol
26.44	148256	1.3895	TTT	
25.95	587827	5.5087	VB	
27.59	11471	0.1075	TTT	
28.20	79471	0.7448	TTT	
29.03	22395	0.2099	S	
49.23	38977	0.3653	BB	
31.43	43700	0.4096	BP	
31.84	82581	0.7740	PV	
32.48	7451	0.0984	VV	
33.14	767	0.0719	S	
34.41	42620	0.3995	BB	
36.80	7194	0.0674	BV	
36.81	27961	0.2620	VB	
38.37	11042	0.1035	BB	
39.19	3626	0.0340	BP	
	10668600			

SUMMARY

TOTAL PEAKS	48
MUL. FACTOR	1.0000
SAMPLE AMT	100.3000
DILUTION	1.0000