# AGROTECHNIQUES FOR SAFED MUSLI
## (*Chlorophytum borivilianum* SANTAPAU AND FERNANDES) IN KERALA

SUMA, V.K.

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**Department of Agronomy**
**COLLEGE OF AGRICULTURE**
**VELLAYANI, THIRUVANANTHAPURAM-695 522**

## DECLARATION

I hereby declare that this thesis entitled "**Agrotechniques for safed musli (*Chlorophytum borivilianum* Santapau and Fernandes) in Kerala**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
18-10 -2005.

**SUMA, V.K.**
(2003-11-03)

## CERTIFICATE

Certified that this thesis entitled "**Agrotechniques for safed musli (*Chlorophytum borivilianum* Santapau and Fernandes) in Kerala**" is a record of research work done independently by Mrs. Suma, V.K. (2003-11-03) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani,
18-10-2005.

**Smt. L. GIRIJA DEVI**
(Chairperson, Advisory Committee)
Assistant Professor,
Department of Agronomy,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

**Approved by**

*Chairperson :*

**Smt. L. GIRIJA DEVI**
Assistant Professor,
Department of Agronomy,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

*Members:*

**Dr. R. PUSHPAKUMARI**
Associate Professor and Head,
Department of Agronomy,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

**Dr. K.R. SHEELA**
Associate Professor,
Department of Agronomy,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

**Dr. B.R. REGHUNATH**
Associate Professor,
Department of Plantation Crops and Spices,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522.

*External Examiner :*

**Dr. K. SRINIVASAN**
Associate Professor (Agronomy),
Department of Vegetable Crops,
Tamil Nadu Agricultural University,
Coimbatore-641 003.

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# LIST OF ABBREVIATIONS AND SYMBOLS

| | | |
|---|---|---|
| % | – | per cent |
| °C | – | Degree Celsius |
| °E | – | Degree East |
| °N | – | Degree North |
| @ | – | At the rate of |
| BCR | – | Benefit-cost ratio |
| CD | – | Critical difference |
| cm | – | Centimetre |
| $cm^2$ | – | Square centimetre |
| DAP | – | Days after planting |
| *et al.* | – | And others |
| Fig. | – | Figure |
| FYM | – | Farmyard manure |
| g | – | Gram |
| g $day^{-1}$ $plant^{-1}$ | – | Gram per day per plant |
| ha | – | Hectare |
| K | – | Potassium |
| $K_2O$ | – | Potash |
| kg | – | Kilogram |
| kg $ha^{-1}$ | – | Kilogram per hectare |
| l | – | Litre |
| LAD | – | Leaf area duration |
| LAI | – | Leaf area index |
| MAP | – | Months after planting |
| Mg $m^{-3}$ | – | Mega gram per metre cube |
| ml | – | Millilitre |
| MOP | – | Muriate of potash |
| N | – | Nitrogen |
| NS | – | Non significant |
| P | – | Phosphorus |
| $P_2O_5$ | – | Phosphate |
| POP | – | Package of Practices Recommendations |
| Rs | – | Rupees |
| SSP | – | Single super phosphate |
| t $ha^{-1}$ | – | Tonnes per hectare |
| TBR | – | Tuber bulking rate |
| *viz.* | – | Namely |

# Introduction

# 1. INTRODUCTION

Safed musli (*Chlorophytum borivilianum* Santapau and Fernandes), a herbaceous plant of Liliaceae family is a popular crop of Central India. It grows naturally in most parts of Central India and cultivation is getting momentum in Gujarat, Rajasthan, Andhra Pradesh, Madhya Pradesh, Maharashtra and Tamil Nadu. The roots are widely used as a natural sex tonic, often referred to as 'herbal viagra'. It is considered to be the costliest herbal medicine fetching Rs. 1000 $kg^{-1}$ of dried roots and farmers in Kerala have already taken up its cultivation. The medicinal properties of safed musli were known to Indians from very ancient times. It forms a major constituent of more than 100 Ayurvedic preparations (Oudhia, 2000). *Chlorophytum borivilianum* is regarded as a wonder drug in Indian systems of medicine. It is renowned as 'Divya Aushad' due to its aphrodisiac and sex tonic properties. The current demand of safed musli in India is estimated to be 3500 tonnes as against the supply of 500 tonnes per annum (Kothari and Singh, 2001). This resulted in continued exploitation of safed musli leading to reduction in its population in Indian forests. Hence, National Medicinal Plants Board has included safed musli also, among the 32 species to be promoted for commercial cultivation. Earlier studies on suitability of this crop under shaded conditions of Kerala state have indicated that the interspaces of coconut could be effectively utilized for musli cultivation (Bordia *et al.*, 1995). Climatic conditions in Kerala state are found to be favourable for the commercial cultivation of this crop. During the past four or five years safed musli cultivation has gained momentum in Kerala.

Organic agriculture is now growing as a movement with far reaching implications in rural society. Awareness about health and environment is now spreading rapidly. Organic farming uses nature as the best role model for agriculture and considers soil as a living system.

Organic farming is environment friendly, ecologically balanced and socially just. Organic farming serves as a better alternative to achieve the dual objectives of environmental safety and sustainability in production. Organic manures form an integral component in organic agriculture and Kerala has a vast potential of manurial resources. Bulky organic sources like farmyard manure (FYM), crop residues etc and concentrated organic manures like neem cake, groundnut cake etc also play an integral role in sustainable agriculture.

Scientific footing on introduction of safed musli and standardization of its agrotechniques are lacking, though isolated attempts are being made by some farmers. It is a pre-requisite to study the adaptability and performance of a crop before it is introduced to a new agro-ecological situation. As a pioneering study in this line the present project titled "Agrotechniques for safed musli (*Chlorophytum borivilianum* Santapau and Fernandes) in Kerala" is taken up with the following objectives:

1. To study the adaptability and performance of safed musli under Kerala condition.
2. To standardise the optimum size/weight of planting material.
3. To study the efficacy of different organic manures used.
4. Economic evaluation of the system.

# Review of Literature

Groundnut cake is a concentrated organic manure and an edible oil cake. It is comparatively richer in nitrogen content and application of groundnut cake will increase the P and K content of soil (Sadanandan *et al.*, 1998).

## 2.2 EFFECT OF ORGANIC MANURES ON PLANT GROWTH CHARACTERS

Vadiraj *et al.* (1996) observed 30 per cent increase in plant height and 70 per cent increase in leaf area in turmeric by the application of vermicompost. In a study conducted at KAU (1999) in ginger, the highest dry matter accumulation was noticed from the treatments which received FYM alone at the rate of 48 t $ha^{-1}$. The dry matter accumulation in rhizomes at harvest were found increased in galangal intercropped in coconut garden when FYM was applied in combination with vermicompost (Maheswarappa *et al.*, 2000). Vidhyadharan (2000) reported increased plant height, number of leaves $plant^{-1}$, sucker number $hill^{-1}$ and dry matter production by the highest level of FYM application (20 t $ha^{-1}$) in arrowroot. Subbarao and Ravisankar (2001) found out that in ginger the influence of organic manures on leaf number and DMP was superior over inorganic fertilizers. In turmeric, application of FYM showed its superiority in growth character during the initial stage of growth, while during the later stages of growth, coirpith compost was found superior (Rakhee, 2002). Investigations carried out at Ludhiana on different levels of FYM in turmeric revealed that the plant height and content of N, P and K in leaf and rhizome were improved with FYM application (Gill *et al.*, 2004).

## 2.3 EFFECT OF ORGANIC MANURES ON PHYSIOLOGICAL CHARACTERS

Jain and Hasan (1986) found that the oil cakes in general increased the chlorophyll content of leaves and maximum chlorophyll content was recorded by neem cake. Subbarao and Ravisankar (2001) found out that in ginger the influence of organic manures on LAI was superior over inorganic fertilizers. The effect of different organic manures on growth, yield and quality of turmeric revealed that application of FYM and vermicompost resulted in higher CGR and RGR. Leaf area index (LAI) , leaf area duration (LAD) and root shoot ratio were the highest for FYM and coirpith compost treatment (Rakhee, 2002). The application of FYM + Azospirillum + phosphobacteria + VAM recorded larger leaf area , LAI, photosynthetic rate, specific leaf weight and harvest index in turmeric (Velmurugan *et al*., 2002).

## 2.4 EFFECT OF ORGANIC MANURES ON YIELD AND YIELD COMPONENTS

Enhanced efficiency of FYM in increasing yield was revealed by Gomes *et al.* (1983). Application of neem cake @ 1 t $ha^{-1}$ before planting gave maximum yield in ginger (KAU, 1990). The usefulness of FYM in increasing crop yield is well documented (Muthuswamy *et al*., 1990). Vadiraj *et al.* (1996) observed that vermicompost application alone or in combination with inorganic fertilizers increased yield in turmeric. While studying the effect of different organic manures in arrow root intercropped in coconut garden, Maheswarappa *et al.* (1997) found that application of FYM resulted in significantly higher harvest index, number and length of rhizome. He also reported that in arrowroot intercropped in coconut garden, vermicompost recorded the highest rhizome yield compared to composted coirpith. The performance of kacholam under varying levels of N, $P_2O_5$ and $K_2O$ with and without organic manure was tried for two crop years. The results showed that during 1994-1995 application of FYM @ 20 t $ha^{-1}$ increased the yield of rhizomes by 2.03 times as compared to that of absolute control. Application of N, $P2O_5$ and $K_2O$ @ 40 : 20 : 20 kg $ha^{-1}$ over a basal incorporation of FYM @ 20 t $ha^{-1}$ during 1994-95 resulted in getting the highest yield of 2597 kg $ha^{-1}$ whereas during 1995-96 highest yield was with application of NPK @ 80: 40 : 40 kg $ha^{-1}$ along with FYM @ 20 t $ha^{-1}$ (Bai and Augustin, 1998). According to Sadanandan and Hamza (1998) application of organic cakes increased the yield in ginger. Sadanandan *et al.* (1998) reported that the highest turmeric yield was obtained from NPK fertilized plots (4884 kg $ha^{-1}$) followed by neem cake, groundnut cake and cotton cake treatments (4818, 4809 and 4623 kg $ha^{-1}$ respectively). Vidhyadharan (2000) observed that application of FYM @ 20 t $ha^{-1}$ resulted in maximum number of rhizomes plant$^{-1}$ and rhizome yield in arrowroot. Rakhee (2002) reported that rhizome spread of turmeric was influenced by organic manures at 8 MAP and was maximum for coir pith compost treatment which was on par with FYM. Field experiments were conducted at ICAR Research Complex Farm, Meghalaya during kharif 1999 and 2000 to study the response of ginger to phosphorus sources (rock phosphate and single super phosphate), FYM and mother rhizome removal. Maximum rhizome yield of 19.5 t ha$^{-1}$ was noticed with the application of rock phosphate + FYM without mother rhizome removal which was on par with SSP + FYM. Addition of FYM significantly increased rhizome yield irrespective of mother rhizome removal (Venkatesh *et al.*, 2003).

## 2.5 EFFECT OF ORGANIC MANURES ON QUALITY ASPECTS

Vermicompost applied alone or in combination with organic and inorganic fertilizers resulted in better yield and quality of different crops (Gavrilov, 1962). According to Sadanandan and Hamza (1996) neem cake application was found to be superior with respect to curcumin recovery in turmeric. While studying the effect of different organic manures in arrowroot intercropped in coconut garden, Maheswarappa *et al.* (1997) found that application of FYM resulted in significantly higher starch and crude protein content. Performance of kacholam under varying levels of organic and inorganic fertilizers was studied by Bai and Augustin (1998). The results of the study revealed that there was an increase in oil yield from 18.9 to 28.4 l ha$^{-1}$ by the use of organic manures. According to Sadanandan and Hamza (1998) application of organic cakes increased oleoresin production in ginger. According to Vidhyadharan (2000) highest protein content in arrowroot was recorded with highest level of FYM (20 t ha$^{-1}$) and N (120 kg ha$^{-1}$). In turmeric, application of organic manure favoured increased curcumin and oleoresin contents (Nampoothiri, 2001).

## 2.6 EFFECT OF ORGANIC MANURES ON SOIL NUTRIENT STATUS

Muthuvel *et al.* (1977) and Srivastava (1985) reported an increase in the available nitrogen content of the soil and increased nitrogen recovery due to organic sources of nitrogen. The earthworm casts or vermicompost is high in bacteria, organic matter, total and nitrate nitrogen, available P and K (Gaur, 1982 and Brady, 1994). Kanwar and Prihar (1982) reported that continuous application of FYM increased the organic carbon as well as nitrogen content of soil. Srivastava (1985) observed that the application of organic manure resulted in increased organic carbon content, total N and available P and K status of soil. The application of neem cake added organic carbon and potash to the soil (Sadanandan and Iyer, 1986). Increased content of mineralized nitrogen was observed in the presence of large earthworm biomass (Scheu, 1987). Carbon content of soil increased from 0.91 to 1.52 per cent by the continuous application of organic manures (Udayasooriam *et al.*, 1988). Badanur *et al.* (1990) reported that available P content of soil was significantly increased with the incorporation of subabul, sunhemp loppings and FYM. Haimi and Hahuta (1990) reported that earthworms increased the proportion of mineral N availability for plants at any given time although N was clearly immobilized in the initial stages. Kabeerathumma *et al.* (1990) in a long term manurial experiment observed an increase in nutrients like N, P, K and organic carbon with the inclusion of FYM and application of respective nutrients to the soil. Neem, mahua, karanj and castor oil cakes have great value as means of immobilizers, thus conserving the applied and soil nitrogen and mineralizing steadily over a longer period. They could aid in metered supply of nitrogen over a stipulated period of crop growth (Hulagur, 1993). More (1994) reported that addition of farm wastes and organic manures increased the status of available N and available P of the soil. Compared to FYM, Reddy and Mahesh (1995) could obtain increased availability of N and K in soil by the application of vermicompost. Vasanthi and Kumaraswamy (1996) observed an increase in soil nutrient status due to application of vermicompost.

## 2.7 EFFECT OF ORGANIC MANURES ON NUTRIENT UPTAKE

Venkatesh *et al.* (2003) reported that in ginger, N, P and K uptake by rhizomes increased due to the application of P sources (single super phosphate and rock phosphate) and FYM.

## 2.8 ECONOMICS OF ORGANIC MANURING OF CROPS

Economic analysis of different treatments revealed that 80 kg N $ha^{-1}$ through nimbin coated urea produced higher BC ratio than 100 kg N $ha^{-1}$ through prilled urea (Porwal *et al.*, 1993). In Australia, the results of three farming systems, organic, integrated and conventional were compared in terms of economic results, fertilizer input and leaching and pest control and found out that total returns on organic farming were higher than from other systems due to high premium on standard product prices (Bhardwaj, 1999). A study on the benefit cost ratio analysis of ginger indicated that application FYM @ 48 t $ha^{-1}$ recorded highest return of Rs. 120245/- and benefit-cost ratio of 2.32 : 1 (KAU, 1999). This treatment gave an additional profit of 32.04 per cent over control (POP recommendation of KAU). Ingle *et al.* (2001) reported that maximum yield and monetory returns $rupee^{-1}$ investment was obtained from 600 g N, 300 g $P_2O_5$, 300 g $K_2O$ + 15 kg neem cake $plant^{-1}$ $year^{-1}$ in acid lime. In a study on turmeric it was revealed that the BC ratio was maximum with coirpith compost and was on par with FYM, vermicompost and poultry manure (Rakhee, 2002).

## 2.9 EFFECT OF TUBER SIZE ON CROP GROWTH AND PRODUCTION

It is well documented that sett size affects growth and production in crops. The general trend of yield increase with increase in sett sizes has been repeatedly confirmed in various experiments in tuber crops.

### 2.9.1 Sprouting and Growth

Husain and Said (1967) reported that in turmeric larger size rhizomes resulted in significantly higher sprouting than smaller size rhizome. The use of largest rhizome (40 g) for planting gave the greatest plant height and number of leaves $clump^{-1}$ in ginger (Sengupta *et al.*, 1986). Korla *et al* (1989) observed that there was significant difference in responses between 10 to 15 g and 15 to 20 g rhizome bits of ginger for number of tillers, leaf breadth and length and breadth of rhizome.

### 2.9.2 Yield

Husain and Said (1967) reported that in turmeric larger size rhizomes resulted in significantly higher fresh yield than smaller size rhizome. In ginger, larger rhizomes gave higher yield than smaller ones (Randhawa *et al.*, 1972). Nair (1977) reported that in ginger, sprouts detached from mother rhizomes resulted in good yield. Experiment conducted at KAU (1981) revealed that whole rhizomes were the best planting material in turmeric for realising maximum green yield. Timpo (1982) observed that in ginger yield increased with increased size of planting material. Weight of planting material significantly influenced the yield of green and cured turmeric rhizomes (KAU, 1984a). Experiments with costus, showed that the yield of rhizome was proportionally higher when heavier planting material was tried (KAU, 1984b). The use of largest rhizome (40 g) for planting gave the greatest rhizome yield in ginger (Sengupta *et al.*, 1986). Ahmed *et al.* (1988) revealed that in ginger, the highest yield of 13.42 t $ha^{-1}$ was obtained with the largest rhizomes (21-30 g) planted at the closest spacing. In ginger, the fresh yield was highest with the highest planting and fertilizer rates (Mohanty *et al.*, 1988). Okwuowulu (1988) reported that in ginger smaller setts gave rapid seed ginger multiplication. Korla *et al* (1989) found that there was no significant difference in responses between 10 to 15 g and 15 to 20 g rhizome bits for yield $plant^{-1}$ and yield $pot^{-1}$ in *Zingiber officinale* cv Local Dharja. In *Acorus calamus*, the yield of fresh rhizome was always higher (Philip *et al.*, 1992) for a larger planting material (6 cm with top) compared to smaller planting material (3 cm with top). Bordia *et al.* (1995) estimated 250 to 300 kg of safed musli tubers for planting 1 ha of land. According to Paturde *et al.* (2000) planting material weighing 12.5 g $unit^{-1}$ produced the maximum tuber yield in safed musli. Singh *et al.* (2002) reported that in safed musli there was no difference in tuber yield among 5.0, 7.5 and 10.0 g weight of each unit of planting material.

### 2.9.3 Quality

Studies at KAU (1984b) with costus, showed that the yield of rhizome and diosgenin content were higher when heavier planting material were used.

# Materials and Methods

# 3. MATERIALS AND METHODS

To study the adaptability and performance of safed musli in Kerala condition and to standardize the size/weight of planting material and its nutrient requirement, a field experiment was laid out at the College of Agriculture, Vellayani during the period 2004–05. The materials used and methods adopted for the study are presented in this chapter.

## 3.1 EXPERIMENTAL SITE

The field experiment was conducted at the E block of the Instructional Farm, College of Agriculture, Vellayani. The area is located at 8° 30' N latitude and 76° 54' E longitude, at an altitude of 29 m above mean sea level.

### 3.1.1 Soil

The soil of the experimental site was red loam and belonged to Vellayani series under the order oxisol. The important physical and chemical properties of the soil are given in Table 3.1. The soil was acidic with a pH of 5.1. The fertility status of soil was classified as low in available nitrogen (N) and potassium (K) and medium in available phosphorous (P).

Table 3.1. Soil characteristics of the experimental site

**A. Physical properties**

| Characteristics | Content | Method |
|---|---|---|
| Mechanical composition | | |
| Clay | 27.2 % | International pipette method (Piper, 1966) |
| Silt | 21.6 % | |
| Fine sand | 19.3 % | |
| Coarse sand | 31.7 % | |

| | | |
|---|---|---|
| Textural class | Sandy clay loam | |
| pH | 5.1 | pH meter with glass electrode (Jackson, 1973) |
| Bulk density (Mg $m^{-3}$) | 1.6 | Core method (Gupta and Dakshinamoorthy, 1980) |
| Soil aggregation | 42.77 | Wet sieving (Gupta and Dakshinamoorthy, 1980) |
| Porosity (%) | 32 | (Gupta and Dakshinamoorthy, 1980) |
| **B. Chemical properties** | | |
| Organic carbon (%) | 0.52 | Walkley and Black's rapid titration method (Jackson, 1973) |
| Available nitrogen (kg $ha^{-1}$) | 204.86 | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available $P_2O_5$ (kg $ha^{-1}$) | 37.37 | Bray colorimetric method using ascorbic acid (Jackson, 1973) |
| Available $K_2O$ (kg $ha^{-1}$) | 95.05 | Neutral normal ammonium acetate method (Jackson, 1973) |

### 3.2 SEASON

The field experiment was conducted from May 2004 to April 2005. The crop was planted on 2nd June and harvested on 28th March.

### 3.3 WEATHER CONDITIONS

Vellayani experiences a typical tropical humid climate. Data on maximum and minimum temperatures, relative humidity, rainfall and evaporation during the entire crop season was collected and presented as monthly averages in Appendix I and Fig. 1.

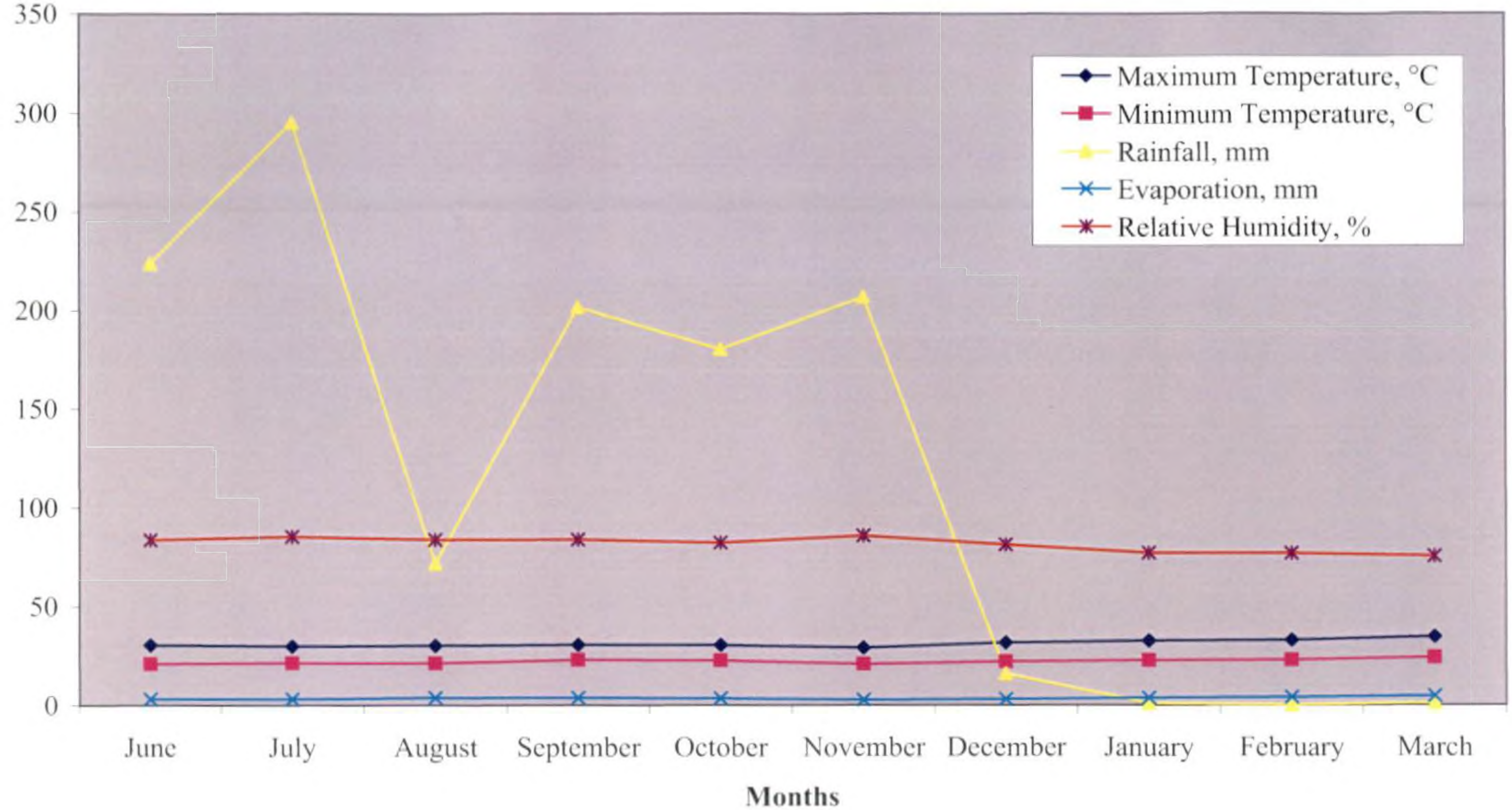


**Fig. 1. Weather data during the cropping period (June 2004 – March 2005)**

## 3.4 MATERIALS

### 3.4.1 Planting Material

Healthy rhizomatous tuberous roots of safed musli free from disease and pest were collected from one of the progressive farmers at Poovar in Thiruvananthapuram district. The sprouting portion of safed musli is known as disc or crown. Depending upon the size of the disc/crown, each disc was split into three to five units of planting material in such a way that each unit contains some portion of the disc and one to three fingers. Splitting of disc was done with the help of scalpels.

### 3.4.2 Manures

Four sources of organic manures were used in the experiment *viz.*, farmyard manure, vermicompost, neem cake and groundnut cake. The organic manures were applied as per treatment on nitrogen equivalent basis after analysing their nutrient content. The nutrient content of the different organic sources used is given in Table 3.2. For control treatment, urea (46 % N), mussoriephos (20 % $P_2O_5$) and muriate of potash (60 % $K_2O$) were used as sources of N, P and K respectively.

Table 3.2. Per cent content of nutrients in different organic sources

| Sources | Nutrient content (%) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| Farmyard manure | 0.9 | 0.4 | 1.2 |
| Vermicompost | 0.6 | 0.5 | 1.2 |
| Neem cake | 1.7 | 0.2 | 2.0 |
| Groundnut cake | 5.8 | 0.6 | 1.2 |

## 3.5 METHODS

### 3.5.1 Design and Layout

The experiment was laid out in factorial Randomised Block Design (RBD) with three replications. The layout plan is given in Figure 2.

N

**Replication – I**

1 m

| | | | | | |
|---|---|---|---|---|---|
| $M_2P_1$ | $M_2P_2$ | $M_5P_1$ | $M_1P_1$ | $M_4P_2$ | $M_4P_1$ |
| $M_1P_2$ | $M_6P_2$ | $M_3P_1$ | $M_3P_2$ | $M_5P_2$ | $M_6P_1$ |

1 m

**Replication – II**

| | | | | | |
|---|---|---|---|---|---|
| $M_2P_2$ | $M_2P_1$ | $M_1P_2$ | $M_4P_1$ | $M_5P_2$ | $M_6P_2$ |
| $M_6P_1$ | $M_5P_1$ | $M_3P_1$ | $M_1P_1$ | $M_3P_2$ | $M_4P_2$ |

**Replication – III**

| | | | | | |
|---|---|---|---|---|---|
| $M_1P_2$ | $M_2P_2$ | $M_4P_2$ | $M_6P_1$ | $M_1P_1$ | $M_2P_1$ |
| $M_5P_2$ | $M_4P_1$ | $M_6P_2$ | $M_5P_1$ | $M_3P_1$ | $M_3P_2$ |

**Fig. 2 Layout plan of the experiment**

**Plate 1. General view of the experimental field**

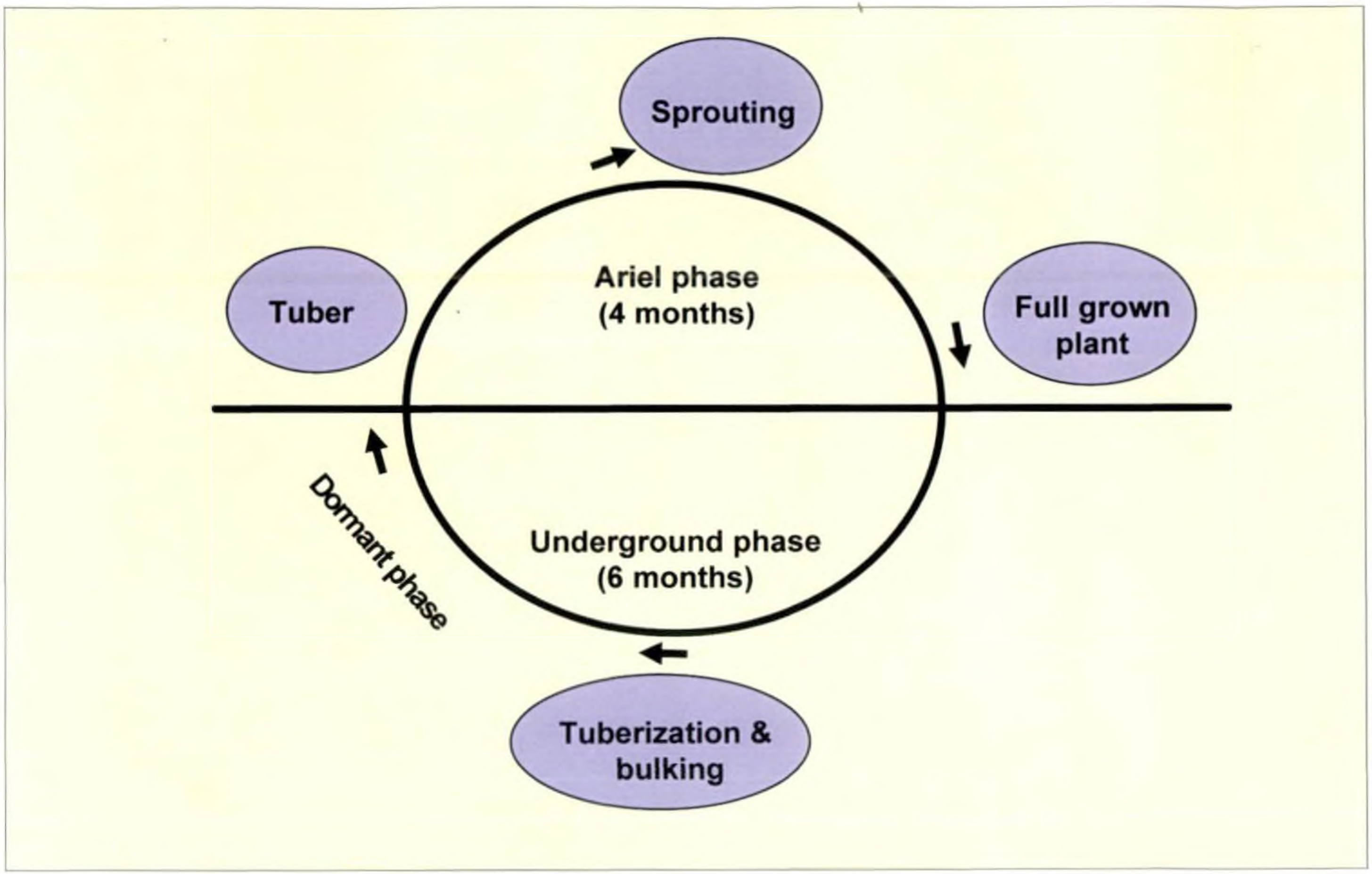


Fig. 3. Lifecycle of Safed musli

### 3.5.2 Treatments

| | | |
|---|---|---|
| Design | : | Factorial RBD |
| Treatments | : | 12 |
| Replications | : | 3 |
| Crop | : | Safed musli |
| Plot size | : | 1 x 1 m (One bed consists of one plot) |
| Number of plots | : | 36 |
| Spacing | : | 25 x 20 cm |

The treatments consisted of combinations of six organic sources and two planting weights of tubers.

**1. Organic sources**

$M_1$ – FYM @ 30 t $ha^{-1}$ (farmers' practice)

$M_2$ – Vermicompost alone

$M_3$ – 50 per cent FYM + 50 per cent vermicompost

$M_4$ – 50 per cent FYM + 50 per cent groundnut cake

$M_5$ – 50 per cent FYM + 50 per cent neem cake

$M_6$ – FYM @ 10 t $ha^{-1}$ as basal + NPK @ 100 : 80 : 80 kg $ha^{-1}$(Control)

**2. Planting weights of tuber**

$P_1$ – 10 g $unit^{-1}$

$P_2$ – 15 g $unit^{-1}$

The doses of different organic sources such as vermicompost, neem cake and groundnut cake were fixed according to nitrogen equivalent basis of 30 t $ha^{-1}$ of farmyard manure. Additional requirement of P and K was met from rock phosphate and wood ash.

**Treatment combination details (6 x 2)**

| Sl. No. | Treatment details | Notation |
|---|---|---|
| 1 | FYM @ 30 t $ha^{-1}$ + 10 g tuber $pit^{-1}$ | $M_1P_1$ |
| 2 | Vermicompost @45 t $ha^{-1}$ + 10 g tuber $pit^{-1}$ | $M_2P_1$ |
| 3 | FYM @15 t $ha^{-1}$ + vermicompost @ 22.5 t $ha^{-1}$ + 10 g tuber $pit^{-1}$ | $M_3P_1$ |
| 4 | FYM @ 15 t $ha^{-1}$ + groundnut cake @ 2.3 t $ha^{-1}$ + rock phosphate @ 0.23 t $ha^{-1}$ + wood ash @ 2.55 t $ha^{-1}$ + 10 g tuber $pit^{-1}$ | $M_4P_1$ |
| 5 | FYM @ 15 t $ha^{-1}$ + neem cake @ 8 t $ha^{-1}$ + rock phosphate @ 0.22 t $ha^{-1}$ + wood ash @ 0.35 t $ha^{-1}$ + 10 g tuber $pit^{-1}$ | $M_5P_1$ |
| 6 | FYM @ 10 t $ha^{-1}$ + urea @ 0.22 t $ha^{-1}$ + mussoriephos @ 0.4 t $ha^{-1}$ + MOP @ 0.8 t $ha^{-1}$ + 10g tuber $pit^{-1}$ | $M_6P_1$ |
| 7 | FYM @ 30 t $ha^{-1}$ + 15 g tuber $pit^{-1}$ | $M_1P_2$ |
| 8 | Vermicompost @ 45 t $ha^{-1}$ + 15 g tuber $pit^{-1}$ | $M_2P_2$ |
| 9 | FYM @ 15 t $ha^{-1}$ + vermicompost @ 22.5 t $ha^{-1}$ + 15 g tuber $pit^{-1}$ | $M_3P_2$ |
| 10 | FYM @ 15 t $ha^{-1}$ + groundnut cake @ 2.3 t $ha^{-1}$ + rock phosphate @ 0.23 t $ha^{-1}$ + wood ash @ 2.55 t $ha^{-1}$ + 15 g tuber $pit^{-1}$ | $M_4P_2$ |
| 11 | FYM @ 15 t $ha^{-1}$ + neem cake @ 8 t $ha^{-1}$ + rock phosphate @ 0.22 t $ha^{-1}$ + wood ash @ 0.35 t $ha^{-1}$ + 15 g tuber $pit^{-1}$ | $M_5P_2$ |
| 12 | FYM @ 10 t $ha^{-1}$ + urea @ 0.22 t $ha^{-1}$ + mussoriephos @ 0.4 t $ha^{-1}$ + MOP @ 0.8 t $ha^{-1}$ + 15 g tuber $pit^{-1}$ | $M_6P_2$ |

**Plate 2. Safed musli plant at flowering stage**

### 3.5.3 Seed Treatments

Tuber bits of safed musli were treated with biocontrol agent, *Pseudomonas fluorescens* to protect the seedlings from soil borne pathogen. Commercial inoculum of *Pseudomonas fluorescens* obtained from the Department of Plant Pathology, College of Agriculture, Vellayani was used for seed treatment. The cut tubers were treated with starch solution to make it wet. The tuber bits were rolled over the inoculum so as to adhere the inoculum on the surface of rhizome. It was then partially dried and planted.

Commercial inoculum of biocontrol agent, *Trichoderma harzianum* obtained from the Department of Plant Pathology, College of Agriculture, Vellayani was applied to the pits taken in the beds for planting of tuber bits, before planting.

### 3.5.4 Land Preparation and Planting

The field was worked to a fine tilth and raised beds of 1 x 1 m size and 50 cm height were taken. Between two beds a spacing of 20 cm was maintained for drainage. Small pits were taken at a spacing of 25 x 20 cm in the prepared raised beds. Tuber bits weighing 10 and 15 g according to treatment were planted in the pits to a depth of 4 to 5 cm with the buds facing upwards and then covered with soil.

### 3.5.5 Application of Manures and Fertilizers

Organic manures were applied in the beds one week before planting as per the treatment and were thoroughly mixed while preparing the beds. Lime was applied @ 1500 kg $ha^{-1}$ two weeks before planting.

In the control plot, fertilizers were applied as per the treatment. N in the form of urea and K in the form of muriate of potash (MOP) were applied in two split doses, *viz.*, 15 days after planting (DAP) and 30 DAP. Full dose of P was applied at the time of planting.

### 3.5.6 After Cultivation

The crop was grown as rainfed crop. Life irrigation was given as and when required. Hand weeding was done throughout the crop period depending upon the intensity of weed growth. Pinching of inflorescence was practiced as and when needed, to encourage tuber bulking. The total duration of the crop was ten months. The vegetative phase lasted for three months after which the leaves dried and entered into senescence phase. During the remaining seven months the crop remained in a dormant stage which was the tuber bulking phase.

### 3.5.7 Plant Protection

During the first month of crop growth, yellowing and scorching of leaves were noticed, which were due to *Fusariam* wilt. The disease was controlled by spraying of Carbendazim at 0.2 per cent. Spraying was carried out three times at an interval of 14 days. In the initial three months, attack of grasshopper and aphid was noticed, which was controlled by repeated spraying of neem kernel emulsion (neem kernel based EC containing azadiractin 0.15 per cent).

### 3.5.8 Harvesting

The crop was harvested ten months after planting when the tubers started germinating, which is the maturity index of the crop. Prior to harvesting, the field was thoroughly irrigated. Then each plant was dug out carefully without breakage of tubers. The harvested tubers were then washed with clean water and stored.

## 3.6 OBSERVATIONS

Random sampling method was adopted. For selecting observational plants, five plants from each treatment were selected at random and were tagged as observational plants. Pre-harvest observation started one month after planting and continued upto harvest. Observations on growth characters like plant spread, leaf area, number of suckers hill$^{-1}$ and number of leaves plant$^{-1}$ were recorded. from sample plants upto three months after planting. Data on dry matter production and accumulation in tuber and tuber development and tuberization were recorded at monthly intervals from fourth month of planting upto harvest.

### 3.6.1 Growth Characters

#### 3.6.1.1 Plant Spread

The distance occupied by the plant in east-west direction was measured and expressed in centimetre (cm).

#### *3.6.1.2 Number of Suckers Hill$^{-1}$*

The number of ariel shoots arising around the plants were counted.

#### *3.6.1.3 Number of Leaves Plant$^{-1}$*

The number of fully opened leaves were counted.

### 3.6.2 Physiological Parameters

#### *3.6.2.1 Days to Emergence*

Duration in days from planting to 50 and 75 per cent emergence of the plant was recorded.

#### *3.6.2.2 Days to Suckering*

Duration in days from planting to suckering was recorded.

#### *3.6.2.3 Days to Flowering*

Duration in days from planting to 50 and 75 per cent flowering of the crop was recorded.

#### *3.6.2.4 Days to Maturity*

The time taken for maturity of the crop was recorded.

#### *3.6.2.5 Leaf Area*

The length and breadth of all leaves from the sample plants were measured at monthly intervals and leaf area was found out and expressed in $cm^2$.

### *3.6.2.6 Leaf Area Index*

Leaf area index was computed using the following relationship (Watson, 1947).

$$\text{LAI} = \frac{\text{Leaf area of the plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}}$$

### *3.6.2.7 Leaf Area Duration*

Leaf area duration (LAD) was calculated using the formula given by Power *et al.* (1967).

$$\text{LAD} = \frac{L_1 + (L_1 + 1) \times (t_2 - t_1)}{2}$$

$L_1$ - LAI at 1 MAP

$L_1 + 1$ - LAI at 3 MAP

$t_2 - t_1$ - time interval in days

### *3.6.2.8 Dry Matter Production*

Sample plants were uprooted, washed, sun dried and oven dried to a constant weight at 70°C in a hot air oven at monthly interval upto harvest and dry matter production expressed in kg $ha^{-1}$.

### *3.6.2.9 Phenology and Development Pattern*

The development pattern of leaves and tubers were observed. The time taken for production of new leaves, number of leaves produced, length and breadth of leaves and total leaf area at monthly interval upto three month period were recorded.

### *3.6.2.10 Tuber Development and Tuberization*

The number, length and diameter of tubers at monthly intervals were recorded from fourth month of planting upto harvest.

*3.6.2.11 Tuber Bulking Rate*

Tuber bulking rate (TBR)is the rate of increase in tuber weight unit$^{-1}$ time, expressed as g day$^{-1}$ plant$^{-1}$ (dry weight).

$$TBR = \frac{w_2 - w_1}{t_2 - t_1}$$

$w_2$ - dry weight of tuber at $t_2$

$w_1$ - dry weight of tuber at $t_1$

$t_2 - t_1$ - time interval in days

**3.6.3 Yield and Yield Attributes**

*3.6.3.1 Fresh Tuber Yield*

After the harvest of the crop the fresh tuber yield was recorded and expressed in kg ha$^{-1}$.

*3.6.3.2 Number of Tubers*

The total number of tubers from sample plants were counted and the mean values calculated.

*3.6.3.3 Length of Tubers*

The length of tubers was measured from the tip of tuber to the crown portion using a fine thread and scale and mean length expressed in cm.

*3.6.3.4 Diameter of Tubers*

The diameter of tubers was measured at the middle portion of the tuber using a fine thread and scale and mean diameter expressed in cm.

*3.6.3.5 Colour of Tubers*

The colour of outer skin of tubers was recorded by visual observation.

### 3.6.4 Quality Parameters

#### *3.6.4.1 Fresh and Dry Weight of Tubers after Peeling*

The sample plants were uprooted, the tubers separated, washed and peeled by using a sharp knife. The fresh weight of peeled tubers was recorded. Then it was dried in partial shade for one week and after that in hot air oven at 70°C until constant weight and dry weight of peeled tubers was recorded.

#### *3.6.4.2 Moisture Content in Dry Tubers*

The moisture content in dry tubers was determined using the following formula and expressed in percentage.

$$\text{Moisture content in dry tubers} = \left[ \frac{\text{Initial dry weight} - \text{Final dry weight}}{\text{Initial dry weight}} \right] \times 100$$

#### *3.6.4.3 Phytochemical Analysis*

The active ingredient of the crop is saponin. For estimation of saponin, 1 g dried tuber powder was treated with 100 ml chloroform and kept overnight. Then chloroform was discarded and the residue was extracted with 100 ml acetone for 12 hours with intermittent stirring. After 12 hours the supernatent was collected and evaporated to dryness and the saponin content was estimated and expressed in percentage (Hudson and El-Difrawi, 1979).

### 3.6.5 Soil Analysis

Soil samples were taken before the commencement of experiment and after the harvest of the crop. The data on initial analysis showing the physical and chemical composition of the soil is presented in Table 1. The soil collected after the harvest of the crop was analysed for available N (Alkaline permanganate method), available P (Bray No. 1 ascorbic acid blue method) and available K (Neutral normal ammonium acetate method) .

### 3.6.6 Plant Analysis

The sample plants were dried to constant weight in an electric hot air oven at 80 ± 5°C, ground into fine powder using Willey mill and were used for analysis of N, P and K.

#### *3.6.6.1 Nitrogen*

Total nitrogen content of the tuber was estimated by modified microkjeldahl method (Jackson, 1973).

#### *3.6.6.2 Phosphorus*

The phosphorus content of the tuber was estimated by Vanado molybdo phosphate yellow colour method after extraction with triple acid (9 : 4 : 1 of $HNO_3$, $H_2SO_4$ and $HClO_4$ respectively). The intensity of yellow colour developed was read in a Klett Summerson photoelectric colorimeter at 470 nm (Jackson, 1973).

#### *3.6.6.3 Potassium*

The potassium content of the tuber was determined photometrically using flame photometer (Jackson, 1973).

### 3.6.7 Nutrient Uptake Studies

The uptake of N, P and K by the plant was calculated by multiplying the nutrient content of the plant with the respective dry weight of plant parts and expressed in kg $ha^{-1}$.

### 3.6.8 Economics of Cultivation

The economics of cultivation was worked out after taking into account the cost of cultivation of safed musli and existing price of musli tubers. For calculating the cost, different variable cost items like planting material, manures, fertilizers, plant protection chemicals, irrigation, labour charge, etc. were considered at existing rates during 2004-05. The net returns and benefit-cost ratio were calculated as follows.

Net returns (Rs $ha^{-1}$) = Gross income – Gross expenditure

$$\text{Benefit cost ratio} = \frac{\text{Gross income}}{\text{Gross expenditure}}$$

### 3.6.9 Statistical Analysis

Data relating to each character were analysed by applying the analysis of variance technique as applied to randomised block design described by Cochran and Cox (1965) and the significance was tested by F test (Snedecor and Cochran, 1967). While analysing the data statistically CD were provided only when the F values were significant.

# Results

# 4. RESULTS

A field experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during the year 2004-2005 to study the performance of safed musli when different sources of organic manures such as FYM, vermicompost, neem cake and groundnut cake were used separately and in combination. Standardisation of agrotechniques like planting weights of tuber and doses of different organic sources were also undertaken. The results of the study are presented herein.

## 4.1 GROWTH CHARACTERS

### 4.1.1 Plant Spread (Tables 4.1 and 4.2)

Plant spread was found significantly influenced by organic manures at all the three stages of growth, *viz.*, 1, 2 and 3 MAP. At all the stages 50 per cent FYM + 50 per cent groundnut cake application ($M_4$) recorded the maximum plant spread (56.79, 67.70 and 69.57 cm respectively) and was significantly superior to other organic sources. This was followed by $M_6$ (10 t ha $^{-1}$ FYM + 100:80:80 kg NPK ha$^{-1}$) and was on par with other treatments such as $M_1$ (FYM), $M_2$ (vermicompost), $M_3$ (50 per cent FYM + 50 per cent vermicompost) and $M_5$ (50 per cent FYM + 50 per cent neem cake).

Planting weight of tuber also significantly influenced the plant spread at 1, 2 and 3 MAP. At all these stages planting weight of tuber @ 15 g unit$^{-1}$ ($P_2$) recorded the maximum plant spread (53.09, 61.13 and 62.61 cm respectively).

None of the interaction effects were significant at any of the growth stages.

### 4.1.2 Number of Suckers Hill$^{-1}$ (Table 4.1)

Organic manures did not influence sucker production.

Table 4.1 Main effect of organic manure and planting weight of tuber on plant spread and sucker number hill $^{-1}$

| Treatments | Plant spread (cm) Months after planting | | | Sucker number hill $^{-1}$ at 3 MAP |
|---|---|---|---|---|
| | 1 MAP | 2 MAP | 3 MAP | |
| Organic manures | | | | |
| $M_1$ | 50.88 | 56.04 | 57.10 | 2.25 |
| $M_2$ | 50.97 | 55.41 | 56.89 | 2.20 |
| $M_3$ | 50.59 | 56.44 | 58.16 | 2.28 |
| $M_4$ | 56.79 | 67.70 | 69.57 | 1.90 |
| $M_5$ | 52.03 | 59.32 | 60.69 | 2.65 |
| $M_6$ | 51.91 | 61.35 | 62.90 | 2.27 |
| F (5,22) | 17.718** | 53.380** | 57.335** | 0.739 $^{NS}$ |
| SE | 0.553 | 0.638 | 0.640 | 0.276 |
| CD | 1.621 | 1.872 | 1.876 | |
| Planting weight of tuber | | | | |
| $P_1$ | 51.30 | 57.63 | 59.15 | 1.96 |
| $P_2$ | 53.09 | 61.13 | 62.61 | 2.55 |
| F (1,22) | 15.632** | 45.215** | 43.873** | 6.825* |
| SE | 0.319 | 0.368 | 0.369 | 0.159 |
| CD | 0.936 | 1.081 | 1.083 | 0.467 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.2 Interaction effect of organic manure and planting weight of tuber on plant spread

| Treatments | Plant spread (cm) Months after planting | | |
|---|---|---|---|
| | 1 MAP | 2 MAP | 3 MAP |
| $M_1P_1$ | 50.35 | 54.68 | 55.47 |
| $M_2P_1$ | 49.48 | 54.63 | 56.17 |
| $M_3P_1$ | 49.94 | 53.66 | 55.04 |
| $M_4P_1$ | 56.03 | 65.38 | 67.58 |
| $M_5P_1$ | 51.78 | 58.17 | 59.53 |
| $M_6P_1$ | 50.23 | 59.25 | 61.18 |
| $M_1P_2$ | 51.41 | 57.40 | 58.73 |
| $M_2P_2$ | 52.47 | 56.20 | 57.66 |
| $M_3P_2$ | 51.23 | 59.21 | 61.28 |
| $M_4P_2$ | 57.55 | 70.03 | 71.56 |
| $M_5P_2$ | 52.27 | 60.48 | 61.84 |
| $M_6P_2$ | 53.58 | 63.46 | 64.61 |
| F(5,22) | 1.049 $^{NS}$ | 1.446 $^{NS}$ | 1.587 $^{NS}$ |
| SE | 0.781 | 0.903 | 0.905 |
| CD | - | - | - |

* Significant at 5% level ** Significant at 1% level NS Non significant

Planting weight of tuber significantly influenced the sucker production and planting weight @ 15 g unit$^{-1}$ tuber ($P_2$) produced the maximum sucker (2.55) and was significantly superior to $P_1$ (10 g unit$^{-1}$) where the sucker production was only 1.96.

Interaction effects were not significant.

### 4.1.3 Number of Leaves Plant$^{-1}$ (Tables 4.3 and 4.4)

Organic manure application as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) produced the maximum number of leaves (13.42) at 1 MAP and was significantly superior to all other organic sources. At 2 and 3 MAP also organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) produced the maximum number (16.55 and 17.95 respectively) and was significantly superior to treatments $M_5$ (50 per cent FYM + 50 per cent neem cake), $M_3$ (50 per cent FYM + 50 per cent vermicompost), $M_1$ (30 t ha$^{-1}$ FYM) and $M_6$ (10 t ha$^{-1}$ FYM + NPK @ 100: 80:80 kg ha$^{-1}$). At 2 MAP, the lowest leaf production was in $M_2$ where organic manure as vermicompost alone was applied (11.99). At 3 MAP, $M_3$ (50 per cent FYM + 50 per cent vermicompost) produced the lowest number of leaves (13.22) and was on par with other organic manure treatments such as $M_5$ (50 per cent FYM + 50 per cent neem cake), $M_6$ (10 t ha$^{-1}$ FYM + NPK @ 100:80:80 kg ha$^{-1}$), $M_2$ (vermicompost) and $M_1$ (30 t ha$^{-1}$ FYM).

Planting weight of tuber also significantly influenced the leaf production throughout the vegetative stage. At all the stages, planting weight of tuber @ 15 g unit$^{-1}$ ($P_2$) produced the highest leaf number (12.34, 13.73 and 15.00 respectively) and was significantly superior to the planting weight of 10 g unit$^{-1}$ tuber ($P_1$).

Interaction effects were significant only at 3 MAP and organic manure application as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) along with 15 g unit$^{-1}$ weight of tuber ($P_2$) produced the highest leaf number (19.8) and was significantly superior to other combinations. The leaf production was lowest (12.83) in treatment combination $M_2P_1$ (vermicompost alone with 10 g unit$^{-1}$ weight of tuber).

Table 4.3 Main effect of organic manure and planting weight of tuber on number of leaves plant$^{-1}$

| Treatments | Number of leaves plant$^{-1}$ Months after planting | | |
|---|---|---|---|
| | 1 MAP | 2 MAP | 3 MAP |
| Organic manures | | | |
| $M_1$ | 11.10 | 12.42 | 13.53 |
| $M_2$ | 10.88 | 11.99 | 13.23 |
| $M_3$ | 10.83 | 12.50 | 13.22 |
| $M_4$ | 13.42 | 16.55 | 17.95 |
| $M_5$ | 11.99 | 13.08 | 13.88 |
| $M_6$ | 12.01 | 12.58 | 13.80 |
| F (5,22) | 7.312** | 23.052** | 19.935** |
| SE | 0.366 | 0.351 | 0.409 |
| CD | 1.074 | 1.029 | 1.198 |
| Planting weight of tuber | | | |
| $P_1$ | 11.07 | 12.65 | 13.54 |
| $P_2$ | 12.34 | 13.73 | 15.00 |
| F (1,22) | 18.136** | 14.325** | 19.184** |
| SE | 0.211 | 0.202 | 0.236 |
| CD | 0.62 | 0.594 | 0.692 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.4 Interaction effect of organic manures and planting weight of tuber on number of leaves plant$^{-1}$

| Treatments | Number of leaves plant$^{-1}$ Months after planting | | |
|---|---|---|---|
| | 1 MAP | 2 MAP | 3 MAP |
| $M_1P_1$ | 10.53 | 12.00 | 13.30 |
| $M_2P_1$ | 10.10 | 11.35 | 12.83 |
| $M_3P_1$ | 9.97 | 12.32 | 13.20 |
| $M_4P_1$ | 12.67 | 15.70 | 16.10 |
| $M_5P_1$ | 11.63 | 12.27 | 13.07 |
| $M_6P_1$ | 11.51 | 12.23 | 12.73 |
| $M_1P_2$ | 11.67 | 12.84 | 13.77 |
| $M_2P_2$ | 11.67 | 12.63 | 13.63 |
| $M_3P_2$ | 11.70 | 12.67 | 13.23 |
| $M_4P_2$ | 14.17 | 17.40 | 19.80 |
| $M_5P_2$ | 12.35 | 13.90 | 14.70 |
| $M_6P_2$ | 12.50 | 12.93 | 14.87 |
| F(5,22) | 0.283 $^{NS}$ | 0.598 $^{NS}$ | 2.683 $^{NS}$ |
| SE | 0.518 | 0.496 | 0.578 |
| CD | - | - | - |

* Significant at 5% level ** Significant at 1% level NS Non significant

## 4.2 PHYSIOLOGICAL PARAMETERS

### 4.2.1 Days to Emergence (Table 4.5)

Among the organic manures, application of 50 per cent FYM + 50 per cent groundnut cake ($M_4$) took less time for 50 and 75 per cent crop emergence (8.67 and 14.33 days respectively) and which was on par with vermicompost alone application ($M_2$). These two treatments were significantly superior to all other organic sources. Days to emergence was more in farmers' practice of 30 t ha $^{-1}$ FYM application ($M_1$) and was on par with both $M_5$ (50 per cent FYM + 50 per cent neem cake) and $M_6$ (10 t ha$^{-1}$ FYM + NPK @ 100:80:80 kg ha$^{-1}$).

Time taken for 75 per cent crop emergence was significantly influenced by planting weight of tuber and tuber weight @ 15 g unit$^{-1}$ ($P_2$) took less time for 75 per cent emergence (16.67 days) and was significantly superior to 10 g unit$^{-1}$ weight of tuber ($P_1$).

Interaction effects were not significant.

### 4.2.2 Days to Suckering (Table 4.5)

Organic manure application as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) took less time for 50 and 75 per cent suckering (14.50 and 30 days respectively) and was on par with $M_2$ (vermicompost alone) and $M_3$ (50 per cent FYM + 50 per cent vermicompost). These were significantly superior to other organic sources. The farmers' practice of FYM application @ 30 t ha$^{-1}$ ($M_1$) required more time for 50 per cent suckering (20.50 days), whereas, for 75 per cent suckering the treatment $M_5$ (50 per cent FYM + 50 per cent neem cake) took more time (43.67 days).

Planting weight of tuber significantly influenced period for 75 per cent sucker production. Planting weight @ 15 g unit$^{-1}$ tuber ($P_2$) took less time (35.39 days) and was significantly superior to the planting weight of tuber @ 10 g unit $^{-1}$ ($P_1$).

Interaction effects were not significant.

### 4.2.3 Days to Flowering (Table 4.6)

The period for 50 and 75 per cent flowering was significantly influenced by organic manures. Application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) took less time for 50 and 75 per cent flowering (25.83 and 50.50 days respectively). The time taken for 50 per cent flowering was maximum (34.67 days) in $M_3$ (50 per cent FYM + 50 per cent vermicompost) and was on par with $M_6$ (10 t $ha^{-1}$ FYM as basal + NPK @ 100:80:80 kg $ha^{-1}$), $M_2$ (vermicompost alone) and $M_1$ where FYM @ 30 t $ha^{-1}$ was applied. The treatment $M_6$ (10 t FYM + NPK @ 100:80:80 kg $ha^{-1}$) required more time for 75 per cent flowering (71.5 days) and was on par with the treatments $M_5$ (50 per cent FYM + 50 per cent neem cake) and $M_1$ (FYM application @ 30 t $ha^{-1}$).

Planting weight of tuber did not influence the time taken for 50 and 75 per cent flowering in the crop.

Interaction effects were not significant.

### 4.2.4 Days to Maturity (Table 4.6)

Organic manure and planting weight of tuber did not influence the maturity period.

Interaction effects were also not significant.

### 4.2.5 Leaf Area (Tables 4.7 and 4.8)

Influence of organic manure was significant throughout the vegetative growth stage, *viz.*, 1, 2 and 3 MAP. The leaf area was the highest (98.69, 101.88 and 103.2 $cm^2$ respectively) in the treatment where organic manure was applied as 50 per cent FYM + 50 per cent groundnut cake ($M_4$). This was significantly superior to all other organic sources. The leaf area was the lowest (56.57 $cm^2$) in $M_6$ (10 t $ha^{-1}$ FYM + NPK @ 100:80:80kg $ha^{-1}$) at 1 MAP and was on par with treatments $M_2$ (vermicompost) and $M_3$ (50 per cent FYM + 50 per cent vermicompost). The leaf area was the lowest in the same treatment $M_6$ at 2 and 3 MAP also (50.36 and 53.45 $cm^2$ respectively) but was significantly inferior to all other organic sources.

Table 4.5 Main effect of organic manure and planting weight of tuber on days to 50 and 75 per cent crop emergence and suckering

| Treatments | Crop emergence (days) | | Suckering (days) | |
|---|---|---|---|---|
| | 50% emergence | 75% emergence | 50% suckering | 75% suckering |
| Organic manures | | | | |
| $M_1$ | 12.17 | 18.17 | 20.50 | 37.67 |
| $M_2$ | 8.67 | 15.00 | 14.67 | 30.00 |
| $M_3$ | 10.67 | 17.50 | 15.50 | 30.67 |
| $M_4$ | 8.67 | 14.33 | 14.50 | 30.00 |
| $M_5$ | 11.00 | 19.17 | 19.83 | 43.67 |
| $M_6$ | 11.00 | 19.67 | 18.67 | 40.33 |
| F (5,22) | 13.693** | 12.669** | 4.573** | 28.302** |
| SE | 0.380 | 0.615 | 1.264 | 0.945 |
| CD | 1.116 | 1.804 | 3.708 | 2.771 |
| Planting weight of tuber | | | | |
| $P_1$ | 10.56 | 17.94 | 17.67 | 37.44 |
| $P_2$ | 10.17 | 16.67 | 16.89 | 35.39 |
| F (1,22) | 1.567 $^{NS}$ | 6.473* | 0.568 $^{NS}$ | 7.100* |
| SE | 0.220 | 0.355 | 0.730 | 0.545 |
| CD | - | 1.042 | - | 1.600 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.6 Main effect of organic manure and planting weight of tuber on days to 50 and 75 per cent flowering and maturity

| Treatments | Flowering (days) | | Maturity (days) |
|---|---|---|---|
| | 50% flowering | 75% flowering | |
| Organic manures | | | |
| $M_1$ | 32.33 | 71.17 | 111.83 |
| $M_2$ | 32.17 | 64.67 | 106.67 |
| $M_3$ | 34.67 | 69.33 | 112.67 |
| $M_4$ | 25.83 | 50.50 | 104.17 |
| $M_5$ | 31.17 | 71.00 | 114.83 |
| $M_6$ | 33.17 | 71.50 | 107.83 |
| F (5,22) | 20.101** | 120.434** | 2.351 $^{NS}$ |
| SE | 0.678 | 0.745 | 2.657 |
| CD | 1.987 | 2.185 | - |
| Planting weight of tuber | | | |
| $P_1$ | 31.72 | 66.39 | 110.94 |
| $P_2$ | 31.39 | 66.33 | 108.39 |
| F (1,22) | 0.363 $^{NS}$ | 9.382 $^{NS}$ | 1.388 $^{NS}$ |
| SE | 0.391 | 0.430 | 1.534 |
| CD | - | - | - |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.7 Main effect of organic manure and planting weight of tuber on leaf area

| Treatments | Leaf area ($cm^2$) | | |
|---|---|---|---|
| | Months after planting | | |
| | 1 MAP | 2 MAP | 3 MAP |
| Organic manures | | | |
| $M_1$ | 64.01 | 69.04 | 71.02 |
| $M_2$ | 60.15 | 67.04 | 68.98 |
| $M_3$ | 60.81 | 68.10 | 72.22 |
| $M_4$ | 98.69 | 101.88 | 103.20 |
| $M_5$ | 68.16 | 74.46 | 74.48 |
| $M_6$ | 56.57 | 50.36 | 53.45 |
| F (5,22) | 33.339** | 38.847** | 39.010** |
| SE | 2.685 | 2.698 | 2.594 |
| CD | 7.875 | 7.913 | 7.609 |
| Planting weight of tuber | | | |
| $P_1$ | 60.16 | 64.94 | 68.53 |
| $P_2$ | 75.97 | 78.82 | 79.25 |
| F (1,22) | 52.063** | 39.704** | 25.617** |
| SE | 1.550 | 1.558 | 1.498 |
| CD | 4.546 | 4.569 | 4.393 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.8 Interaction effect of organic manures and planting weight of tuber on leaf area

| Treatments | Leaf area ($cm^2$) | |
|---|---|---|
| | Months after planting | |
| | 2 MAP | 3 MAP |
| $M_1P_1$ | 67.15 | 68.86 |
| $M_2P_1$ | 66.88 | 69.42 |
| $M_3P_1$ | 60.91 | 68.10 |
| $M_4P_1$ | 91.84 | 92.87 |
| $M_5P_1$ | 65.32 | 69.50 |
| $M_6P_1$ | 37.53 | 42.42 |
| $M_1P_2$ | 71.71 | 73.17 |
| $M_2P_2$ | 67.19 | 68.53 |
| $M_3P_2$ | 75.28 | 76.33 |
| $M_4P_2$ | 111.92 | 113.54 |
| $M_5P_2$ | 83.60 | 79.46 |
| $M_6P_2$ | 63.19 | 64.47 |
| F(5,22) | 3.213* | 3.046* |
| SE | 3.815 | 3.669 |
| CD | 11.191 | 10.761 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Planting weight of tuber significantly influenced the leaf area throughout the vegetative stages. At all the stages, planting weight of tuber @ 15 g unit$^{-1}$ ($P_2$) recorded the highest leaf area of 75.97, 78.82 and 79.25 cm$^2$ respectively and was significantly superior to 10 g unit$^{-1}$ weight of tuber ($P_1$) at all the stages (60.16, 64.94 and 68.53 cm$^2$ respectively).

Interaction effects were significant only at 2 and 3 MAP. At these stages the leaf area was highest in $M_4P_2$ where organic manure as 50 per cent FYM + 50 per cent groundnut cake was given in combination with 15 g unit$^{-1}$ weight of tuber (111.92 and 113.54 cm$^2$ respectively). This was significantly superior to all other combinations. The leaf area was lowest in $M_6P_1$ where organic manure as 10 t ha$^{-1}$ FYM + NPK @ 100 : 80 : 80 kg ha$^{-1}$ was given in combination with 10 g unit$^{-1}$ weight of planting material (37.53 and 42.42 cm$^2$ respectively) .

#### 4.2.6 Leaf Area Index (Tables 4.9 and 4.10)

Influence of organic manures was significant throughout the vegetative growth stage, *viz.*, 1, 2 and 3 MAP. The leaf area index was highest at all the three growth stages in the treatment $M_4$ where organic manure was applied as 50 per cent FYM + 50 per cent groundnut cake (0.197, 0.204 and 0.207 respectively). This was significantly superior to other organic sources. The leaf area index was lowest in $M_6$ where 10 t ha$^{-1}$ FYM + NPK @ 100:80:80 kg ha$^{-1}$ was applied (0.101, 0.107 and 0.113 respectively).

Planting weight of tuber also significantly influenced the leaf area index throughout the vegetative growth stages. At all the stages, planting weight of tuber @ 15 g unit$^{-1}$ ($P_2$) recorded the highest leaf area index (0.151, 0.158 and 0.159 respectively) and was significantly superior to 10 g unit$^{-1}$ weight of tuber ($P_1$).

Interaction effects were significant only at 2 and 3 MAP. At these stages the leaf area index was highest when organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) was given in combination with 15 g unit$^{-1}$ weight of tuber ($P_2$) and was significantly superior to all other combinations (0.224 and 0.227 respectively).

Table 4.9 Main effect of organic manure and planting weight of tuber on leaf area index and leaf area duration

| Treatments | Leaf area index (LAI) Months after planting | | | LAD |
|---|---|---|---|---|
| | 1 MAP | 2 MAP | 3 MAP | |
| Organic manures | | | | |
| $M_1$ | 0.134 | 0.139 | 0.142 | 8.14 |
| $M_2$ | 0.120 | 0.134 | 0.138 | 7.81 |
| $M_3$ | 0.119 | 0.136 | 0.145 | 7.99 |
| $M_4$ | 0.197 | 0.204 | 0.207 | 12.12 |
| $M_5$ | 0.136 | 0.149 | 0.149 | 8.56 |
| $M_6$ | 0.101 | 0.107 | 0.113 | 6.61 |
| F (5,22) | 12.491** | 39.004** | 39.505** | 54.805** |
| SE | 0.009 | 0.005 | 0.005 | 0.253 |
| CD | 0.030 | 0.016 | 0.015 | 0.743 |
| Planting weight of tuber | | | | |
| $P_1$ | 0.126 | 0.130 | 0.137 | 7.73 |
| $P_2$ | 0.151 | 0.158 | 0.159 | 9.34 |
| F (1,22) | 12.450** | 39.877** | 25.907** | 60.668** |
| SE | 0.005 | 0.003 | 0.003 | 0.146 |
| CD | 0.015 | 0.009 | 0.009 | 0.429 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.10 Interaction effect of organic manures and planting weight of tuber on leaf area index

| Treatments | Leaf area index (LAI) Months after planting | |
|---|---|---|
| | 2 MAP | 3 MAP |
| $M_1P_1$ | 0.134 | 0.138 |
| $M_2P_1$ | 0.134 | 0.139 |
| $M_3P_1$ | 0.122 | 0.136 |
| $M_4P_1$ | 0.184 | 0.186 |
| $M_5P_1$ | 0.131 | 0.139 |
| $M_6P_1$ | 0.075 | 0.085 |
| $M_1P_2$ | 0.143 | 0.147 |
| $M_2P_2$ | 0.134 | 0.137 |
| $M_3P_2$ | 0.150 | 0.153 |
| $M_4P_2$ | 0.224 | 0.227 |
| $M_5P_2$ | 0.167 | 0.169 |
| $M_6P_2$ | 0.126 | 0.129 |
| F(5,22) | 3.190* | 3.065* |
| SE | 0.008 | 0.007 |
| CD | 0.022 | 0.021 |

* Significant at 5% level ** Significant at 1% level NS Non significant

### 4.2.7 Leaf Area Duration (Table 4.9)

The leaf area duration was highest in the treatment $M_4$ where 50 per cent FYM and 50 per cent groundnut cake was applied as organic source (12.12 days). This was significantly superior to all other organic sources. The leaf area duration was lowest in the treatment $M_6$ where 10 t $ha^{-1}$ FYM + NPK @ 100:80:80 kg $ha^{-1}$ was applied (6.61 days).

Planting weight of tuber also significantly influenced the leaf area duration. The leaf area duration was highest in the treatment $P_2$ where 15 g $unit^{-1}$ weight of tuber was used as planting material (9.34 days). This was significantly superior to $P_1$ (10 g $unit^{-1}$ weigh of tuber).

Interaction effects were not significant.

### 4.2.8 Dry Matter Production (Tables 4.11 and 4.12)

The dry matter yield was highest in the treatment $M_4$ where 50 per cent FYM + 50 per cent groundnut cake was applied as organic manure and was significantly superior to other organic sources (3,896.74 kg $ha^{-1}$). The dry matter yield was lowest (2250.42 kg $ha^{-1}$) in farmers' practice ($M_1$).

Planting weight of tuber also significantly influenced the dry matter production. The dry matter yield was highest in $P_2$ where 15 g $unit^{-1}$ weight of planting material was used (2,909.33 kg $ha^{-1}$). This was significantly superior to the dry matter yield in $P_1$ where 10 g $unit^{-1}$ weight of tuber was used (2209.75kg $ha^{-1}$).

Among the interactions, 50 per cent FYM + 50 per cent groundnut cake ($M_4$) in combination with 15 g $unit^{-1}$ weight of tuber ($P_2$) produced the highest dry matter yield of 4,443.81 kg $ha^{-1}$ and was significantly superior to all other treatment combinations. The dry matter yield was lowest in $M_1P_1$ where 30 t $ha^{-1}$ FYM and 10 g $unit^{-1}$ weight of tuber used (1625.02 kg $ha^{-1}$) and was on par with the treatment combination of vermicompost alone with 10 g $unit^{-1}$ weight of tuber ($M_2P_1$).

Table 4.11 Main effect of organic manure and planting weight of tuber on dry matter yield

| Treatments | Dry matter yield (kg $ha^{-1}$) |
|---|---|
| Organic manures | |
| $M_1$ | 2250.42 |
| $M_2$ | 1827.27 |
| $M_3$ | 2387.16 |
| $M_4$ | 3896.74 |
| $M_5$ | 2292.00 |
| $M_6$ | 2703.63 |
| F (5,22) | 45.920** |
| SE | 105.219 |
| CD | 308.616 |
| Planting weight of tuber | |
| $P_1$ | 2209.75 |
| $P_2$ | 2909.33 |
| F (1,22) | 3.312** |
| SE | 60.748 |
| CD | 178.129 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.12 Interaction effect of organic manure and planting weight of tuber on dry matter yield

| Treatments | Dry matter yield (kg $ha^{-1}$) |
|---|---|
| $M_1P_1$ | 1625.02 |
| $M_2P_1$ | 1626.71 |
| $M_3P_1$ | 2175.29 |
| $M_4P_1$ | 3349.67 |
| $M_5P_1$ | 1964.64 |
| $M_6P_1$ | 2517.14 |
| $M_1P_2$ | 2875.83 |
| $M_2P_2$ | 2027.83 |
| $M_3P_2$ | 2599.03 |
| $M_4P_2$ | 4443.81 |
| $M_5P_2$ | 2619.37 |
| $M_6P_2$ | 2890.11 |
| F(5,22) | 3.312* |
| SE | 148.802 |
| CD | 436.448 |

* Significant at 5% level ** Significant at 1% level NS Non significant

### 4.2.9 **Tuber Bulking Rate** (Table 4.13)

Tuber bulking rate was significantly influenced by organic manures at two different stages of tuber growth, *viz.*, 5 and 7 MAP. At these stages tuber bulking rate was the highest in $M_4$ where 50 per cent FYM + 50 per cent groundnut cake was applied as organic source and were significantly superior to other organic sources. This was followed by $M_5$ (50 per cent FYM + 50 per cent neem cake) and was on par with other treatments such as $M_1$ (FYM @ 30 t $ha^{-1}$), $M_2$ (vermicompost alone), $M_3$ (50 per cent FYM + 50 per cent vermicompost) and $M_6$ (10 t $ha^{-1}$ FYM + NPK @ 100:80:80 kg $ha^{-1}$).

Planting weight of tuber did not influence the tuber bulking rate.

Interaction effects were not significant.

## 4.3 YIELD AND YIELD ATTRIBUTES

### 4.3.1 **Fresh Tuber Yield** (Tables 4.14 and 4.15)

The fresh tuber yield was the highest in the treatment where 50 per cent FYM + 50 per cent groundnut cake ($M_4$) was applied as organic source (16,669 kg $ha^{-1}$). This was significantly superior to all other organic sources. The fresh tuber yield was the lowest in the treatment where vermicompost alone ($M_2$) was applied (8,463 kg $ha^{-1}$).

Planting weight of tuber also significantly influenced the fresh tuber yield. The fresh tuber yield was the highest in $P_2$ where 15 g $unit^{-1}$ weight of tuber was used as planting material (12,353.44 kg $ha^{-1}$). This was significantly superior to the planting weight of tuber @ 10 g $unit^{-1}$ ($P_1$).

Interaction effects were not significant.

### 4.3.2 **Number of Tubers** (Tables 4.14 and 4.15)

Among the organic manures, application of 50 per cent FYM + 50 per cent groundnut cake ($M_4$) as organic source produced the highest mean number of tuber $plant^{-1}$ (18.61) and was significantly superior to all other organic sources.

Table 4.13. Main effect of organic manure and planting weight of tuber on tuber bulking rate

| Treatments | Tuber bulking rate (g $day^{-1}$ $plant^{-1}$) | | | | |
|---|---|---|---|---|---|
| | Months after planting | | | | |
| | 5 MAP | 6 MAP | 7 MAP | 8 MAP | 9 MAP |
| Organic manures | | | | | |
| $M_1$ | 0.053 | 0.067 | 0.040 | 0.033 | 0.033 |
| $M_2$ | 0.048 | 0.048 | 0.042 | 0.033 | 0.030 |
| $M_3$ | 0.048 | 0.055 | 0.038 | 0.033 | 0.022 |
| $M_4$ | 0.078 | 0.065 | 0.095 | 0.033 | 0.025 |
| $M_5$ | 0.052 | 0.077 | 0.048 | 0.030 | 0.028 |
| $M_6$ | 0.037 | 0.052 | 0.045 | 0.033 | 0.028 |
| F (5,22) | 8.049** | 1.501 $^{NS}$ | 8.943** | 0.550 $^{NS}$ | 1.580 $^{NS}$ |
| SE | 0.005 | 0.009 | 0.007 | 0.002 | 0.003 |
| CD | 0.014 | - | 0.021 | - | - |
| Planting weight of tuber | | | | | |
| $P_1$ | 0.053 | 0.057 | 0.052 | 0.032 | 0.029 |
| $P_2$ | 0.052 | 0.064 | 0.051 | 0.033 | 0.027 |
| F (1,22) | 0.078 $^{NS}$ | 1.183 $^{NS}$ | 0.079 $^{NS}$ | 0.550 $^{NS}$ | 0.718 $^{NS}$ |
| SE | 0.003 | 0.005 | 0.004 | 0.001 | 0.001 |
| CD | - | - | - | - | - |

* Significant at 5% level ** Significant at 1% level NS Non significant

The mean number of tuber plant$^{-1}$ was lowest in $M_5$ where 50 per cent FYM + 50 per cent neem cake was applied as organic source (12.44).

Planting weight of tuber also significantly influenced the number of tuber plant$^{-1}$. Tuber weight @ 15 g unit$^{-1}$ ($P_2$) as planting material produced the highest mean number of tuber plant$^{-1}$ (15.43) and was significantly superior to the other planting weight of tuber @ 10 g unit$^{-1}$.

Interaction effects were not significant.

### 4.3.3 Length of Tuber (Tables 4.14 and 4.15)

The longest tuber (18.9 cm) was produced in $M_4$ where 50 per cent FYM + 50 per cent groundnut cake was applied as organic source and this was significantly superior to all other organic sources. The shortest tuber (9.77 cm) was produced in $M_2$ where vermicompost alone was applied.

Planting weight of tuber also had significant influence on length of tubers and the longest tuber was produced in $P_2$ where a tuber weight of 15 g unit$^{-1}$ was used as planting material (13.00 cm).

Among the interactions, 50 per cent FYM + 50 per cent groundnut cake ($M_4$) in combination with 15 g unit$^{-1}$ weight of tuber ($P_2$) produced the longest tuber (22.4 cm) and was significantly superior to all other treatment combinations. The least interaction effect was in the treatment combination $M_2P_1$ where vermicompost alone along with 10 g unit$^{-1}$ weight of tuber was used (7.73 cm).

### 4.3.4 Diameter of Tuber (Tables 4.14 and 4.15)

Organic manures did not have significant influence on diameter of tuber. But planting weight of tuber significantly influenced the diameter of tuber and diameter of tuber was highest in $P_2$ where @ 15 g unit$^{-1}$ weight of planting material was used (2.68 cm) and was significantly superior to the other planting weight of 10 g unit$^{-1}$ tuber (2.42 cm).

Interaction effects were not significant.

Table 4.14 Main effect of organic manure and planting weight of tuber on number, length, diameter and fresh yield of tuber

| Treatments | Number | Length (cm) | Diameter (cm) | Fresh yield (kg $ha^{-1}$) |
|---|---|---|---|---|
| Organic manures | | | | |
| $M_1$ | 13.67 | 11.53 | 2.48 | 10405.00 |
| $M_2$ | 12.97 | 9.77 | 2.23 | 8463.33 |
| $M_3$ | 13.92 | 11.46 | 2.51 | 11199.67 |
| $M_4$ | 18.61 | 18.90 | 2.77 | 16669.00 |
| $M_5$ | 12.44 | 10.72 | 2.49 | 10361.33 |
| $M_6$ | 13.12 | 10.62 | 2.79 | 11733.33 |
| F (5,22) | 15.686** | 54.547** | 2.577 $^{NS}$ | 18.847** |
| SE | 0.571 | 0.455 | 0.130 | 639.806 |
| CD | 1.674 | 1.335 | | 1876.602 |
| Planting weight of tuber | | | | |
| $P_1$ | 12.81 | 11.33 | 2.42 | 10590.44 |
| $P_2$ | 15.43 | 13.00 | 2.68 | 12353.44 |
| F (1,22) | 31.495** | 20.311** | 5.912* | 11.389** |
| SE | 0.329 | 0.263 | 7.512 | 369.392 |
| CD | 0.966 | 0.771 | 0.220 | 1083.456 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.15 Interaction effect of organic manure and planting weight of tuber on number, length, diameter and fresh yield of tuber

| Treatments | Number | Length (cm) | Diameter (cm) | Fresh yield (kg $ha^{-1}$) |
|---|---|---|---|---|
| $M_1P_1$ | 11.53 | 12.23 | 2.73 | 8115.33 |
| $M_2P_1$ | 13.09 | 7.73 | 2.16 | 7749.33 |
| $M_3P_1$ | 12.19 | 10.29 | 2.75 | 10371.33 |
| $M_4P_1$ | 12.26 | 15.40 | 2.79 | 16729.33 |
| $M_5P_1$ | 10.69 | 10.70 | 2.64 | 9499.33 |
| $M_6P_1$ | 17.13 | 11.60 | 2.99 | 11078.00 |
| $M_1P_2$ | 15.82 | 10.82 | 2.23 | 12694.67 |
| $M_2P_2$ | 12.84 | 11.80 | 2.30 | 9177.33 |
| $M_3P_2$ | 15.66 | 12.63 | 2.28 | 12028.00 |
| $M_4P_2$ | 13.97 | 22.40 | 2.75 | 16608.67 |
| $M_5P_2$ | 14.19 | 10.74 | 2.35 | 11223.33 |
| $M_6P_2$ | 20.09 | 9.63 | 2.60 | 12388.67 |
| F(5,22) | 2.062 $^{NS}$ | 14.495** | 0.967 $^{NS}$ | 1.442 $^{NS}$ |
| SE | 0.807 | 0.644 | 0.184 | 904.822 |
| CD | | 1.888 | | |

* Significant at 5% level ** Significant at 1% level NS Non significant

## 4.4 QUALITY PARAMETERS

### 4.4.1 **Fresh Weight of Tuber after Peeling** (Tables 4.16 and 4.17)

Among the organic manures, application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) produced the highest fresh weight of tuber after peeling which was significantly superior to other organic sources (46.3 g plant$^{-1}$). The fresh weight of tuber after peeling was lowest in $M_2$ where vermicompost alone was applied (21.07 g plant$^{-1}$).

Planting weight of tuber also significantly influenced the fresh tuber weight after peeling and planting weight @ 15 g unit$^{-1}$ ($P_2$) produced the highest fresh weight of tuber after peeling (35.53 g plant $^{-1}$).

Among the interactions, the fresh weight of tuber after peeling was highest in $M_4P_2$ where 50 per cent FYM + 50 per cent groundnut cake along with 15 g unit$^{-1}$ weight of tuber was used as planting material (50.90 g plant$^{-1}$). This was significantly superior to other treatment combinations. The fresh weight of tuber after peeling was lowest in $M_2P_1$ where vermicompost alone was applied along with 10 g unit$^{-1}$ weight of tuber (19.40 g plant$^{-1}$).

### 4.4.2 **Dry Weight of Tuber after Peeling** (Tables 4.16 and 4.17)

Like the fresh weight of tuber after peeling, the dry weight of tuber after peeling was also highest in $M_4$ where 50 per cent FYM + 50 per cent groundnut cake applied (11.58 g plant$^{-1}$). This was significantly superior to other organic sources. The dry weight of tuber after peeling was lowest in $M_2$ where vermicompost alone was applied (5.27 g plant$^{-1}$).

Planting weight of tuber also significantly influenced the dry tuber weight after peeling and planting weight @ 15 g unit$^{-1}$ tuber ($P_2$) produced the highest dry tuber weight of 8.14 g plant$^{-1}$ after peeling

Among the interactions, similar to fresh weight, the dry weight of tuber after peeling was also found highest in $M_4P_2$ (12.73 g plant$^{-1}$). This was significantly superior to other treatment combinations. Just like fresh weight, the dry weight of tuber after peeling was lowest in $M_2P_1$ (4.83 g plant$^{-1}$). This was

Table 4.16 Main effect of organic manure and planting weight of tuber on fresh and dry weight of tuber after peeling and moisture content in dry tuber

| Treatments | Fresh weight (g plant$^{-1}$) | Dry weight (g plant$^{-1}$) | Moisture content (%) |
|---|---|---|---|
| Organic manures | | | |
| $M_1$ | 25.88 | 6.50 | 21.26 |
| $M_2$ | 21.07 | 5.27 | 21.59 |
| $M_3$ | 28.20 | 7.07 | 22.71 |
| $M_4$ | 46.37 | 11.58 | 22.28 |
| $M_5$ | 25.87 | 6.50 | 22.20 |
| $M_6$ | 29.68 | 7.42 | 21.72 |
| F (5,22) | 184.513** | 188.947** | 0.398 $^{NS}$ |
| SE | 0.645 | 0.159 | 0.844 |
| CD | 1.891 | 0.465 | |
| Planting weight of tuber | | | |
| $P_1$ | 26.49 | 6.63 | 22.12 |
| $P_2$ | 35.53 | 8.14 | 21.80 |
| F (1,22) | 131.32** | 136.064** | 0.227 $^{NS}$ |
| SE | 0.372 | 0.092 | 0.487 |
| CD | 1.092 | 0.269 | |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.17 Interaction effect of organic manure and planting weight of tuber on fresh and dry weight of tuber after peeling

| Treatments | Fresh weight (g plant$^{-1}$) | Dry weight (g plant$^{-1}$) |
|---|---|---|
| $M_1P_1$ | 20.27 | 5.10 |
| $M_2P_1$ | 19.40 | 4.83 |
| $M_3P_1$ | 25.90 | 6.50 |
| $M_4P_1$ | 41.83 | 10.43 |
| $M_5P_1$ | 23.70 | 6.00 |
| $M_6P_1$ | 27.87 | 7.00 |
| $M_1P_2$ | 31.50 | 7.90 |
| $M_2P_2$ | 22.73 | 5.70 |
| $M_3P_2$ | 30.50 | 7.63 |
| $M_4P_2$ | 50.90 | 12.73 |
| $M_5P_2$ | 28.03 | 7.03 |
| $M_6P_2$ | 31.50 | 7.87 |
| F(5,22) | 6.522** | 6.778** |
| SE | 0.912 | 0.224 |
| CD | 2.674 | 0.658 |

* Significant at 5% level ** Significant at 1% level NS Non significant

found on par with the farmers' practice of FYM application @ 30 t $ha^{-1}$ along with 10 g $unit^{-1}$ weight of planting material ($M_1P_1$).

### 4.4.3 **Moisture Content in Dry Tubers** (Table 4.16)

The main as well as interaction effects had no significant influence in the moisture content in dry tubers.

### 4.4.4 **Phytochemical Analysis**

The data was not statistically analysed as only three samples were chemically analysed for saponin content. The saponin content in the tuber from treatments $M_2$ (vermicompost alone), $M_4$ (50 per cent FYM + 50 per cent groundnut cake) and control (FYM basal @ 10 t $ha^{-1}$ + NPK @ 100:80:80 kg $ha^{-1}$) were only analysed. The results revealed that the highest saponin content was in $M_4$ where nutrients was given as 50 per cent FYM + 50 per cent groundnut cake (1.45%). Saponin content of 1.01% was recorded in the treatment $M_2$ (vermicompost alone application). The lowest saponin content was in control where FYM @10 t $ha^{-1}$ as basal + NPK @ 100:80:80 kg $ha^{-1}$ was given (0.82%).

## 4.5 NUTRIENT STUDIES

### 4.5.1 **Uptake of N** (Tables 4.18 and 4.19)

Nitrogen uptake was significantly influenced by organic sources. The highest significant uptake was in $M_4$ where 50 per cent FYM + 50 per cent groundnut cake was given (149.68 kg $ha^{-1}$). The lowest uptake was in $M_5$ where 50 per cent FYM + 50 per cent neem cake was given (56.18 kg $ha^{-1}$). This was found on par with $M_1$ (FYM @ 30 t $ha^{-1}$) and $M_2$ (vermicompost alone application).

Between the two planting weight of tuber, the uptake was significantly higher for the higher planting weight of tuber, *i.e.*, @ 15 g $unit^{-1}$ (96.62 kg $ha^{-1}$).

Among the interactions, combination of $M_4$ (50 per cent FYM + 50 per cent groundnut cake) with $P_2$ (planting weight of tuber @ 15 g $unit^{-1}$) recorded the highest uptake of 176.51 kg $ha^{-1}$ and was significantly superior to all other treatment combinations. The lowest uptake of 40.03 kg $ha^{-1}$ was in farmers' practice of 30 t $ha^{-1}$ FYM application along with 10 g $unit^{-1}$ weight of tuber ($M_1P_1$). This was on par with other two interactions, *viz.*, $M_3P_1$ (50 per cent FYM + 50 per cent vermicompost and 10g $unit^{-1}$ weight of tuber) and $M_5P_1$ (50 per cent FYM + 50 per cent neem cake and 10 g $unit^{-1}$ weight of tuber).

**4.5.2 Uptake of P** (Tables 4.18 and 4.19)

Phosphorus uptake was significantly influenced by organic sources and planting weight of tuber. Like N uptake, P uptake was also highest in $M_4$ (9.83 kg $ha^{-1}$). This was significantly superior to all other organic sources except $M_5$ where 50 per cent FYM + 50 per cent neem cake was applied (9.05 kg $ha^{-1}$). The uptake was lowest in $M_1$ where FYM @ 30 t $ha^{-1}$ alone was given (5.11 kg $ha^{-1}$). This was found on par with $M_2$ (vermicompost alone).

P uptake was also highest with the higher planting weight of tuber, *viz.*, @ 15 g $unit^{-1}$ (8.20 kg $ha^{-1}$) and was significantly superior to the lower planting weight of tuber @ 10 g $unit^{-1}$ (6.39 kg $ha^{-1}$).

Interaction effects were not significant.

**4.5.3 Uptake of K** (Tables 4.18 and 4.19)

Potassium uptake was also significantly influenced by organic sources and planting weight of tuber. Similar to N and P, K uptake was also found highest in $M_4$ (100.61 kg $ha^{-1}$). This was significantly superior to all other organic sources. The K uptake was lowest in $M_2$ where vermicompost alone was applied (35.01 kg $ha^{-1}$). This was found on par with the farmers' practice of FYM application @ 30 t $ha^{-1}$ ($M_1$).

Between the two planting weights, planting weight of tuber @ 15 g $unit^{-1}$ ($P_2$), recorded the highest uptake of 57.56 kg $ha^{-1}$ which was significantly superior to the other planting weight $P_1$, *viz.*, @ 10 g $unit^{-1}$ (49.91 kg $ha^{-1}$).

Similar to N, the K uptake was also found to be highest in $M_4P_2$ (106.92 kg $ha^{-1}$) and lowest in $M_1P_1$ (29.92 kg $ha^{-1}$). The lowest uptake in $M_1P_1$ was on par with the uptake in $M_2P_2$ (vermicompost alone with 15 g $unit^{-1}$ weight

Table 4.18 Main effect of organic manure and planting weight of tuber on nutrient uptake

| Treatments | Uptake of nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|
| | N | P | K |
| Organic manures | | | |
| $M_1$ | 63061 | 5.11 | 35.57 |
| $M_2$ | 60.88 | 4.92 | 35.01 |
| $M_3$ | 75.78 | 7.87 | 46.91 |
| $M_4$ | 149.68 | 9.83 | 100.61 |
| $M_5$ | 56.18 | 9.05 | 46.96 |
| $M_6$ | 75.86 | 6.98 | 57.38 |
| F (5,22) | 105.183** | 21.755** | 97.395** |
| SE | 3.403 | 0.432 | 2.475 |
| CD | 9.982 | 1.268 | 7.261 |
| Planting weight of tuber | | | |
| $P_1$ | 64.04 | 6.39 | 49.91 |
| $P_2$ | 96.62 | 8.20 | 57.56 |
| F (1,22) | 137.501** | 26.151** | 14.332** |
| SE | 1.965 | 0.250 | 1.429 |
| CD | 5.763 | 0.732 | 4.192 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.19 Interaction effect of organic manure and planting weight of tuber on nutrient uptake

| Treatments | Uptake of nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|
| | N | P | K |
| $M_1P_1$ | 40.03 | 3.61 | 29.92 |
| $M_2P_1$ | 62.82 | 4.23 | 31.22 |
| $M_3P_1$ | 50.01 | 7.49 | 37.69 |
| $M_4P_1$ | 122.84 | 8.43 | 94.30 |
| $M_5P_1$ | 44.64 | 7.74 | 44.69 |
| $M_6P_1$ | 63.90 | 6.85 | 61.64 |
| $M_1P_2$ | 87.19 | 6.62 | 41.21 |
| $M_2P_2$ | 58.93 | 5.62 | 38.80 |
| $M_3P_2$ | 101.55 | 8.25 | 56.13 |
| $M_4P_2$ | 176.51 | 11.23 | 106.92 |
| $M_5P_2$ | 67.73 | 10.35 | 49.22 |
| $M_6P_2$ | 87.83 | 7.11 | 53.11 |
| F(5,22) | 10.844** | 1.798 NS | 3.476** |
| SE | 4.813 | 0.611 | 3.501 |
| CD | 14.116 | | 10.268 |

* Significant at 5% level ** Significant at 1% level NS Non significant

of tuber), $M_3P_1$ (50 per cent FYM + 50 per cent vermicompost with 10 g unit$^{-1}$ weight of tuber) and $M_2P_1$ (vermicompost alone with 10 g unit$^{-1}$ weight of tuber).

#### 4.5.4 **Available N in Soil** (Tables 4.20 and 4.21)

Organic manures significantly influenced available N content in soil. Application of organic manure as 50 per cent FYM + 50 per cent neem cake ($M_5$) recorded the highest available N content (249.35 kg ha$^{-1}$) which was significantly superior to other organic sources. The lowest available N content was recorded in farmers' practice ($M_1$) where 30 t ha$^{-1}$ FYM alone was applied (220.43 kg ha$^{-1}$).

Between the two planting weights, planting weight of tuber @ 10 g unit$^{-1}$ ($P_1$) recorded the highest available N content (234.45 kg ha$^{-1}$) and was significantly superior to the other planting weight of 15 g unit$^{-1}$ (231.12 kg ha$^{-1}$).

The highest available N content was in the treatment combination $M_5P_1$ where 50 per cent FYM + 50 per cent neem cake along with 10 g unit$^{-1}$ weight of tuber was used as planting material and was significantly superior to all other treatment combinations (257.6 kg ha$^{-1}$). The lowest available N content was in $M_1P_2$ where FYM @ 30 t ha$^{-1}$ along with 15 g unit$^{-1}$ weight of tuber was used as planting material (213.97 kg ha$^{-1}$).

#### 4.5.5 **Available P in Soil** (Tables 4.20 and 4.21)

Among the organic manures, application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) recorded the highest available P in soil (41.72 kg ha$^{-1}$) and was significantly superior to other organic sources. The treatment where organic manure was applied as 50 per cent FYM + 50 per cent vermicompost ($M_3$) recorded the lowest available P content (32.35 kg ha$^{-1}$).

Planting weight of tuber did not influence the available P content in soil.

The highest available P content of 44.97 kg ha$^{-1}$ was in $M_4P_2$ where 50 per cent FYM + 50 per cent groundnut cake along with 15 g unit$^{-1}$ weight of tuber tried and was significantly superior to all other treatment combinations. The available P content was lowest in the treatment combination $M_3P_2$ where

50 per cent FYM + 50 per cent vermicompost along with 15 g $unit^{-1}$ weight of tuber used (32.07 kg $ha^{-1}$).

**4.5.6 Available K in Soil** (Tables 4.20 and 4.21)

Like P, the highest available K content in soil was found in $M_4$ (249.81 kg $ha^{-1}$) and the lowest in $M_3$ (218.85 kg $ha^{-1}$).

Between the two planting weight, the higher planting weight of tuber, *viz.*, @ 15 g $unit^{-1}$ ($P_2$) recorded the highest available K content of 232.42 kg $ha^{-1}$ and was significantly superior to the lower planting weight of tuber @ 10 g $unit^{-1}$ (230.88 kg $ha^{-1}$).

Similar to available P, the highest available K content in soil was found in $M_4P_2$ (251.24 kg $ha^{-1}$) and the lowest in $M_3P_2$ (215.26 kg $ha^{-1}$).

4.6 ECONOMIC ANALYSIS

**4.6.1 Net Returns and Benefit Cost Ratio** (Tables 4.22, 4.23 and 4.24)

The highest net return was in the combination $M_4P_2$ where 50 per cent FYM + 50 per cent groundnut cake along with 15 g $unit^{-1}$ weight of tuber used as planting material (Rs. 6049380). This was followed by $M_4P_1$ where 50 per cent FYM + 50 per cent groundnut cake along with 10 g $unit^{-1}$ weight of tuber used as planting material (Rs. 5364313). The lowest net returns was in $M_4P_2$ where vermicompost alone was applied along with 15 g $unit^{-1}$ weight of tuber (Rs. 1635933).

The highest benefit : cost ratio was in $M_4$ where 50 per cent FYM + 50 per cent groundnut cake was applied as organic source (4.57). This was significantly superior to all other organic sources. The lowest benefit : cost ratio was in $M_2$ where vermicompost alone was applied as organic source (1.98).

Between the two planting weight of tuber, planting with lower weight of tuber, *viz.*, @ 10 g $unit^{-1}$ ($P_1$) gave the highest BCR of 3.30 and was significantly superior to the higher planting weight of 15 g $unit^{-1}$ (2.75).

Among the interactions, the highest BCR was highest in $M_4P_1$ where 50 per cent FYM + 50 per cent groundnut cake ($M_4$) in combination with 10 g unit$^{-1}$ weight of tuber ($P_1$) tried and was significantly superior to all other treatment combinations (5.00). This was followed by $M_4P_2$ where 50 per cent FYM + 50 per cent groundnut cake along with 15 g unit$^{-1}$ weight of tuber tried (4.14). The lowest BCR was in $M_2P_2$ where vermicompost alone was applied in combination with 15 g unit$^{-1}$ weight of tuber (1.81).

Table 4.20 Main effect of organic manure and planting weight of tuber on available nutrient content in soil

| Treatments | Available nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|
| | N | P | K |
| Organic manures | | | |
| $M_1$ | 220.43 | 38.38 | 236.91 |
| $M_2$ | 231.69 | 39.98 | 233.92 |
| $M_3$ | 228.96 | 32.35 | 218.85 |
| $M_4$ | 233.34 | 41.72 | 224.68 |
| $M_5$ | 249.35 | 37.57 | 249.81 |
| $M_6$ | 232.94 | 38.02 | 225.73 |
| F (5,22) | 162.426** | 33.881** | 355.853** |
| SE | 0.739 | 0.543 | 0.585 |
| CD | 2.166 | 1.593 | 1.717 |
| Planting weight of tuber | | | |
| $P_1$ | 234.45 | 38.42 | 230.88 |
| $P_2$ | 231.12 | 37.58 | 232.42 |
| F (1,22) | 30.403** | 3.584 $^{NS}$ | 10.392** |
| SE | 0.426 | 0.314 | 0.338 |
| CD | 1.251 | - | 0.991 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.21 Interaction effect of organic manure and planting weight of tuber on available nutrient content in soil

| Treatments | Available nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|
| | N | P | K |
| $M_1P_1$ | 226.89 | 42.17 | 236.07 |
| $M_2P_1$ | 235.52 | 37.73 | 227.26 |
| $M_3P_1$ | 236.85 | 32.63 | 222.44 |
| $M_4P_1$ | 227.77 | 38.47 | 231.24 |
| $M_5P_1$ | 257.60 | 40.17 | 248.37 |
| $M_6P_1$ | 222.02 | 39.37 | 219.89 |
| $M_1P_2$ | 213.06 | 34.60 | 237.74 |
| $M_2P_2$ | 227.86 | 42.23 | 240.57 |
| $M_3P_2$ | 221.08 | 32.07 | 215.26 |
| $M_4P_2$ | 238.91 | 44.97 | 218.12 |
| $M_5P_2$ | 241.09 | 34.97 | 251.24 |
| $M_6P_2$ | 243.82 | 36.67 | 231.57 |
| F(5,22) | 117.15** | 25.452** | 77.924** |
| SE | 1.044 | 0.768 | 0.828 |
| CD | 3.064 | 2.253 | 2.429 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.22 Main effect of organic manure and planting weight of tuber on benefit cost ratio

| Treatments | Benefit cost ratio (BCR) |
|---|---|
| Organic manures | |
| $M_1$ | 2.70 |
| $M_2$ | 1.98 |
| $M_3$ | 3.00 |
| $M_4$ | 4.57 |
| $M_5$ | 2.71 |
| $M_6$ | 3.18 |
| F (5,22) | 210.497** |
| SE | 5.926 |
| CD | 0.174 |
| Planting weight of tuber | |
| $P_1$ | 3.30 |
| $P_2$ | 2.75 |
| F (1,22) | 128.172 NS |
| SE | 3.421 |
| CD | |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.23 Interaction effect of organic manure and planting weight of tuber on benefit cost ratio

| Treatments | Benefit cost ratio (BCR) |
|---|---|
| $M_1P_1$ | 2.61 |
| $M_2P_1$ | 2.16 |
| $M_3P_1$ | 3.37 |
| $M_4P_1$ | 5.00 |
| $M_5P_1$ | 3.02 |
| $M_6P_1$ | 3.63 |
| $M_1P_2$ | 2.80 |
| $M_2P_2$ | 1.81 |
| $M_3P_2$ | 2.63 |
| $M_4P_2$ | 4.14 |
| $M_5P_2$ | 2.41 |
| $M_6P_2$ | 2.72 |
| F(5,22) | 12.269** |
| SE | 8.380 |
| CD | 0.246 |

* Significant at 5% level ** Significant at 1% level NS Non significant

Table 4.24 Economics of safed musli cultivation as influenced by different treatments

| Treatments | Total cost (Rs) | Total returns (Rs) | Net returns (Rs) | BCR |
|---|---|---|---|---|
| $M_1P_1$ | 1219840 | 3246160 | 2026320 | 2.61 |
| $M_2P_1$ | 1435000 | 3099760 | 1664760 | 2.16 |
| $M_3P_1$ | 1230800 | 4148533 | 2917733 | 3.37 |
| $M_4P_1$ | 1327420 | 6691733 | 5364313 | 5.00 |
| $M_5P_1$ | 1263865 | 3786400 | 2522535 | 3.02 |
| $M_6P_1$ | 1219725 | 4431200 | 3211475 | 3.63 |
| $M_1P_2$ | 1819840 | 4726160 | 2906320 | 2.80 |
| $M_2P_2$ | 2035000 | 3670933 | 1635933 | 1.81 |
| $M_3P_2$ | 1830800 | 4811200 | 2980400 | 2.63 |
| $M_4P_2$ | 1927420 | 7976800 | 6049380 | 4.14 |
| $M_5P_2$ | 1863865 | 4489333 | 2625468 | 2.41 |
| $M_6P_2$ | 1819725 | 4955466 | 3135742 | 2.72 |

# *Discussion*

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# 5. DISCUSSION

The results of the experiment to study the performance of safed musli (*Chlorophytum borivilianum* Santapau and Fernandes) under different sources and doses of organic manures are discussed below. The effect of planting weight of tuber on growth and production is also discussed herewith.

## 5.1 GROWTH CHARACTERS

### 5.1.1 Plant Spread

The results showed that there was significant difference among various organic manures with respect to plant spread (Table 4.1). Plant spread throughout the vegetative growth period was maximum in the treatment that received nutrients through 50 per cent FYM and 50 per cent groundnut cake (Fig. 4). The application of equal ratio of FYM and groundnut cake might have ensured steady supply of nitrogen, which in turn resulted in better canopy growth. Similar observation was also noticed by Ahmed and Tanki (1991). The plant spread which is a measure of crop growth in turn is decided by the canopy development. The canopy development in safed musli is through the production of new leaves rather than increasing the height of the plant. In this particular study, the results in Tables 4.3, 4.7 and Fig. 5 revealed that there was an increase in number of leaves and total leaf area with the application of nutrients as 50 per cent FYM and 50 per cent groundnut cake. The higher nitrogen content in groundnut cake (5.8 per cent) and narrow C : N ratio might have facilitated an easier release of nutrients resulting in enhanced leaf production which ultimately led to increased plant spread. The beneficial effects of organic amendments in increasing the growth parameters was reported by Pushpa (1996) in tomato.

The results on planting weight of tuber showed that 15 g unit$^{-1}$ weight of tuber is superior to 10 g unit$^{-1}$ weight of tuber with respect to plant spread during all the three stages of growth (Fig. 4). This could be due to the greater nutrient storage and supplying capacity of larger tubers. Similar results were obtained by George and Nair (1993) in elephant foot yam. The relative growth rate (RGR) – biomass accumulated unit$^{-1}$ dry weight unit$^{-1}$ time - which is a measure of growth analysis in plants, might also be higher when higher planting weight of tuber is used. Since RGR was higher when higher planting weight of tuber used, uptake of nutrients was also higher, resulting in increased vigour in terms of growth characters.

### 5.1.2 Number of Suckers Hill$^{-1}$

The results presented in Table 4.1 revealed that organic manures had no significant influence in sucker production. On the other hand, tuber weight significantly influenced the sucker production. The highest sucker production was with 15 g unit$^{-1}$ weight of planting tuber ($P_2$) at all the stages of plant growth. Sucker production is a function of stored food in planting material. It seemed likely that greater amount of food material initially available in the large sized tuber enabled the plants to put forth more number of suckers. This is in accordance with the findings of Onwueme (1973) in yams.

### 5.1.3 Number of Leaves Plant$^{-1}$

Application of organic manure as 50 per cent FYM and 50 per cent groundnut cake ($M_4$) registered significantly higher leaf number at all the stages of vegetative growth (Table 4.3 and Fig. 5). The higher nitrogen content in groundnut cake (5.8 per cent) and easier release of nutrients might have enhanced leaf production. Nitrogen, being a constituent of chloroplast, amino acid and nucleic acid, has a significant role in cell division (Russel, 1973). The increased cell division might have contributed to the enhanced production of leaves resulting in more number

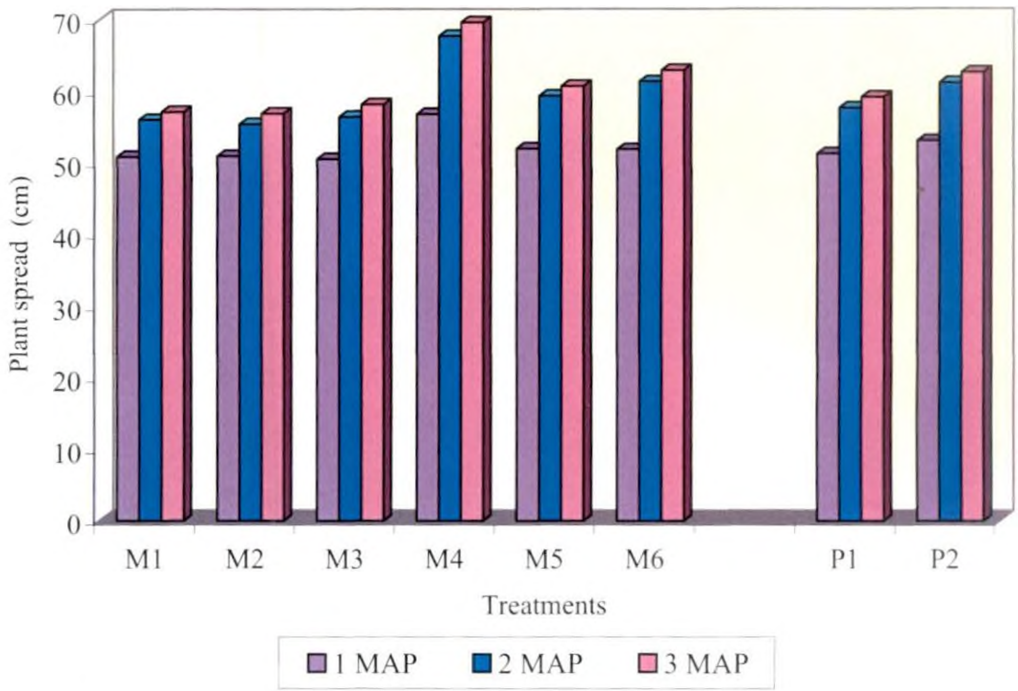


**Fig. 4. Effect of organic manure and planting weight of tuber on plant spread**

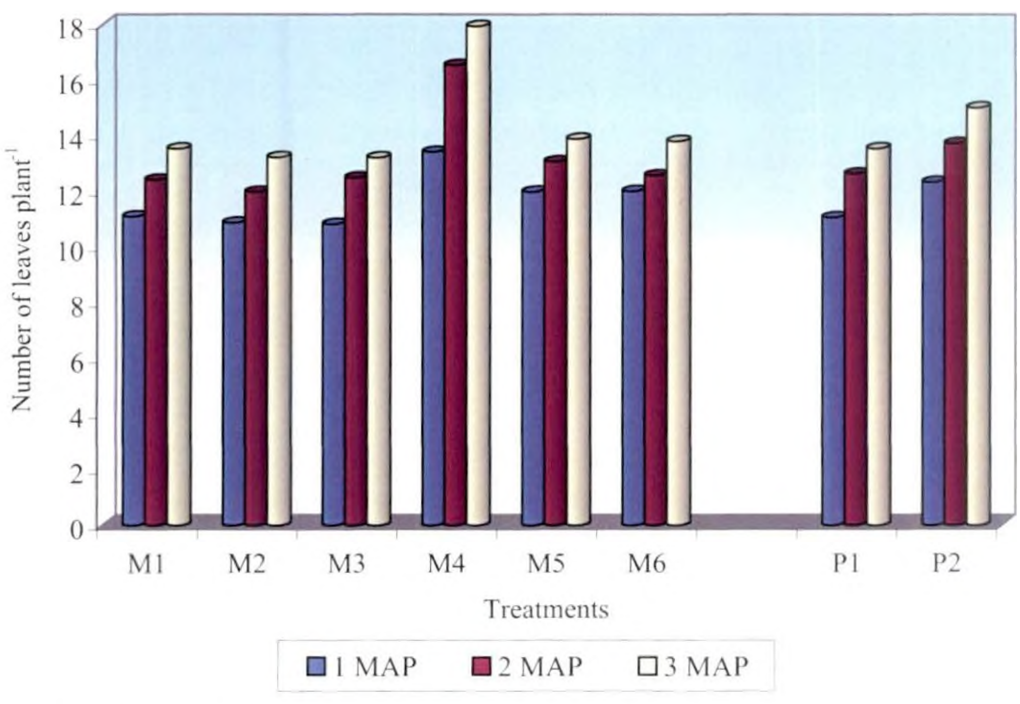


**Fig. 5. Effect of organic manure and planting weight of tuber on number of leaves plant$^{-1}$**

**50 per cent FYM + 50 per cent ground nut cake along with 15 g unit$^{-1}$ weight of tuber**

**Plate 3. Plant spread at 3 MAP**

of leaves. This is in agreement with the findings of Vidyadharan (2000) in arrowroot.

Increasing planting weight of tuber to 15 g unit$^{-1}$ produced more leaves throughout the vegetative period (mean value 13.69). The increased sucker production might have contributed to the production of more leaves also.

Among the interactions, the treatment combination $M_4P_2$ (50 per cent FYM + 50 per cent groundnut cake along with 15 g unit$^{-1}$ weight of tuber) produced the plants with highest leaf number at 3 MAP. This could be due to the complementary significant influence of FYM and groundnut cake along with higher planting weight of tuber on leaf number which is clear from Table 4.6.

## 5.2 PHYSIOLOGICAL PARAMETERS

### 5.2.1 Phenology and Development Pattern

#### *5.2.1.1 Days to Emergence, Suckering and Flowering*

Application of organic manure as 50 per cent FYM and 50 per cent groundnut cake ($M_4$) reduced the period for crop emergence and flowering (Tables 4.5, 4.6 and Fig. 6). The higher nutrient content and the narrow C : N ratio in groundnut cake might have accelerated the mineralisation process and released available form of nutrients which could be easily utilized by the plants, leading to early emergence and flowering of the crop under this treatment.

The data on days to emergence indicate that the period for crop emergence was shorter when higher planting weight of tuber used. In larger sized planting material, the availability of reserve food material is ample for early emergence and growth. This earliness in emergence also resulted in early suckering and early flowering.

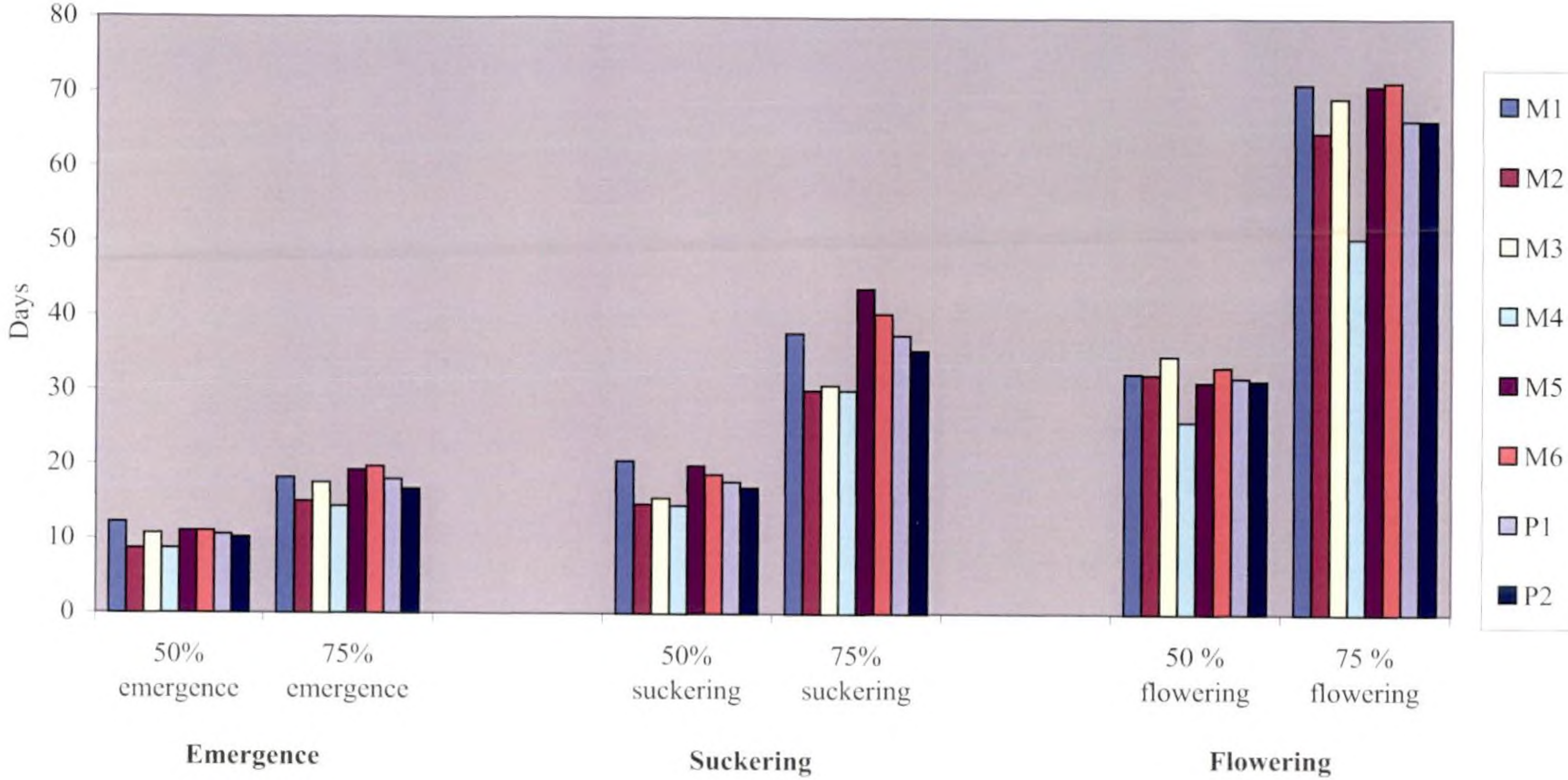


**Fig. 6. Effect of organic manure and planting weight of tuber on days to emergence, suckering and flowering**

*5.2.1.2 Leaf Area and Leaf Area Index*

The results on leaf characters like leaf area and leaf area index revealed that plants which received 50 per cent FYM and 50 per cent groundnut cake ($M_4$) produced the highest leaf area and leaf area index (LAI) at all the three stages of vegetative growth (Tables 4.7, 4.9 and Fig. 7 and 8). Organic manure usually constitute a dependable source of minor and major nutrient elements. Apart from this, the nitrogen content in groundnut cake is high (5.8 per cent ) and its C : N ratio is narrow. This might have accelerated the mineralisation process of groundnut cake resulting in the release of available form of nutrients which could be easily utilized by the plant. The increased nutrient status and availability could also have increased protein synthesis, allowing the leaves to grow larger and with more surface area available for photosynthesis (Russel, 1973).

The leaf area and LAI were also appreciably favoured by higher planting weight of tuber (15 g $unit^{-1}$) with a mean value of 78 $cm^2$ and 0.156 respectively during the three vegetative growth stages (Fig. 7 and 8). Larger tubers tend to emerge earlier and produce vigorous initial growth of roots and leaves resulting in increased photosynthetic efficiency, which might have increased the leaf area and hence the greater values of LAI. The data on early emergence with the higher planting weight of tuber (15 g $unit^{-1}$) in the present experiment supports this. Similar findings were also recorded by Nair (1985) in *Dioscorea esculenta* and Onwueme (1975) in yams.

The interaction between organic manures and planting weight of tuber was significant on leaf area and LAI at 2 and 3 MAP. Application of organic manure as 50 per cent FYM and 50 per cent groundnut cake ($M_4$) in combination with higher planting weight of tuber (15 g $unit^1$) recorded higher leaf area and LAI at these two stages of growth. This might be due

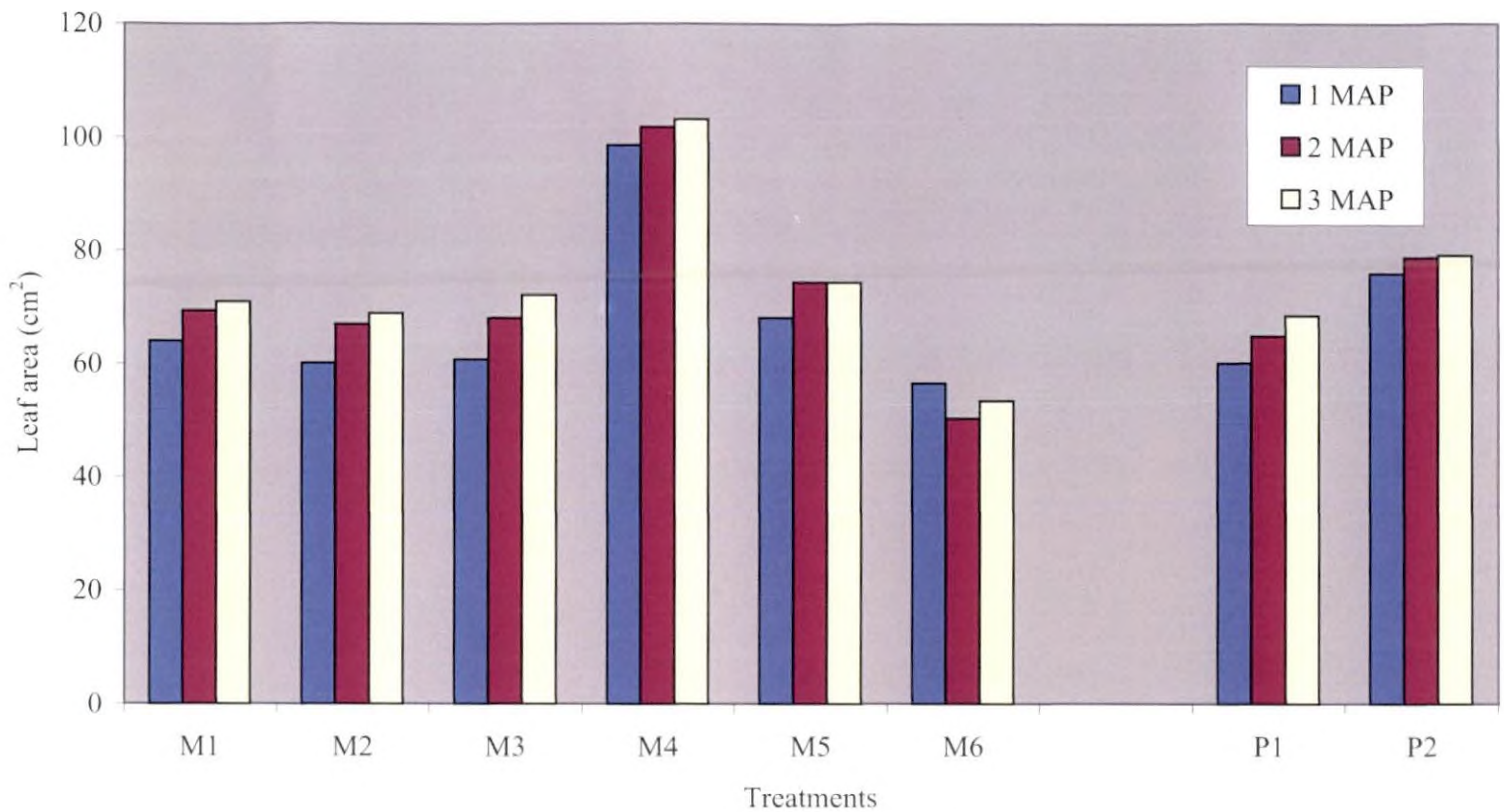


**Fig. 7. Effect of organic manure and planting weight of tuber on leaf area**

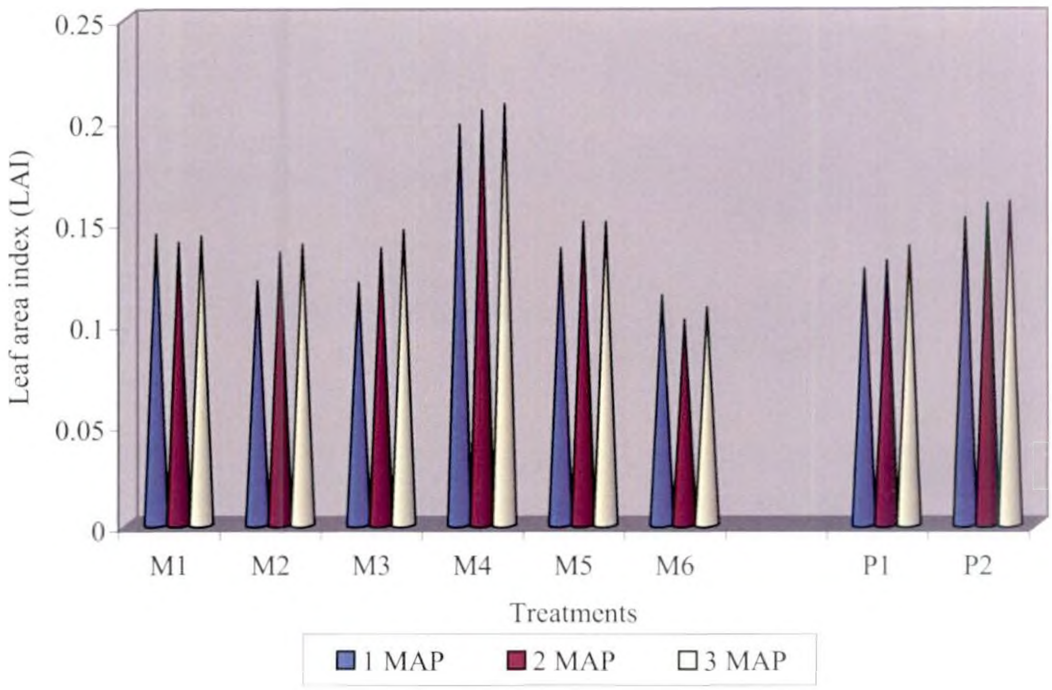


**Fig. 8. Effect of organic manure and planting weight of tuber on LAI**

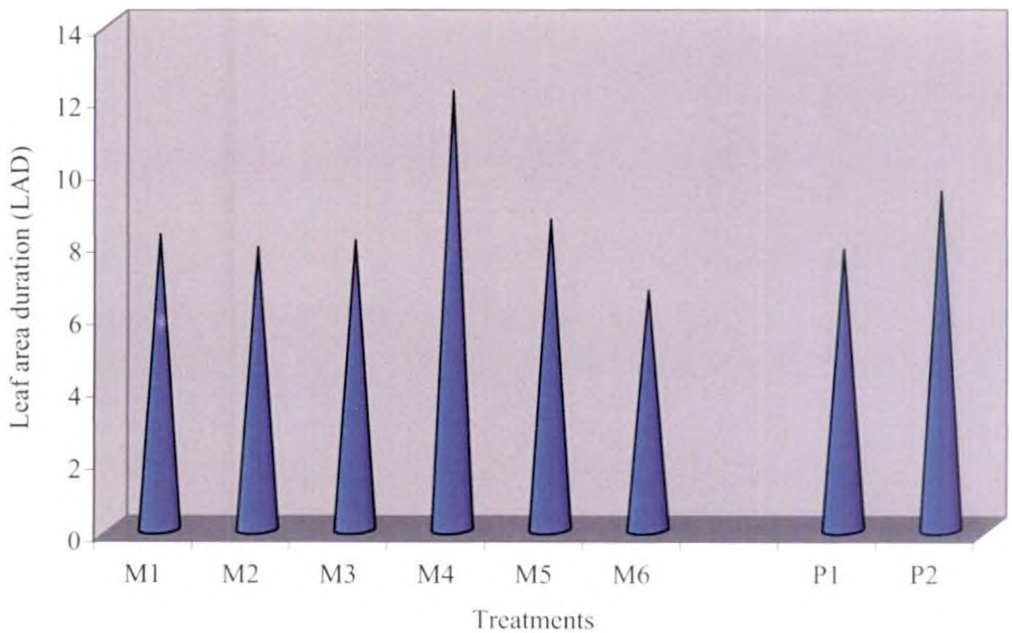


**Fig. 9. Effect of organic manure and planting weight of tuber on leaf area duration**

**Plate 4. Method of harvesting**

to the combined positive influence of organic manure and planting weight of tuber on leaf area and LAI as clear from Tables 4.10 and 4.12.

#### *5.2.1.3 Leaf Area Duration*

Highest leaf area duration (Table 4.9 and Fig. 9) was realized from the plots that received organic manure as 50 per cent FYM and 50 per cent groundnut cake ($M_4$). The higher N uptake under this treatment in the present study (Table 4.20) might have resulted in increased synthesis of chlorophyll. Higher chlorophyll content could contribute to better photosynthesis leading to higher sugar concentration in leaves and hence better retention of leaves (Terashima and Hikosaka, 1995) leading to increased leaf area for photosynthesis and thus higher leaf area duration (LAD).

Higher planting weight of tuber (15 g $unit^{-1}$) recorded significantly higher LAD (Fig. 9). Early emergence coupled with increased nutrient uptake resulted in more number of leaves and LAI leading to increased photosynthetic efficiency and thus higher LAD.

### 5.2.2 Dry Matter Production and Root Development and Tuberisation

#### *5.2.2.1 Dry Matter Production*

Maximum dry matter production was in plots that received nutrients through 50 per cent FYM and 50 per cent groundnut cake (Table 4.11 and Fig. 10). The effect of organic manure in increasing dry matter yield was reported in many crops like yams (Mohankumar and Nair, 1979), elephant foot yam (Patel and Mehta, 1987), turmeric (Balashanmugham *et al.*, 1989), kacholam (Bai and Augustin, 1998) and arrowroot (Vidyadharan, 2000). The physical condition brought about by organic manure addition, higher microbial population and dehydrogenase activity might have influenced the nutrient uptake, chlorophyll synthesis, plant growth and finally dry matter yield.

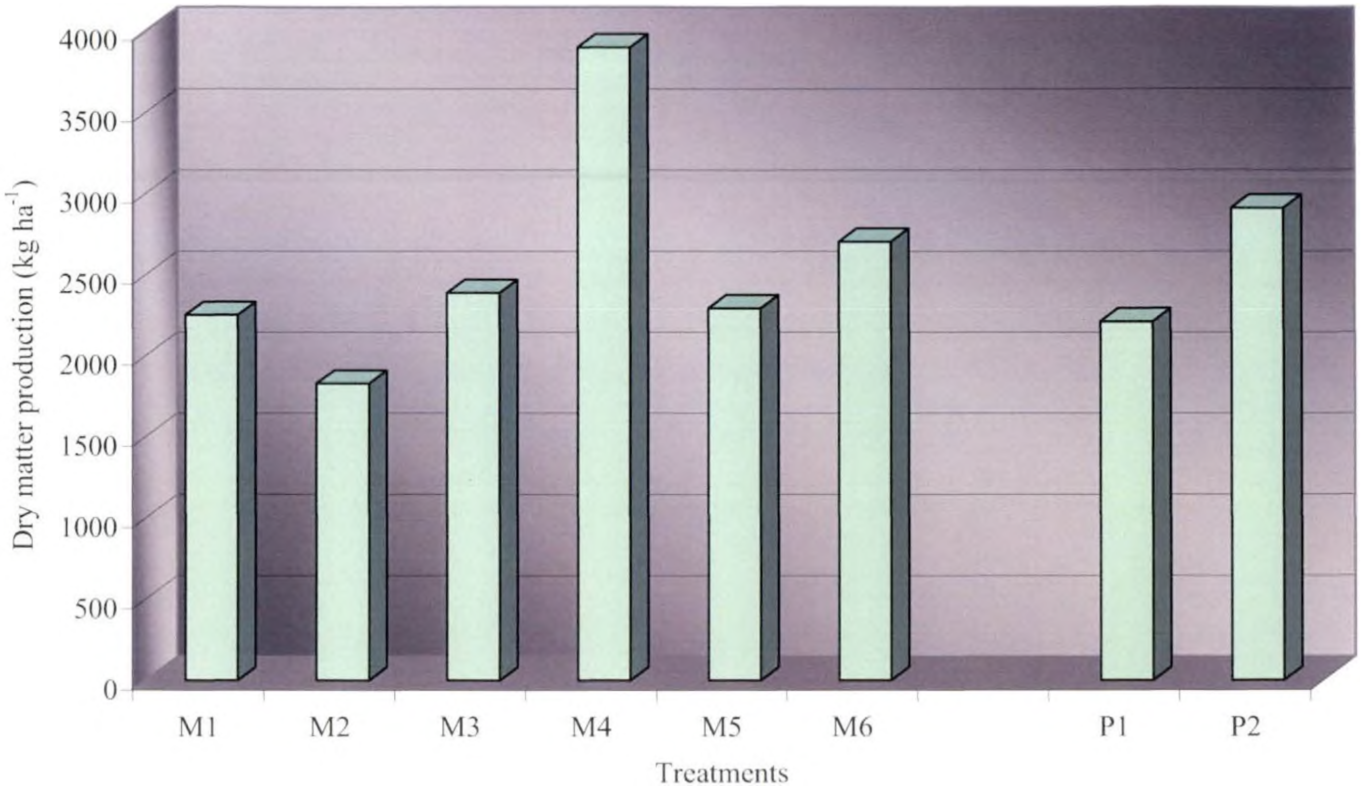


**Fig. 10. Effect of organic manure and planting weight of tuber on dry matter production**

Larger sized tuber (15 g unit$^{-1}$) produced plants with greatest total dry matter and also accumulated maximum dry matter in tubers which resulted in greater dry yield hectare$^{-1}$ (Fig. 10). The vigorous initial growth of roots, tubers and leaves produced by larger planting weight of tuber put the plant in an advantageous position that lasted throughout the growing season (Onwueme, 1972; Nwoke *et al.*, 1973). Moreover, the greater leaf area produced resulted in greater carbon assimilation in the plant and also assimilate translocation to the tubers. Thus in plants established from large tubers, mean tuber bulking rate was higher contributing to higher dry matter yield.

Among the interactions, plants receiving 50 per cent FYM and 50 per cent groundnut cake when planted with 15 g unit$^{-1}$ weight of tuber resulted in the highest dry tuber yield of 4.43 t ha$^{-1}$ (Table 4.14). This might be due to the combined positive effect of organic manure and higher planting weight of tuber. Maintenance of constant nutrient supplying capacity of organic manure in combination with growth and yield promoting effects of larger tuber was influential in producing the highest dry tuber yield.

#### *5.2.2.2 Tuber Bulking Rate*

Application of organic manure as 50 per cent FYM and 50 per cent groundnut cake ($M_4$) registered the highest tuber bulking rate (TBR) at different tuber growth stages (Table 4.13 and Fig. 11). Groundnut cake is reported to have narrow C : N ratio which help in the quick release of nutrients in an easily available form. This resulted in higher plant spread, leaf area, LAI and LAD (Tables 4.3, 4.9 and 4.11) which might have increased dry matter partitioning and hence a higher tuber bulking rate during different tuber growth stages.

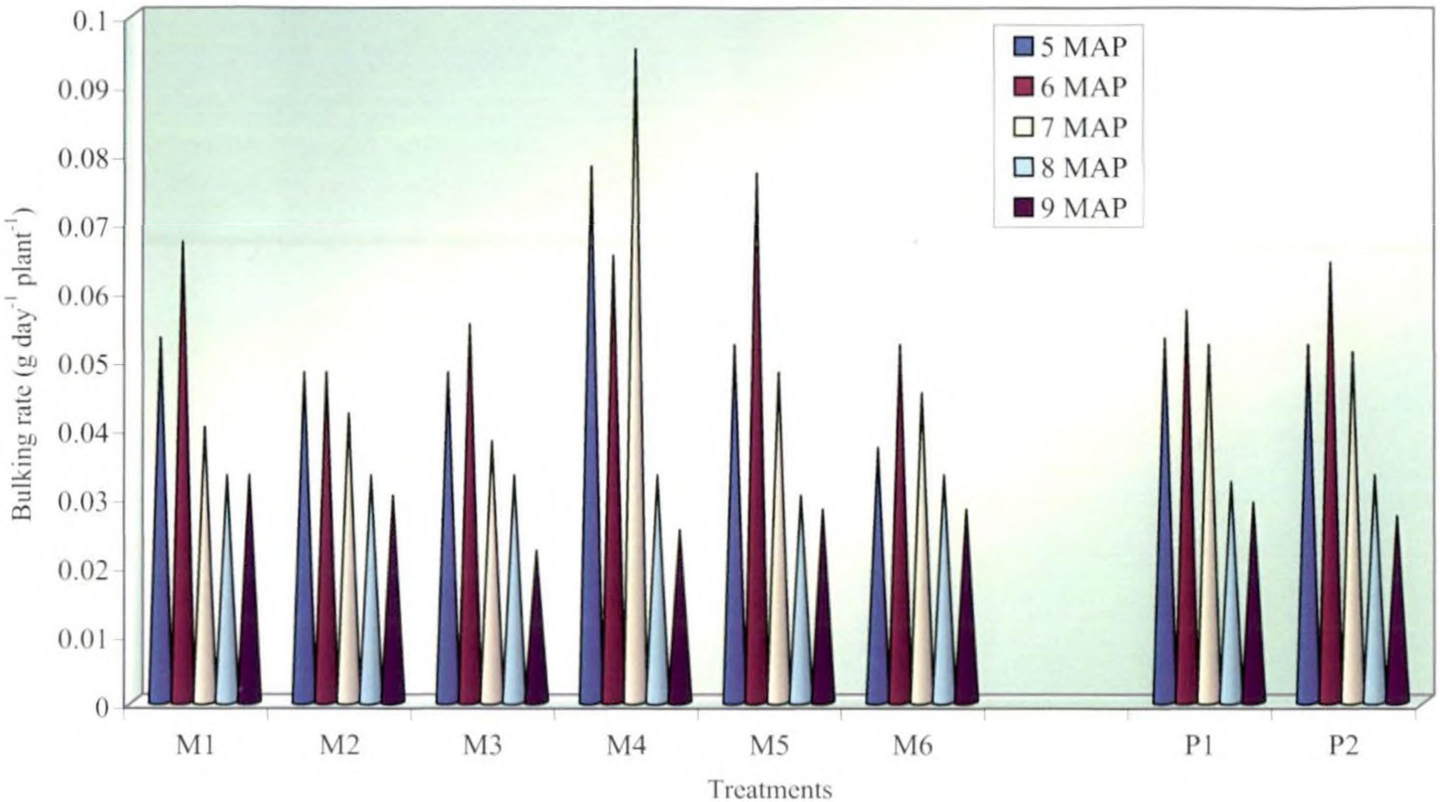


**Fig. 11. Effect of organic manure and planting weight of tuber on tuber bulking rate**

## 5.3 YIELD AND YIELD ATTRIBUTES

The results on yield attributes like number and length of tubers clearly indicate the positive effect of the treatment $M_4$ (50 per cent FYM and 50 per cent groundnut cake) on these attributes (Table 4.14 and Fig. 12). The application of organic manure might have provided better soil physical environment for root growth in terms of root length and spread which in turn might have resulted in higher uptake of nutrients and water, leading to more tuber yield. Moreover, FYM serve as a buffer against fluctuations in moisture availability and promoted better root growth (Tandon, 1994). The fresh tuber yield also followed the same trend as that of yield attributing characters and was also the highest in plots that received nutrients through 50 per cent FYM and 50 per cent groundnut cake (Table 4.16 and Fig. 13). The higher response of yield attributing characters like tuber number (18.61) and tuber length (18.90 cm) to this treatment has favoured the increased absorption of nutrients and translocation of photosynthates resulting in increased fresh tuber yield.

The yield attributes were also appreciably favoured by the higher planting weight of tuber (Fig. 12). Large sized tubers tend to emerge earlier, promote vigorous initial growth of roots and leaves, initiate tubers earlier resulting in rapid tuber bulking and hence tuber yield. Moreover, larger tubers had more food material which could be translocated directly to the new tuber (Nwoke *et al.*, 1973; Onwueme, 1975). The fresh tuber yield was also the highest with higher planting weight of tuber (Fig. 13). In general, yield tends to increase with increasing tuber size. Large tuber size resulted in more rapid emergence (Onwueme, 1972; Onwueme, 1973). The greater potential of direct transfer of food material to the new tubers and the vigorous plant growth put forth by the large sized tubers effecting early, longer and greater tuber bulking and larger storage size might have eventually resulted in higher tuber yield (Onwueme and Charles, 1994). Moreover, the uptake of nutrients was also higher with higher planting

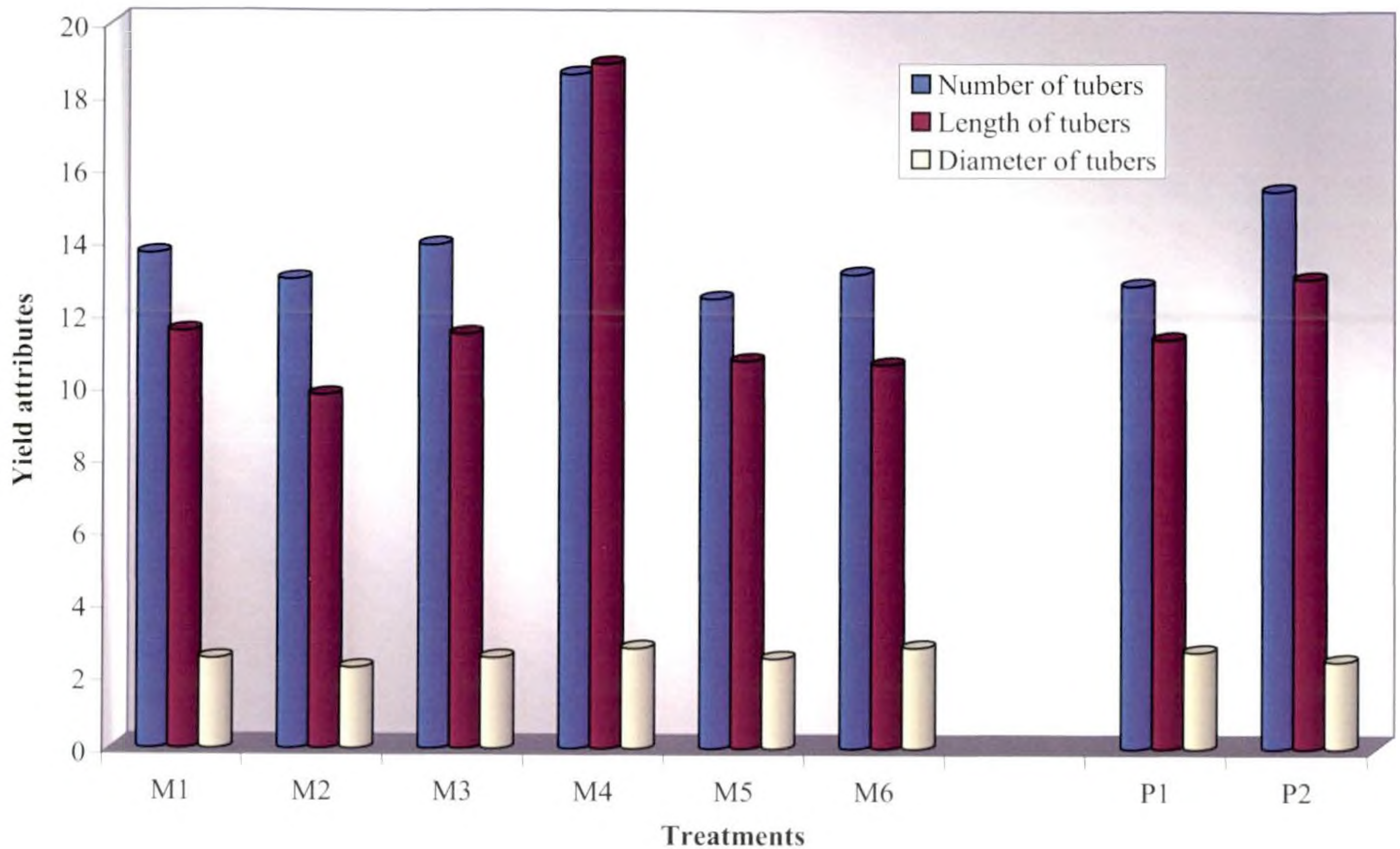


**Fig. 12. Effect of organic manure and planting weight of tuber on number, length and diameter of tubers**

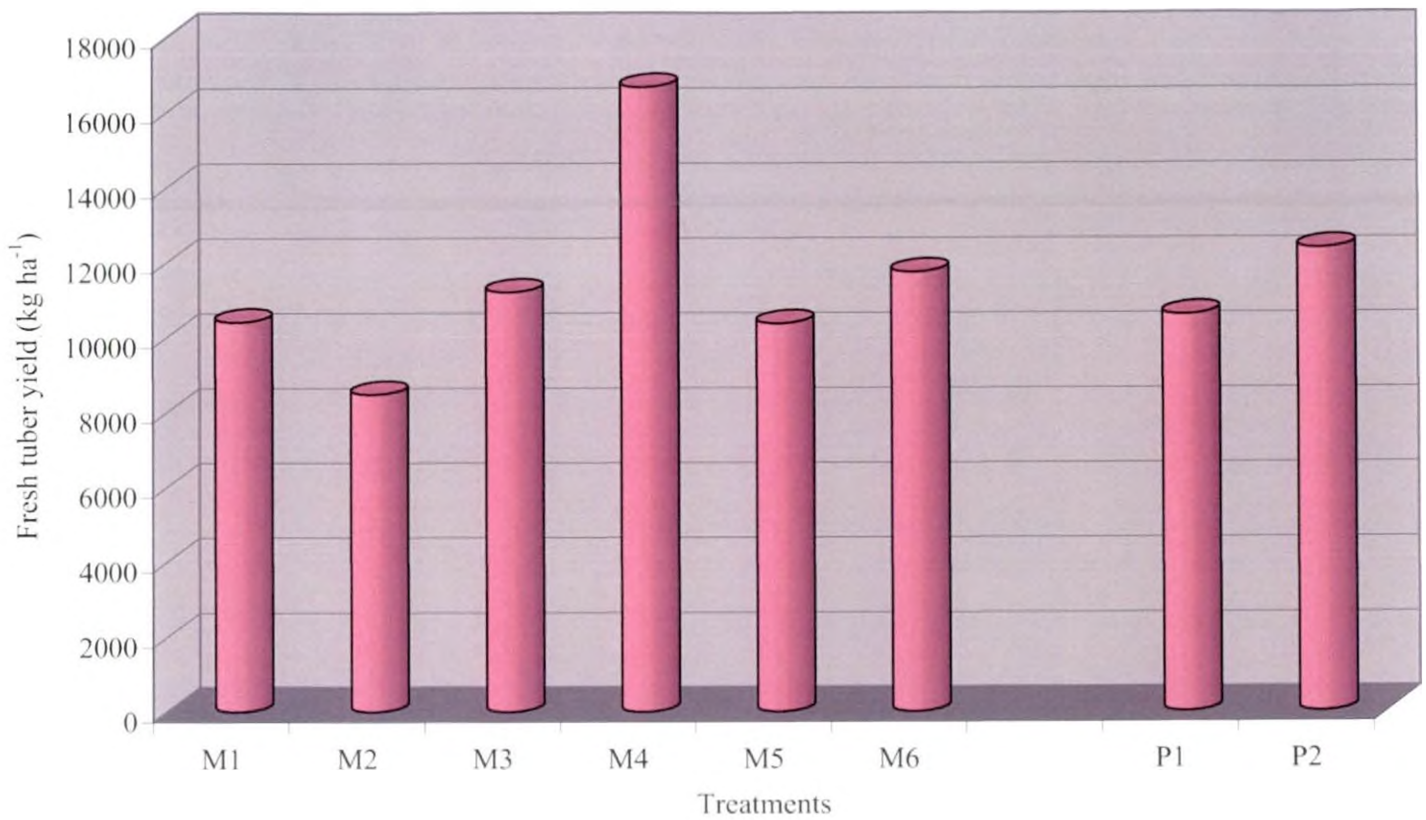


**Fig. 13. Effect of organic manure and planting weight of tuber on fresh tuber yield**

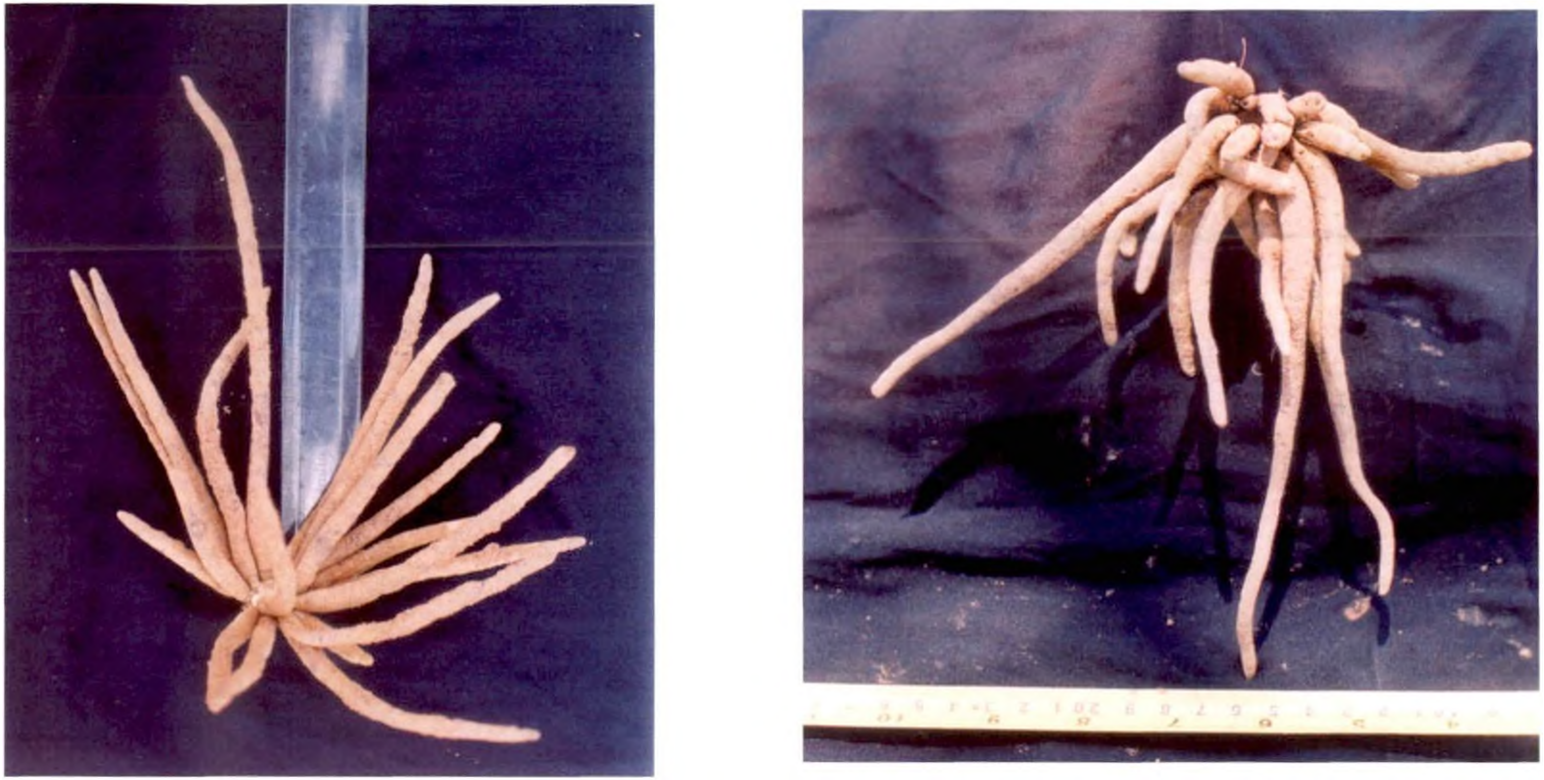

**Plate 5. Length and spread of tuber as influenced by 50 per cent FYM + 50 per cent ground nut cake + 15 g unit$^{-1}$ weight of tuber ($M_4P_2$)**

weight of tuber which finally contributed to the overall growth performance and yield. This is in agreement with the findings of Sengupta *et al.* (1986) in ginger.

The interaction of organic manure with planting weight of tuber positively influenced the root length. The favourable effect of organic manure and higher planting weight of tuber jointly accounted for the highest root length which is clear from the table (Table 4.1).

5.4 QUALITY PARAMETERS

**5.4.1 Fresh and Dry Weight of Tubers after Peeling**

Among the organic manures, 50 per cent FYM and 50 per cent groundnut cake ($M_4$) and between the two planting weights, higher planting weight of tuber (15 g unit$^{-1}$) recorded the maximum fresh and dry weight of tubers after peeling (Table 4.16 and Fig. 14 and 15). Since the contribution of peel weight towards the fresh tuber weight was marginal, same trend as in fresh tuber yield was observed in fresh weight of tubers after peeling. The dry tuber yield after peeling also followed the same trend as that of fresh tuber weight after peeling.

Among the interactions, the treatment combination $M_4P_2$ (50 per cent FYM + 50 per cent groundnut cake along with 15 g unit$^{-1}$ weight of tuber) resulted in the highest fresh weight of tuber after peeling. This could be due to the complementary significant influence of FYM and groundnut cake along with higher planting weight of tuber on fresh tuber yield after peeling which is clear from Table 4.17.

**5.4.2 Phytochemical Analysis**

The saponin content in the crop from treatments $M_2$ (vermicompost alone), $M_4$ (50 per cent FYM + 50 per cent groundnut cake) and control (FYM basal @ 10 t ha$^{-1}$ + NPK @ 100:80:80 kg ha$^{-1}$) were only analysed. From the results it could be seen that the saponin content was the highest (1.45%) in the treatment where nutrients were

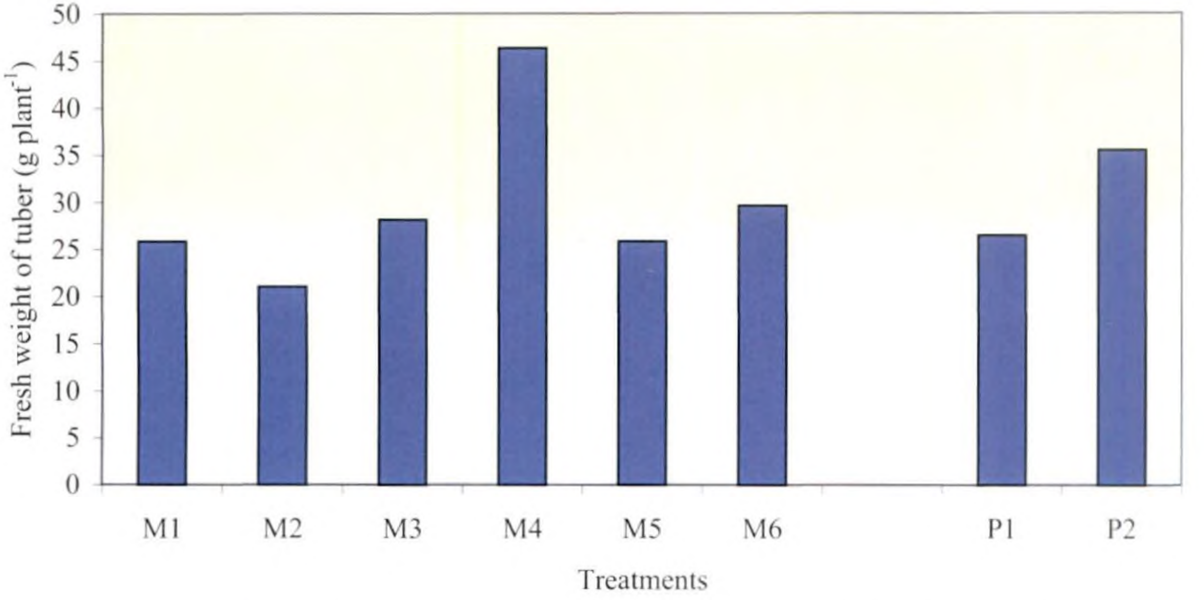


**Fig. 14. Effect of organic manure and planting weight on fresh weight of tuber after peeling**

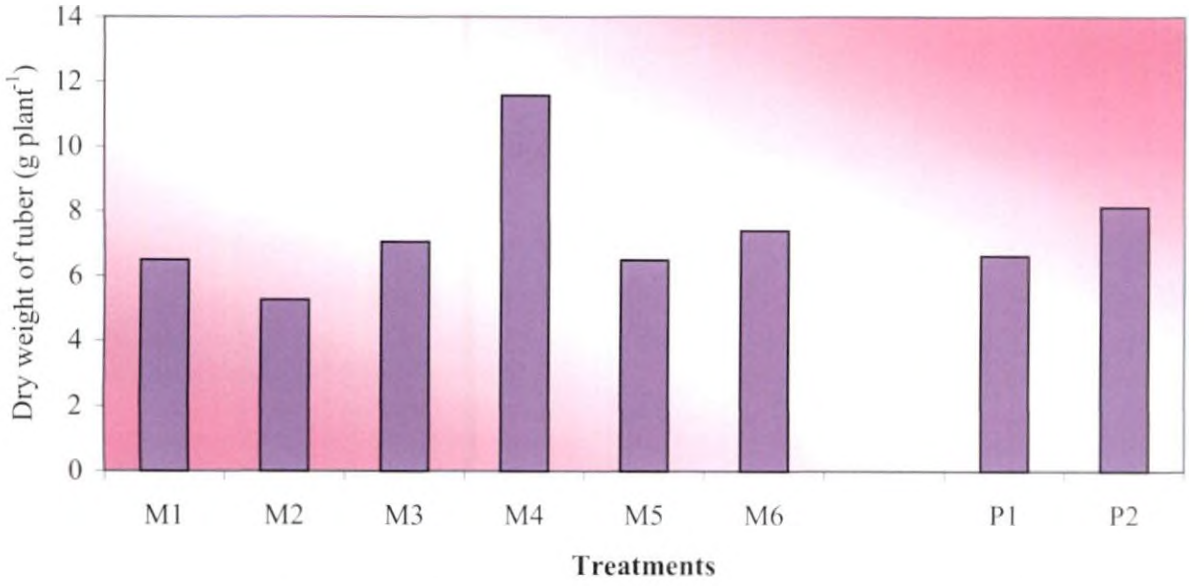


**Fig. 15. Effect of organic manure and planting weight on dry weight of tuber after peeling**

given as 50 per cent FYM + 50 per cent groundnut cake ($M_4$). Saponin content of 1.01% was recorded in the treatment $M_2$ (vermicompost alone application). The lowest saponin content was in control where FYM @ 10 t $ha^{-1}$ as basal + NPK @ 100:80:80 kg $ha^{-1}$ was given (0.82%). Hence it could be inferred that the same organic combination of FYM and groundnut cake ($M_4$) which produced the highest fresh and dry tuber yield in safed musli is effective in improving the quality of the crop also. Also it could be inferred that the application of nutrients as chemical fertiliser may affect the saponin content in the crop leading to an inferior quality produce. Even though vermicompost application ($M_2$) did not cause much reduction in saponin content when compared to $M_4$, the fresh tuber yield was not satisfactory in $M_2$. Hence it is wise to use the combination of organic sources to get good yield and better quality produce.

## 5.5 NUTRIENT UPTAKE

### 5.5.1 Uptake of N, P and K

Organic manures had significant influence in the uptake of N, P and K (Table 4.18 and Fig. 16). Significantly higher uptake for N, P and K was observed in plots that received nutrients through 50 per cent FYM and 50 per cent groundnut cake ($M_4$). Higher uptake of N under this treatment could be attributed to the narrow C : N ratio and high content of N (5.8 per cent) in groundnut cake. This was reflected in better growth of the crop and ultimately higher fresh tuber yield. Increased P uptake could be attributed to the release of fixed P to available form by the phosphatase enzyme in FYM. Bopiah and Shetty (1991) also reported that application of FYM increased the activity of phosphatase enzyme which enhanced P availability. The K uptake also followed the same trend as that of N and P. Organic manure application might have improved the soil physical property which in turn favoured the production of better root system. As uptake of K is mostly through root interception, better root system

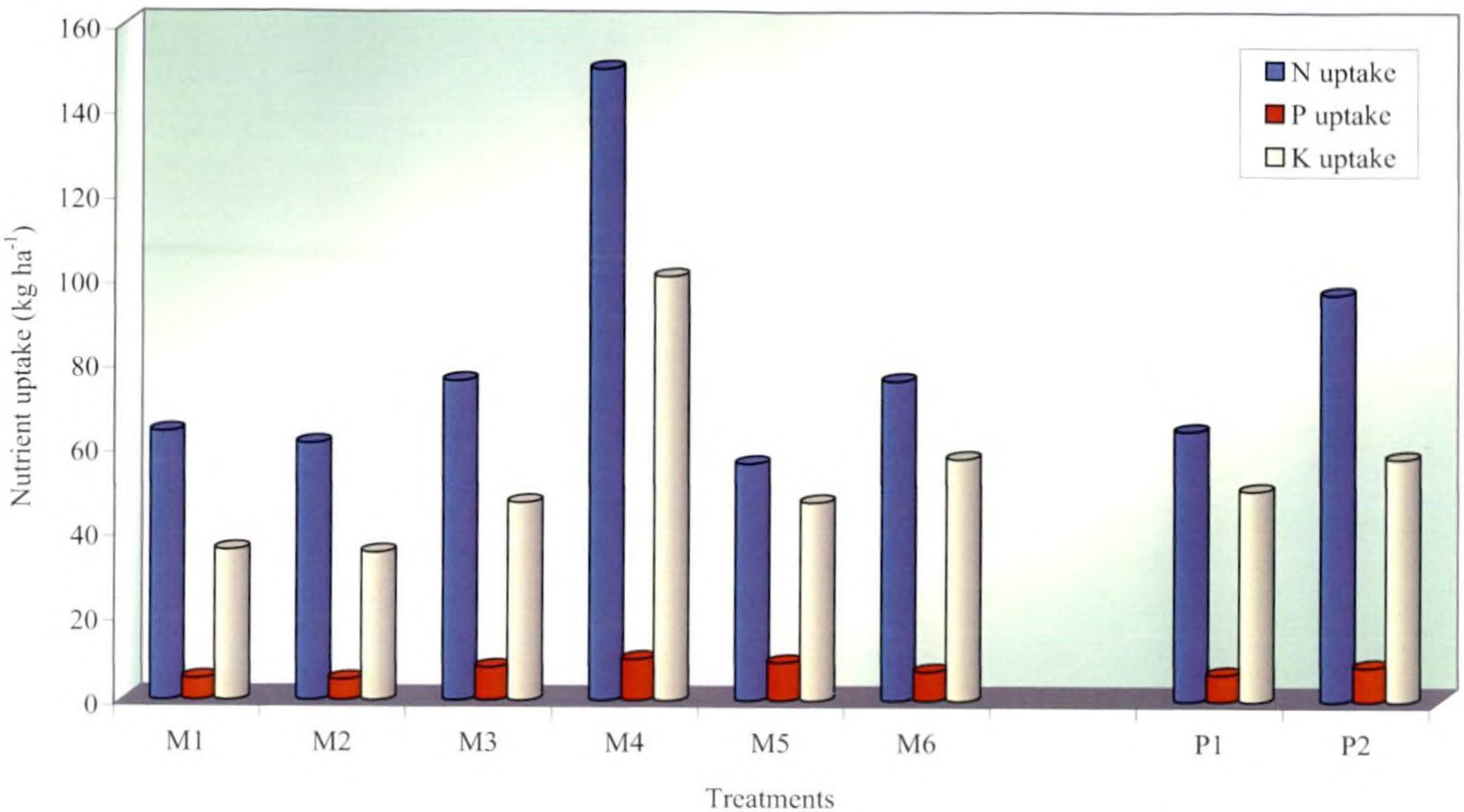


**Fig. 16. Effect of organic manure and planting weight of tuber on nutrient uptake**

resulted in more K uptake. This agrees with the findings of Niranjana (1998).

Uptake of nutrient was significantly influenced by planting weight of tuber (Fig. 16). Planting weight of tuber @ 15 g $unit^{-1}$ recorded significantly superior values for uptake of N (96.62 kg $ha^{-1}$), P (8.20 kg $ha^{-1}$) and K (57.56 kg $ha^{-1}$). When 15 g $unit^{-1}$ weight of planting material was used, it resulted in early emergence, better canopy spread, higher leaf number and leaf area. All these parameters might have resulted in better photosynthesis leading to better biomass production which in turn resulted in better uptake of nutrients.

Considering the interaction, higher planting weight of tuber (15 g $unit^{-1}$) with 50 per cent FYM and 50 per cent groundnut cake ($M_4$) resulted in higher uptake of N and K. This could be due to the combined favourable influence of organic manure and planting weight of tuber on uptake of N and K which is clear from Table 4.21.

### 5.5.2 Available Nutrient Content in Soil

As indicated in Table 4.20, available N content in soil was significantly higher in plots that received 50 per cent FYM and 50 per cent neem cake ($M_5$). Neem, mahua, karanj and castor oil cakes have great value as means of immobilisers, thus conserving the applied and soil nitrogen and mineralizing steadily over a longer period. The could aid in metered supply of nitrogen over a stipulated period of crop growth (Hulagur, 1993). In this particular study, since safed musli was a crop with a shorter vegetative growth period it was not benefitted by the above metered supply of nitrogen in neem cake and hence the uptake was also less resulting in high availability of N in soil after the experiment. Among the various organic manures, the highest value for soil P (41.72 kg $ha^{-1}$) was recorded by $M_4$ (50 FYM + 50 per cent groundnut cake). The application of organic manure is important to maintain and sustain a higher level of soil fertility and crop productivity. Due to the increased microbial activity in organic manure, P solubilisation might have improved, increasing the P status of soil. Sadanandan *et al.* (1998) reported that in ginger, groundnut cake application increased the Bray P and exchangeable K content of soil. For soil K the highest value was for the treatment receiving 50 per cent FYM + 50 per cent neem cake (249.81 kg $ha^{-1}$). In the presence of organic manures, the K fixation might have reduced thereby releasing more K in the soil and thus increasing the K status of soil. Sadanandan and Iyer (1986) also reported that the application of neem cake added organic carbon and potash to the soil.

Available nutrient status was significantly influenced by planting weight of tubers. Lower planting weight of tuber (10 g $unit^{-1}$) registered higher value for N availability (234.45 kg $ha^{-1}$). This might be due to lower uptake of N by lower weight of tuber. In case of K availability, higher planting weight recorded higher available K in soil (232.42 kg $ha^{-1}$). The growth factors such as plant spread, number of leaves and suckers and leaf area were higher in the treatment where higher planting weight of tuber was used. For safed musli the vegetative period was only upto four months (Fig. 3) and hence the foliage was retained only upto 4 MAP and after that the leaves dried and plant entered into senescence phase. These dried leaves fallen to soil, might have decomposed and contributed to the potash content of the soil resulting in higher K availability with higher weight of planting material.

The interaction of organic manure with planting weight of tuber also significantly influenced the available nutrient status. The available N and K were highest in the treatment combination $M_5P_1$ (50 per cent FYM and 50 per cent neem cake along with 10 g $unit^{-1}$ tuber) and $M_5P_2$ (50 per cent FYM and 50 per cent neem cake along with 15 g $unit^{-1}$ tuber) which is clear from Table 4.23. The reduced crop uptake of N and K in these treatments along with the slow release of N in neem cake contributed to enhanced N and K in $M_5P_1$ and $M_5P_2$.

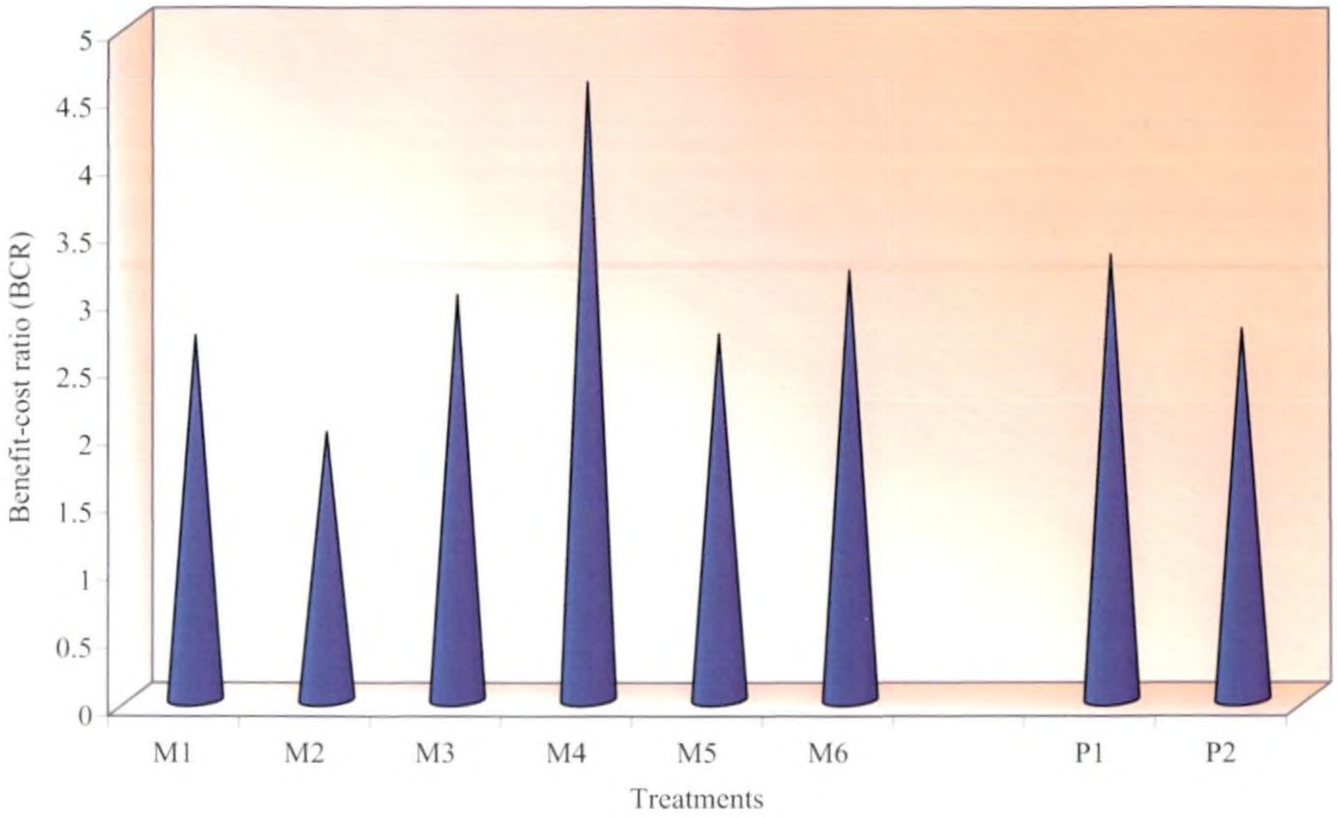


**Fig. 17. Effect of organic manure and planting weight of tuber on benefit cost ratio**

Plate 6. Harvested musli tubers in treatment $M_4P_2$ (50 per cent FYM + 50 per cent groundnut cake + 15 g unit$^{-1}$ weight of tuber)

## 5.6 ECONONOMIC ANALYSIS

The economics of cultivation of safed musli with different sources and doses of organic manure with two different planting weights of tuber revealed wide variation in economics (Tables 4.22, 4.23 and 4.24 and Fig. 17). The highest net returns was in $M_4P_2$ (50 per cent FYM and 50 per cent groundnut cake along with 15 g $unit^{-1}$ weight of tuber), followed by $M_4P_1$. This clearly indicated the advantage of using FYM and groundnut cake in combination for economic returns. The highest B:C ratio was in $M_4P_1$ followed by $M_4P_2$ reminding the high input cost involved in the purchase of higher quantity of planting material. The lowest net returns and B:C ratio were in $M_2P_2$, revealing the high cost of per rupee investment involved in nutrients.

# *Summary*

# 6. SUMMARY

A field experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during the year 2004-2005 to study the adaptability and performance of safed musli when different sources of organic manures such as FYM, vermicompost, neem cake and groundnut cake were used separately and in combination. Standardisation of agro techniques like planting weight of tuber and doses of different organic sources were also undertaken.

The experiment was laid out in factorial randomised block design with three replications. The treatments consisted of five sources of organic manures - $M_1$ – FYM @ 30 t $ha^{-1}$ (farmers' practice), $M_2$ – vermicompost, $M_3$ – 50 per cent FYM + 50 per cent vermicompost, $M_4$ – 50 per cent FYM + 50 per cent groundnut cake, $M_5$ – 50 per cent FYM + 50 per cent neem cake and $M_6$ (control), *viz.*, FYM @ 10 t $ha^{-1}$ as basal + NPK @ 100 : 80 : 80 kg $ha^{-1}$and two different planting weight of tuber such as 10 g $unit^{-1}$($P_1$) and 15 g $unit^{-1}$ ($P_2$). The salient findings of the experiment are summarised below :

1. Organic manure and planting weight of tuber significantly influenced plant spread and number of leaves throughout the vegetative stage of growth, *viz.*, 1, 2 and 3 MAP. At all the stages 50 per cent FYM + 50 per cent groundnut cake ($M_4$) and planting weight @ 15g $unit^{-1}$of tuber ($P_2$) recorded the maximum plant spread and number of leaves. Interaction effects were significant in leaf production at 3 MAP. Application of nutrients as 50 per cent FYM + 50 per cent groundnut cake along with 15 g $unit^{-1}$ weight of planting material ($M_4P_2$) produced the highest number of leaves and was significantly superior to other combinations.

2. Organic manure had no significant influence on sucker production. On the other hand, planting weight of tuber significantly influenced the

sucker production and planting weight @ 15 g $unit^{-1}$ ($P_2$) produced maximum sucker.

3. Duration for 50 and 75 percent crop emergence, suckering and flowering were significantly influenced by organic sources and application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) took less time for crop emergence, suckering and flowering. The treatment $M_4$ was on par with $M_2$ (vermicompost alone) in crop emergence and with $M_2$ and $M_3$ (50% FYM + 50% vermicompost) in suckering.

   Planting weight of tuber significantly influenced the period for 75 per cent crop emergence and suckering and planting weight @ 15 g $unit^{-1}$ ($P_2$) registered less time and was significantly superior to the other planting weight of 10 g $unit^{-1}$ ($P_1$).

4. Organic manure, planting weight of tuber and their interaction did not influence the maturity period of the crop.

5. Leaf area and leaf area index were significantly influenced by organic manure throughout the vegetative stages, *viz.*, 1, 2 and 3 MAP. The highest leaf area was in the treatment where organic manure was applied as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) and was significantly superior to all other organic sources. Planting weight of tuber also significantly influenced the leaf area and leaf area index at these stages and planting weight @ 15 g $unit^{-1}$ ($P_2$) produced the highest leaf area and was significantly superior to the other planting weight of 10 g $unit^{-1}$ ($P_1$). Interaction effects were significant at 2 and 3 MAP. At these stages the highest leaf area and leaf area index were recorded in $M_4P_2$ (organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) was given in combination with 15 g $unit^{-1}$ weight of tuber) and was significantly superior to all other combinations.

6. The highest leaf area duration was in the treatment where 50 per cent FYM + 50 per cent groundnut cake ($M_4$) was applied as organic source. This was significantly superior to all other organic sources. Planting weight of tuber also significantly influenced the leaf area duration and the highest LAD was in the treatment $P_2$ where 15 g unit$^{-1}$ weight of tuber was used as planting material. This was significantly superior to the other planting weight of 10 g unit$^{-1}$ ($P_1$).

7. The highest dry matter production was recorded in the treatment where 50 per cent FYM + 50 per cent groundnut cake ($M_4$) was applied as organic source and was significantly superior to other organic sources. Planting weight of tuber also significantly influenced the dry matter production. The highest dry matter production was observed in $P_2$ where 15 g unit$^{-1}$ weight of planting material used and was significantly superior to the lower planting weight of tuber (10 g unit$^{-1}$). Among the interactions, 50 per cent FYM + 50 per cent groundnut cake ($M_4$) in combination with 15 g unit$^{-1}$ weight of tuber ($P_2$) produced the highest dry matter and was significantly superior to other combinations.

8. Tuber bulking rate (TBR) was significantly influenced by organic manures at two different stages of tuber growth, *viz.*, 5 and 7 MAP. The highest TBR was in $M_4$ where organic manure was applied as 50 per cent FYM + 50 per cent groundnut cake.

9. The highest fresh tuber yield was obtained in the treatment where 50 per cent FYM + 50 per cent groundnut cake ($M_4$) was applied as organic source and was significantly superior to all other organic sources. Planting weight of tuber also significantly influenced the fresh tuber yield. The highest fresh tuber yield was recorded in treatment $P_2$ where 15 g unit$^{-1}$ weight of tuber was used as planting material and was significantly superior to the other planting weight of 10 g unit$^{-1}$ ($P_1$).

10. The tuber number and length were significantly influenced by organic sources and application of 50 per cent FYM + 50 per cent groundnut cake ($M_4$) produced the highest and longest tubers. This was significantly superior to all other organic sources. Among the interactions, 50 per cent FYM + 50 per cent groundnut cake ($M_4$) in combination with 15 g unit $^{-1}$ weight of tuber ($P_2$) produced the longest tuber which was significantly superior to all other treatment combinations. The diameter of tuber was significantly influenced by planting weight of tuber only and the highest diameter was observed in $P_1$ where 10 g unit$^{-1}$ weight of planting material used.
11. Among the organic manures, application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) produced the highest fresh and dry weight of tuber after peeling which was significantly superior to other organic sources. The planting weight of tuber also had significant influence on the fresh and dry weight of tuber after peeling and planting weight @ 15 g unit$^{-1}$ ($P_2$) produced significantly higher fresh and dry weight of tuber after peeling. Among the interactions, combination of $M_4$ (50 per cent FYM + 50 per cent groundnut cake) and $P_2$ (planting weight of tuber @ 15 g unit$^{-1}$) recorded the highest fresh and dry weight and was significantly superior to other treatment combinations.
12. The saponin content in the crop from treatments $M_2$ (vermicompost alone), $M_4$ (50 per cent FYM + 50 per cent groundnut cake) and control (FYM basal @10 t ha$^{-1}$ + NPK @ 100:80:80 kg ha$^{-1}$) were only analysed. The analysis revealed the highest saponin content in $M_4$ where the nutrients were given as 50 per cent FYM + 50 per cent groundnut cake.
13. Organic manures significantly influenced the uptake of nutrients. Application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$), recorded the highest uptake of N, P and K and was significantly superior to other organic sources.

Between the two planting weights of tubers, the uptake was significantly higher for the higher planting weight of tuber, *viz.*, @ 15 g unit$^{-1}$ ($P_2$). Among the interactions, combination of $M_4$ (50 per cent FYM + 50 per cent groundnut cake) with $P_2$ (planting weight of tuber @ 15 g unit$^{-1}$) recorded the highest uptake values for N and K and was significantly superior to all other treatment combinations.

14. Organic manures significantly influenced the available nutrient content in soil. Application of organic manure as 50 per cent FYM + 50 per cent neem cake ($M_5$) recorded the highest available N content which was significantly superior to other organic sources. Between the two planting weight of tubers, planting weight of tuber @ 10 g unit$^{-1}$ ($P_1$) recorded the highest available N content and was significantly superior to the other planting weight of 15 g unit$^{-1}$ ($P_2$). The highest available N content was recorded in the treatment combination $M_5P_1$ where 50 per cent FYM + 50 per cent neem cake along with 10 g unit$^{-1}$ weight of tuber was used and was significantly superior to all other treatment combinations.

15. Application of organic manure as 50 per cent FYM + 50 per cent groundnut cake ($M_4$) recorded the highest available P and K content in soil and was significantly superior to other organic sources. Planting weight of tuber @ 15 g unit$^{-1}$ ($P_2$) recorded the highest available K content and was significantly superior to the lower planting weight of 10 g unit$^{-1}$ ($P_1$). The combination $M_4P_2$ where 50 per cent FYM + 50 per cent neem cake along with planting weight of tuber @ 15 g unit$^{-1}$ recorded the highest available P and K content in soil which was significantly superior to all other treatment combinations.

16. Economic analysis of the study revealed that the maximum net returns was obtained for the treatment where 50 per cent FYM + 50 per cent groundnut cake in combination with 15 g $unit^{-1}$ weight of planting material used. But the B:C ratio was highest for the treatment where 50 per cent FYM + 50 per cent groundnut cake along with 10 g $unit^{-1}$ weight of planting material used.

**Future line of work**

- Proper screening of accessions should be done for selection of varieties suitable for Kerala.
- Standardization of other agro techniques like depth of planting, method of planting and spacing should be done.
- The water requirement of crop should be standardized.
- More studies to be conducted for fixing the optimum quantity of nutrients.
- Further studies to be conducted to find out the effect of pinching of inflorescence in tuber yield.
- Micro-propagation techniques to be evolved for rapid propagation of safed musli.

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*Original not seen

# AGROTECHNIQUES FOR SAFED MUSLI
# (*Chlorophytum borivilianum* SANTAPAU AND FERNANDES) IN KERALA

SUMA, V.K.

Abstract of the
thesis submitted in partial fulfilment of the requirement
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Department of Agronomy
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

# ABSTRACT

A field experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during the year 2004-2005, to study the adaptability and performance of safed musli under different sources of organic manures. Standardization of agro techniques such as planting weight of tuber and doses of nutrients were also undertaken.

The experiment was laid out in factorial randomised block design with three replications. The treatments consisted of five sources of organic manures - $M_1$ – FYM @ 30 t $ha^{-1}$ (farmers' practice), $M_2$ – vermicompost, $M_3$ – 50 per cent FYM + 50 per cent vermicompost, $M_4$ – 50 per cent FYM + 50 per cent groundnut cake, $M_5$ – 50 per cent FYM + 50 per cent neem cake and $M_6$ (control), *viz.*, FYM @ 10 t $ha^{-1}$ as basal + NPK @ 100 : 80 : 80 kg $ha^{-1}$ and two different planting weight of tubers such as 10 g $unit^{-1}$ ($P_1$) and 15 g $unit^{-1}$ ($P_2$).

Organic manure and planting weight of tuber had significant influence on most of the growth and yield attributing characters of safed musli. The fresh and dry tuber yield of safed musli as well as saponin content were also influenced by treatments.

Results of the study revealed that application of organic manure as 50 per cent FYM + 50 per cent groundnut cake significantly improved the growth characters like plant spread, number of suckers $hill^{-1}$ and number of leaves $plant^{-1}$ and physiological parameters like LAI, LAD and TBR. Similar trend was also observed for yield and yield attributing characters like length, diameter and number of tubers. Among the quality parameters, fresh and dry weight of tuber after peeling and saponin content were highest in the treatment where 50 per cent FYM + 50 per cent groundnut cake was applied as organic source. The N, P and K uptake were

maximum in 50 per cent FYM + 50 per cent groundnut cake applied plots. The available N and K content in soil were the highest in 50 per cent FYM + 50 per cent neem cake treated plots where as P availability was maximum in plots that received nutrients as 50 per cent FYM + 50 per cent groundnut cake.

Planting weight of tuber also significantly influenced the various growth and yield attributing characters. The growth characters like plant spread, number of suckers $hill^{-1}$ and number of leaves $plant^{-1}$ and physiological parameters like LAI, LAD and TBR were the highest in treatments where 15 g $unit^{-1}$ weight of tuber was used as planting material. The yield, yield attributing characters and quality parameters were also the maximum in the same treatment. The uptake and availability of nutrients were also the maximum in the treatment where higher planting weight of tuber was used (15 g $unit^{-1}$).

Economic analysis revealed that planting safed musli @ 15 g $unit^{-1}$ weight of tuber and applying nutrients as 50 per cent FYM + 50 per cent groundnut cake could fetch maximum net return whereas for getting the highest BCR, it is wise to use 10 g $unit^{-1}$ weight of planting material along with 50 per cent FYM + 50 per cent groundnut cake.

# *Appendix*

# APPENDIX - I

**Weather data during the cropping period (June 2004 – March 2005)**

| Period | Maximum Temperature, °C | Minimum Temperature, °C | Rainfall, mm | Evaporation, mm | Relative Humidity, % |
|---|---|---|---|---|---|
| June | 30.4 | 21.0 | 223.5 | 3.2 | 83.7 |
| July | 29.8 | 21.5 | 295.0 | 3.1 | 85.2 |
| August | 30.2 | 21.3 | 71.7 | 3.8 | 83.6 |
| September | 30.6 | 23.0 | 201.4 | 3.8 | 83.9 |
| October | 30.5 | 22.7 | 180.1 | 3.4 | 82.3 |
| November | 29.1 | 20.8 | 206.6 | 2.7 | 85.7 |
| December | 31.5 | 22.1 | 16.0 | 3.0 | 81.2 |
| January | 32.5 | 22.7 | 1.0 | 3.6 | 76.9 |
| February | 32.9 | 22.9 | 0.2 | 3.9 | 76.7 |
| March | 34.5 | 24.1 | 1.1 | 4.6 | 75.3 |