DEVELOPMENT AND EVALUATION OF BIO-ORGANIC COMPOSITE MANURE FOR VEGETABLES

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DEVELOPMENT AND EVALUATION OF BIO-ORGANIC COMPOSITE MANURE FOR VEGETABLES

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DECLARATION

I hereby declare that this thesis entitled **" Development and evaluation of bio-organic composite manure for vegetables"** is a bonafide record of research 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, fellowship or other similar title, of any other University or Society.

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@	-	at the rate of
Al	–	Aluminium
AMF	–	Arbuscular mycorrhizal fungi
°C	-	Degree Celsius
%	-	Per cent
B	-	Boron
BCR	-	Benefit Cost Ratio
C	-	Carbon
Ca	-	Calcium
CD	-	Critical difference
CEC	–	Cation exchange capacity
CHO	-	Carbohydrate
cm	-	Centimetre
cm^2	-	Square centimeter
C:N	–	Carbon : Nitrogen
COM	–	Composite organic manures
Cu	–	Copper
DAT	–	Days after transplanting
DMP	–	Dry matter production
dSm^{-1}	–	Deci seimens per meter
et al.	-	And others
EC	–	Electrical conductivity
Fe	-	Iron
Fig.	-	Figure
FYM	-	Farmyard manure
g	–	Gram
GA	–	Giberellic acid
g $plant^{-1}$	-	Gram per plant
ha	–	Hectare
IAA	–	Indole acetic acid
i.e.	-	That is
K	-	Potassium
K_2O	-	Potash
Kg	–	Kilogram
kg $plant^{-1}$	–	Kilogram per plant
kg ha^{-1}	-	Kilogram per hectare
l	–	Litre
LAI	–	Leaf area index

m	-	Metre
m^2	-	Square metre
MAI	-	Months after incubation
mm	–	Millimetre
mg	–	Milligram
Mg	-	Magnesium
Mg m^{-3}	–	Megagram per cubic meter
mg 100 g^{-1}	–	Milligram per 100 gram
meq/100g	–	milliequivalent per 100 gram
µg 100 g^{-1}	–	Microgram per 100 gram
N	–	Nitrogen
Na	-	Sodium
No.	-	Number
NS	-	Not significant
P	-	Phosphorus
P_2O_5	–	Phosphate
Plant $^{-1}$	-	Per plant
PM	–	Poultry manure
POP	–	Package of Practices Recommendations
PSB	–	Phosphate solubilising bacteria
PSM	-	Phosphate solubilising microorganism
q ha^{-1}	–	Quintal per hectare
RD	–	Rock dust
RH	-	Relative humidity
RND	–	Recommended nitrogen dose
Rs	-	Rupees
SE	-	Standard Error
Sl.	–	Serial
Si	-	Silicon
t ha^{-1}	-	Tonnes per hectare
TSS	-	Total soluble sugar
VAM	–	Vesicular arbuscular mycorrhiza
VC	–	Vermi compost
viz.	–	Namely
WHC	–	Water holding capacity
Zn	-	Zinc

Introduction

1. INTRODUCTION

In recent years, a concern is being expressed at global level that chemical based energy-intensive modern agriculture is threatening the natural resource system through chemical contamination of soil and water bodies, global warming and ecological degradation. To address this issue, it is proposed to go for organic agriculture. Organic agriculture is holistic production management system that promotes and enhance agro-ecosystem health including bio-diversity, biological cycles and soil biological activity. Organic farming is becoming increasingly important in agriculture for sustainable development. Organic system enhances long term soil fertility, structure and biological activity and conserve soil resources. Organic agriculture is managing the agro-ecosystem as an autonomous system based on the primary production capacity of the soil under the given agro-climatic condition.

Organic manures will improve the physical, chemical and biological properties of the soil. Without organic matter , soil would become dead mass losing its productivity in course of time. Soils managed with organic amendments generally have a larger microbial population than those managed with mineral fertilizers. Thus the incorporation of organic amendment in soil promotes microbial activity (Balasubramanian et al, 1972). The organic matter rich soils have a stimulating tendency in the process of nitrification as well as availability of P and K. The high content of organic matter confers upon the soil, the capacity to hold the essential plant nutrients in sufficient amounts so as to provide nutrients as per the demand of the crop. But different organic manures vary widely in their relative efficiency in releasing nutrient from the soil. Hence a good knowledge of nutrient release pattern of organic manure on soil is highly essential for scheduling organic nutrient practices for crops.

One of the basic principles of soil fertility management in organic system is that plant nutrition depends on biologically- derived nutrients. Animal manures, oilcakes, biofertilizers and byproducts of agro industries are some of the potential sources of nutrients in organic farming. Low nutrient status, slow release of nutrients and imbalanced ratio of nutrients are the bottle necks associated with organic manures in serving as nutrients source for organic crop production. Role of bioinoculants in organic nutrition is well known.

Vegetable being rich source of minerals, vitamins and dietary fiber are vital in a well balanced human diet. These crops are highly responsive to organic manuring. Vegetables are protective as well as quality food and are essential for maintaining health status of people. Since vegetables are mostly consumed fresh or only partially cooked, they should be devoid of residual effect of chemicals. Organic farming is essential for producing quality vegetables devoid of toxic residuals. Organically grown vegetables are preferred for their flavor, taste, nutritive value and extended shelf life.

Considering all these aspects it is worthwhile to develop technologies for organic manure with higher nutrient status, better nutrient release and ideal nutrient ratios suitable for vegetable crops. The result of this investigation may help to develop strategies to develop bio-organic composite manures with safe C:N ratio containing at least 3% of N and N:K ratio of 1:0.5 , ideal ratio for most of the organically cultivated vegetables.

With this background the study was undertaken with the following objectives. To formulate and evaluate the quality of bio organic composite manures, study the mineralization pattern of bio organic composite manures, assess the effect of various bio organic composite manures on amaranthus crop and work out the economics.

Review of Literature

2. REVIEW OF LITERATURE

In recent years there had been a welcome awareness for ecofriendly organic products. Sustainable and ecofriendly agriculture, which minimizes the use of harmful and energy intensive inputs, is achievable through the use of organic and biofertilizers. It is one among the ways to maintain soil health. Organic nutrition in vegetables is especially important as they provide quality foods, which are very important for providing health security to people.

The main objective of the study was to assess the feasibility of developing good quality bio-organic composite manures for organic vegetable production . The available literature relating to the above topic is reviewed here under.

2.1 ORGANIC MANURES

India has vast potential of organic resources, which can be effectively utilized, to sustain yield, improve physical, chemical and biological properties of soil and maintain soil health. Organic manure serves as slow release of N, P and S for plant nutrition and microbial growth.

Farm yard manure and poultry manure are the most commonly used organic manures by the farmers of Kerala. Poultry manure is a rich source of nutrients especially for vegetable production (Jose et al, 1988). Its higher efficiency is due to the large quantities of easily mineralisable nitrogen (Meerabai and Raj, 2001). Due to high content of NPK it has been proved that one ton of poultry manure is equivalent to seven tons of FYM (Channabasavanna and Biradar, 2002).

Oil cake is concentrated organic manure and is comparatively richer in NPK. Neem cake is a non-edible oil cake. In addition to nutrients, it contains the alkaloids, nimbin and nimbicidin and certain sulphur components, which effectively inhibit the nitrification procedure and improve nitrogen use effectively in crops (Reddy and Prasad, 1985).

Coir pith, which is abundantly available in Kerala as a byproduct from coir industries, is found to be a good source of organic manure after decomposing it with *Pleurotus eous* and *Schizophyllum commune* (Reeja, 2002). Composting of coir pith helps in detoxifying phenolic compounds, reducing the bulkiness of the material and converting the plant nutrient to a form more readily available to plant.

Rockdust is a byproduct of quarry industry, 90% of which pass through 200 mesh screen. Rockdust helps to bind up excess atmospheric co_2 in both plant biomass and by chemical reaction (Leonardos et al, 1982)

Wood industries and power plants generate enormous quantities of wood ash. Wood ash K is very soluble in water, which explains its high susceptibility to leaching (Ulery et al., 1993). Calcium, Mg and K are the most acid soluble elements and Si and Al are the least soluble, which suggests, according to Ohno (1992) and Ohno and Erich (1993), that Si and Al are structural components of ash.

2.1.1 Effect of Organic Manures on Soil Properties

Soil organic matter plays a key role in the maintenance of soil fertility and productivity. The effect of organic matter may be either direct or indirect. Directly organic matter acts as a source of plant nutrients and indirectly influences the physicochemical properties of the soil at levels favourable for production.

Loganathan (1990) reported that application of organic amendments namely saw dust, ground nut shell powder, coir dust and FYM each @ 2.5 and 5 t ha^{-1} improved the soil physical characteristics like infiltration rate, total porosity and hydraulic conductivity of red soil with hard pan. Organic manures greatly influences the soil chemical properties like pH, EC, organic carbon and nutrients availability.

Miller and Donahue (1992) reported that application of organic matter increased the cation exchange capacity of the soil. The organic residues that are added to the soil undergo microbial decomposition. In the process, various organic acids and other products of decay are released which act as strong binding agent in the formation of large and stable soil aggregates. The action of gum components, polysaccharides and fulvic acids components of organic matter is considered important in this respect. As a result the soil structure is improved which is reflected in low bulk density values and better water conducting properties of the soil (Manickam , 1993). Incorporation of organic waste significantly increased the soil pH and nutrient status of an acid soil (Lal et al., 2000).Soil physical properties were considerably improved in plots that had residual organic manures as compared to residual POP in amaranthus (Asha , 2006)

2.1.1.1 Effect of Poultry Manure on Soil Properties

Maheswarappa et al. (1998) found a decrease in bulk density due to recycling FYM and poultry waste in coconut based farming systems. Rajasree (1999) found that, in bitter ground, partial substitution of chemical fertilizers with poultry manure decreased the bulk density and particle density of soil and increased the water holding capacity as compared to full dose of chemical fertilizers.

Nair (2003) reported that, in bitter ground, the lowest bulk density, maximum WHC and higher porosity was shown by the application of 100% N as poultry manure and was on par with the application of 100% N as FYM and 100% N as vermicompost. Asha (2006) reported that in amaranthus, the residual effect of poultry manure along with microbial inoculation lowered bulk density and particle density and improved porosity and WHC of the soil. Vimala et al (2006) reported that in cabbage, all rates of processed poultry manure (0, 15, 30, 45 and 60 t ha^{-1}) improved soil chemical properties compared to the inorganic fertilizer

2.1.1.2 Effect of Oil Cake on Soil Properties

Biswas et al.(1969) found that application of groundnut cake in a rice fallow rotation for ten years improved the water retention characteristics of an alluvial sandy loam soil. The application of neem cake added organic carbon and potash to the soil (Sadanandan and Iyer, 1986). Sadanandan and Hamza (1998) reported improved physical condition of the soil as a result of neem cake application in ginger. Asha (2006) reported that in amaranthus, the residual effect of neem cake along with microbial inoculation improved porosity and WHC of the soil

2.1.1.3 Effect of Coir Pith Compost on Soil Properties

Nambiar et al. (1983) observed that continuous application of coir dust for 8years improved the organic carbon status of the soil. Increase in water holding capacity of the soil due to coir pith application has been reported by Bhowmic and Debnath (1985). The use of coir pith as a soil conditioner in tropical farming is well established (Nagarajan et al., 1990). Incorporation of composted coir pith significantly increased the soil moisture content and improved other physical constants of the soil compared to other organic amendments (Subbaraj and Ramaswami, 1992).

Coir pith has high potassium content and low bulk density and particle density (Mapa and Kumara, 1995). High CEC, which varies from 38.9 to 60 meq/100g, enables it to retain large amounts of nutrients and the absorption complex has high contents of exchangeable K, Na, Ca and Mg (Verhagen and Papadopoulos, 1997). Application of coir pith to soil can improve hydraulic conductivity, porosity, water infiltration rate, water holding capacity and nutrient storage capacity (Prabhu and Thomas, 2002).Venkitaswamy (2003) reported that application of 100 per cent of the nutrient supply in coconut as composted coir pith recorded low pH and higher organic carbon content to that of fertilizer treated plots.

2.1.1.4 Effect of Ash on Soil Properties

Chang et al. (1977) have found an increasing hydraulic conductivity of the soil at low ash amendments and an increasing water holding capacity, but without subsequent increase in plant-available water. Etiegni and Campbell (1991) have shown that wood ash particles swell in contact with water and can obstruct soil pores. Consequently this may reduce the aeration and increase the water holding capacity.

According to Clapham and Zibilske (1992), the electrical conductivity of the soil solution increases linearly with wood ash dose and may cause salinity problems. Considering its chemical composition, wood ash constitutes an excellent source of major and minor nutrient elements and is therefore of interest in correcting certain nutrient deficiencies in soils. Application of wood ash increases soil pH and decreases the exchangeable Al content of acid soils (Lerner and Utzinger, 1986; Ohno and Erich, 1990; Ohno and Erich, 1993; Unger and Fernandez, 1990; Williams et al., 1996).

2.1.1.5 Effect of Rock dust on Soil Properties

Fragstein and Vougtmann (1987) observed an improvement in WHC and CEC of soil, by the application of RD. In an incubation study conducted in the laterite soils of Kottarakara during 2001-2003, the lowest bulk density of 1.10 mg m^{-3}, highest WHC of 57.33% and maximum pore space of 54.67% were observed when RD was applied @ 1t ha^{-1} along with lime (Shehana, 2006)

2.1.2 Effect of Organic Manures on Availability of Nutrients

Addition of organic matter primarily provides nitrogen to the crop. The organically bound form of nitrogen becomes available to the crop after decomposition, followed by mineralization into inorganic forms (Tusneem andPatric, 1971). Humus by virtue of its chelating properties increases the availability of N, P, S and other nutrients to plants growing in humus rich soils (Gaur, 1994). Appavu et al (2001) inferred that , incorporation of organic manures (coirpith, poultry manure, goat manure and FYM) increased the available Zn and Fe content of soil. The application of farmyard manure, poultry manure, and sugarcane filter cake alone or in combination with chemical fertilizers improved the soil organic C, total N, P, and K status compared to soils receiving chemical fertilizers only (Kulvinder et al, 2005).

2.1.2.1 *Effect of Poultry Manure on Availability of Nutrients*

Poultry manure is a good source of nutrients, particularly for vegetable production. In this, 60 per cent of the nitrogen is present as uric acid, 30 per cent as more stable organic nitrogen forms and the balance as mineral nitrogen. Application of poultry manure (15 t ha^{-1}) as source of nitrogen increased the exchangeable K and available K content of the soil in a tomato field (Julia et al., 1993). Sharu (2000) reported that highest level of poultry manure (5 t ha^{-1}) recorded highest level of soil N compared to vermicompost, neem cake and POP recommendation in chilli.

Nair (2003) reported that among FYM, poultry manure and vermicompost, poultry manure recorded the highest availability of nutrients N,P,K. Renu (2003) reported that among VC,PM and FYM, PM showed higher availability of N,P,and K. Asha (2006) observed that in amaranthus, residual poultry manure accumulated highest P,K,S and Zn content in soils. Vimala et al (2006) reported that in cabbage, all rates of of processed poultry manure (0, 15, 30, 45 and 60 t/ha) had significant effects on P and K contents.

2.1.2.2 *Effect of Oil Cakes on Availability of Nutrients*

Most of the non–edible oil cakes contain alkaloids, which inhabit the nitrification process of nitrogen transformation in soils. According to Sathianathan(1982) in cassava, neem and mahua cake treatments were efficient in retaining more nitrogen in the ammoniacal form under field condition. Neem cake contain the alkaloids, nimbin and nimbidin , which affectively inhibit the nitrification (Reddy and Prasad, 1985).

The neem , mahua, karanj and castor 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 stipulating period of crop growth (Hulagur, 1996). Asha(1999) reported that , in bhindi, available N content in soil was highest for neem cake application as compared to that of FYM, poultry manure and compost.

2.1.2.3 *Effect of Coir Pith Compost on Availability of Nutrients*

Coir pith acts in many ways in ensuring good nutrition to plants . As coir pith is rich in potash and being acidic, its application can enhance the release of fixed and mineral potassium in soil and hence the quantity of potash fertilizers can be reduced in agriculture (Savithri et al., 1993). As it decomposes slowly, potash will be available slowly for many years. Coir pith can also be enriched with cultures of beneficial microorganisms like Azotobacter and phosphate solubilisers (Moorthy and Rao, 1997).

Asha (1999) reported that addition of rock phosphate or bone meal and microbial inoculants (Azotobacter and Phosphobacter) reduced the decomposition period and improved the manurial value of enriched composts as compared to ordinary compost. Coir pith can prevent the loss of nutrients because of its high nutrients storage capacity by virtue of high CEC (Prabhu and Thomas,2002). Geetha et al. (2004) reported that coir pith could be composted using organic additives such as cow dung, poultry manure , bone meal and neem cake. Among various organic additives N content was found to be higher (0.58 %) with cow dung and bone meal.

2.1.2.4 *Effect of Ash on Availability of Nutrients*

Wood ash is essentially a direct source of other major elements, notably P, Ca, Mg and especially K in soils (Unger and Fernandez, 1990; Ohno and Erich, 1990). Ohno and Erich (1990) have found 48% of total Mg, 40% of total K and 5.7% of total P was available at pH 3.0. In general, P is the least available major nutrient in wood ash. However, application of wood ash to the soil initially results in a reduction of the solubility and availability of Fe, Mn, Zn and Cu (Clapham and Zibilske, 1992)due to the increasing soil pH (Troeh and Thompson, 1993). As soil pH decreases again over time microelements and trace elements from the ash and the soil will become more mobile and plant-available.

Since wood ash generally contains very little carbon and nitrogen, its application to the soil may reduce the total contents in C and N, by increasing the solubility of organic carbon (Kahl et al., 1996) and the nitrification rate (Meiwes, 1995 and Pietikäinen and Fritze, 1995).

2.1.2.5 *Effect of Rock dust on Availability of Nutrients*

Hamaker and Weaver (1982) reported that application of RD for corn crop resulted in an increase of 57% P, 90% K, 47% Ca and 60%Mg than chemically grown crop from the same seed. Fragstein and Vogtmann (1987) reported that RD contains most of the nutrients essential for plant growth except N and P. The incubation study conducted in the laterite soils of Kottarakara during 1999-2000 revealed that the release of available Zn and Mn were maximum immediately after application (Shehana, 2006). Incubation study revealed that increasing the rate of application of RD resulted in an increase in the available nutrient contents of soil (Divya, 2008)

2.1.3 Effect of Organic Manures on Nutrient Release Pattern in Soil

The nutrient release pattern of different organic manures was studied by various workers. Allison and Klein (1945) have reported that immobilization of nitrogen proceed very rapidly during the first seven days, then at a constantly decreasing rate. The average nutrient release percentage of wood ash : phosphorus (P), 5.7%; potassium (K), 40%; magnesium (Mg), 48%; calcium (Ca), 74%; sodium (Na), 16% (Ohno and Erich, 1990).

Eghball et al (2002) observed that mineralization of organic N is expected to be low for composted manure (~ 18%) and high for swine or poultry (hens) manure (~ 55%). In an incubation study conducted with FYM, poultry manure and vermicompost, Nair (2003) reported that there was a progressive increase in the availability of N and P_2O_5 till the 90th day for all the three manures and in the case of available K_2O there was a progressive increase up to the 60th day and there after decreased. Among the three organic manures, poultry manure showed higher availability of the three nutrients.

Sheeba (2004) inferred from an incubation experiment that available N, P_2O_5 and K_2O content of the soil increased up to 45 days of incubation, then the availability slowly declined. Asha (2006) reported that poultry manure mineralized rapidly releasing almost all its nutrients within a period of 30-60 days. Application of RD at a higher rate (12tha^{-1}) along with an equal quantity of FYM resulted in the maximum release of almost all nutrients viz N,P,K,Fe,Mn and Zn throughout the incubation period (Divya, 2008)

2.1.4 Effect of Organic Manures on Growth, Yield and Quality of Crops

Organic manures have been time tested materials for improving the fertility and productivity of soils. Role of various organic manures in improving the growth, yield and quality of crops are reviewed here under.

Gianquinto and Borin (1990) observed an increase in plant growth and yield of tomato plants by the addition of organic manures. Thamburaj (1994) found that organically grown tomato plants were taller with more number of branches. They yielded 28.18 t ha^{-1} which was on par with that of the recommended dose of FYM and NPK (20:100:100). Increase of ascorbic acid content in tomato, pyruvic acid in onion and minerals in gourds are the impact of application of organic manure to vegetable crops (Rani et al., 1997).

Asha(1999) reported that application of neemcake and poultry manure registered higher yields and produced quality fruits in bhindi as compared to that of POP recommendation and FYM. Meerabai et al. (2003) reported that, in chilli substitution of recommended nitrogen with organic manures like neem cake, poultry manure or green manures like cowpea or glyricidia can give comparable yields and net returns as that of the present POP recommendation by Kerala Agricultural University. Sheeba (2004) showed that the treatments with organic sources of plant nutrients recorded the highest value for beta carotene content, protein content and the lowest fiber and oxalate content in amranthus.

2.1.4.1 *Effect of Poultry Manure on Growth, Yield and Quality of Vegetables*

2.1.4.1.1 Growth Characters

Singh et al. (1973) reported that, in potato, poultry manure application exhibited better response over FYM on yield and growth attributes. Anitha (1997) reported that in chilli various growth attributes like plant height, number of branches, dry matter production and yield attributes were better with poultry manure application as compared to FYM or vermicompost.

Awodun (2007) reported that , in fluted pumpkin, poultry manure application increased no: of leaves and branches, length of internodes compared to NPK fertilizers. Shiyam et al (2010) reported that in amaranthus, application of a mixture of 30 kg urea-N ha^{-1} and 15 tones ha^{-1} of poultry manure produced the higher number of leaves per plant, the largest leaf area , highest number of branches per plant and longest vegetative life span

2.1.4.1.2 Yield and Yield Attributes

Anitha (1997) reported that in chilli, yield and yield attributes were better with poultry manure application as compared to FYM or vermicompost . Rajasree (1999) observed that when highest level of N (300 Kg) was supplied through 2:1 ratio of organic- chemical N substitution using poultry manure as organic source, it effectively increased the fruit yield and number of fruits per plant in bitter gourd.

Nair (2003) reported that application of 50 per cent N as poultry manure + 50 per cent N as chemical fertilizer significantly increased the growth, yield attributes and the total yield in bitter gourd. Awodun (2007) reported that , in fluted pumpkin, poultry manure application increased N,P,K,Ca and Mg content of leaves compared to NPK fertilizers.

Meena et al (2007) reported that application of 150% RND as PM produced significantly higher values of green pods/plant, green wt/plant, green pod yield in green peas. Ewolu et al (2008) observed that poultry manure applied at 10, 25, 40 and 50 t ha^{-1} of levels increased average fruit weight of tomato by 58, 102, 37 and 31. Shiyam and Binang (2010) reported that in amaranthus, application of a mixture of 30 kg urea-N ha^{-1} and 15 tones ha^{-1} of poultry manure produced highest fresh leaf mass and highest fresh stem mass

2.1.4.1.3 Quality Attributes

Poultry manure and mineral fertilizers at two rates of application improved the fruit colour of processing tomato and the raw protein content of spinach compared to control treatment (Pimpini et al, 1992). Anitha (1997) observed that chilli plants treated with poultry manure recorded the maximum ascorbic acid content of fruit as compared to vermicompost and control treatments. According to sharu (2000) poultry manure application registered maximum keeping quality of fruits compared to vermicompost, neem cake and POP recommendation.

Arunkumar (2000) reported that in amaranthus maximum protein content was obtained with poultry manure application as compared to that of FYM, vermicompost, coir pith compost and POP recommendation. Nair (2003)reported that quality attributes like ascorbic acid content and iron content were highest when chemical fertilizers was substituted with poultry manure in 1:1 ratio. The application of 150% RND as PM produced significantly higher values of protein content(%) and CHO content(%) in green peas (Meena et al,2007)

2.1.4.1.4 Nutrient Uptake

Abusaleha (1992) observed an increased uptake of N,P,K,Ca and Mg in bhindi when 40kg N was supplied through poultry manure compared to the application of the same quantity through farm yard manure or ammonium sulphate on equivalent nitrogen basis. Anitha (1997) observed the better uptake of N in poultry manure treated chilli plants as compared to control. Rao et al (2002) reported that in groundnut, application of FYM @ 10t ha^{-1} and PM @ 5t ha^{-1} increased uptake of N,P,K,S,Ca and Mg significantly over the control . Highest value for NPK content of plants and NPK uptake was obtained when chemical sources of N was substituted with PM in 1:1 ratio (Renu, 2003).

Asha (2006) observed that in slicing cucumber , K uptake was highest in poultry manure and neem cake applied plants. Meena et al (2007) observed that the total nutrient uptake also increased significantly in organic treatments compared to control and was highest with application of 150% RND as PM in green peas.

2.1.4.2 *Effect of Oil Cakes on Growth, Yield and Quality of Vegetables*

2.1.4.2.1 Growth Characters

Singh and Sitaramaiah (1963) reported increased plant height in bhindi due to oil cake application. Chinnaswamy (1967) observed better growth in tomato plants with the application of FYM and groundnut cake in organic mixture. Som et al. (1992) observed maximum plant height in brinjal with neem cake application (50 q ha^{-1}) as compared to other oil cakes tried. Sharu (2000) reported that in chilli the growth characters like plant height, number of branches and dry matter accumulation as a result of neem cake application was found to be on par with that of the POP recommendation of Kerala Agricultural University .

2.1.4.2.2 Yield and Yield Attributes

Som et al. (1992) while studying the influence of organic manures on growth and yield in brinjal found that maximum fruit length and diameter were recorded when mahua cake and neem cake were applied @ 50q ha^{-1} produced the maximum fruit weight of 125.38g, highest per plant yield of 1.43 kg and highest fruit yield of 22.56 t ha^{-1}. Asha (1999) reported that in bhindi, growth characters like plant height, LAI, DMP, yield attributes like fruit number per plant, fruit weight, fruit length and fruit yield were higher in neem cake treated plants as compared to that of FYM, poultry manure, green leaf and enriched compost on equivalent N basis.

Arunkumar (2000) reported that in amaranthus, application of neem cake produced higher yield as compared to that of chemical fertilizers on equivalent N basis, but was inferior to that of FYM, vermicompost and poultry manure. Asha (2006) observed that in amaranthus, highest green yield of 15.07 t ha^{-1} was recorded in neem cake applied plots compared to enriched vermicompost.

2.1.4.2.3 Quality Attributes

Saharawat and Mukherjee (1997) reported that application of mahua cake improved the grain protein content in rice.

2.1.4.2.4 Nutrient Uptake

Significant increases in crop yield and N uptake were obtained by using cereal straw and neem cake in the proportion of 3:1 in maize crop (Gaur and Mathur, 1979). In bhindi, N and P uptake and available N in soil were highest for neem cake application as compared to FYM, Poultry manure and compost (Asha, 1999)

2.1.4.3 *Effect of Coir Pith Compost on Growth ,Yield and Quality of Vegetables*

2.1.4.3.1 Growth Characters

Suharban et al. (1997) in a pot culture experiment with bhindi reported that plant height was significantly influenced by coir pith compost treatment, where the maximum plant height of 1.37 m was noted in coir pith compost treated plants and lowest (0.97m) under POP recommendation.

2.1.4.3.2 Yield and Yield Attributes

Incorporation of composted coir pith along with farm yard manure (5t ha^{-1}) into the soil gave the highest fruit yield of tomato (19 t ha^{-1}) followed by 20 t ha^{-1} coir pith (16 t ha^{-1}) and the lowest in control plot (11 t ha^{-1}) which were treated with neither farm yard manure nor coir pith (Ahmed, 1993). Suharban et al. (1997) in a pot culture experiment with bhindi reported that the treatment with coir pith compost alone gave the maximum yield of 5.923 kg $plant^{-1}$ followed by treatment with half recommended dose of coir pith and fertilizer (5.13 kg $plant^{-1}$).

However, Arunkumar (2000) reported that application of coir pith compost recorded lower green yield in amaranthus as compared to FYM, poultry manure, vermicompost and POP recommendation on equivalent N basis. Venkitaswamy (2003) reported that application of 100 per cent of the nutrient supply in coconut as composted coir pith recorded the maximum nut yield in coconut as compared to that of fertilizer treated plots. Geetha et al. (2005) reported that in banana fertilizer dose can be reduced to half by addition of coir pith compost @ 15 kg per plant.

2.1.4.3.3 Quality Attributes

Suja (2001) found that tuber quality of white yam in terms of starch and crude protein contents were markedly improved by coir pith compost application.

2.1.4.3.4 Nutrient Uptake

Venkitaswamy (2003) reported that application of 100 per cent of the nutrient supply in coconut as compared coir pith recorded the highest value of leaf N and K status as compared to that of fertilizer treated plots. Higher leaf N and K status in 100 per cent composted coir pith treatment would have been due to the better uptake of N and K with composted coir pith application due to increased availability.

2.1.4.4 *Effect of Ash on Growth ,Yield and Quality of Vegetables*

Several cultivated plants have shown an increased growth and/or yield, spinach ,bean , soybean (Erich, 1991; Etiegni et al., 1991a; Huang et al., 1992). Since wood ash contains virtually no N, combination of wood ash application with additional N is necessary if a balanced fertilization is required. This is not the case when a N-free fertilizer is required such as in forests enriched with N from acid depositions

2.1.4.4.1 Nutrient Uptake

Phosphorus, Ca, K and Mg contents in plants are remarkably affected by applications of wood ash (Clapham and Zibilske, 1992; Krejsl and Scanlon, 1996 and Vance, 1996) . The uptake of K is most spectacular and Erich (1991) and Ohno (1992) suggest that the availability of wood ash K is similar to fertilizer K. Contrarily to P, there is a large and immediate increase of K concentration in the soil solution after application of wood ash . According to Etiegni et al. (1991b), this excess of K is partly the reason of the growth reduction at elevated doses. Wood ash is a good source of available B (Ferm et al., 1992). Voundi et al. (1997) observed that the decreased Mn toxicity in a wood ash-amended tropical acid soil was partly responsible for the yield increase of rye grass (*Lolium perenne* L.).

2.1.4.5 *Effect of Rock dust on Growth ,Yield and Quality of Vegetables*

2.1.4.5.1 Growth Characters

Application of basalt and glacial dust in lettuce, apple and sweet corn increased the soil fertility and plant growth in USA (Barker et al, 1998). Yarrow (1998) reported that the application of RD increased the plant height and earliness of flower in tomatoes. Growth characters like no: of branches per plant and plant spread showed significant variation in coleus due to application of RD @ 10t ha^{-1} mixed with equal quantity of FYM (Divya, 2008)

2.1.4.5.2 Yield and Yield Attributes

Becker (1995) found that application of granite, basalt, glacial slit along with compost increased the grain yield of maize. In USA, Angeles et al (1997) reported that application of glacial sand and gravel increases N fixation and yield in soybean. Yarrow (1997) found that application of granite increased the yield of potato and sugar beet in USA. Application of RD along with half the recommended dose of NPK and FYM also produced the similar yield in coleus (17.2t ha^{-1}) as that of POP (Divya, 2008)

2.1.4.5.3 Quality Attributes

Starch content and cooking quality of the tubers in coleus were also favored by the application of RD @ 10t ha^{-1}(Divya, 2008)

2.1.5 Effect of Organic Manures on Shelf Life of Produce

Considerable scientific data were generated recently to show that the produce obtained from organic farming is nutritionally superior with good taste, luster and better keeping qualities. Luchnik (1975) reported that the use of organic manures resulted in high sugar and vitamin C content, which resulted in better keeping quality of cabbage. Similarly Kansal et al. (1981) reported increased shelf life of spinach leaves due to application of 20 t FYM ha^{-1}.In oriental pickling melon , the organic form of manures showed definite advantage over inorganic fertilizers in respect of storability, While the degree of rotting increased in treatment which received inorganic form of NPK (KAU, 1987).

The better storage life of spinach grown with organic manure was found to be associated with low free amino acid content, lower level of nitrate accumulation and higher protein N to nitrate N (Lampkin, 1990). In bhindi, application of FYM+ enriched compost and FYM + neem cake recorded comparable and lowest crude fiber content and Keeping quality of fruits (Asha, 1999). Nair (2003) reported that vermicompost application registered maximum keeping quality of bitter gourd fruits as compared to FYM and poultry manure.

2.1.6 Quality of Organic Manures

Organic manure not only act as source and sink for nutrients but also provide a favorable environment in soil (Singh, 2005). Hence the quality of organic manure added to soil is an important factor determining soil quality.

2.1.6.1 *Factors Determining Manure Quality*

2.1.6.1.1 Colour of Manure

During composting of domestic refuse, a gradual darkening or mechanisation of the material takes place. The final product, after a sufficiently long period of maturation , is a dark brown or almost black colour. Dark deep brownish colour of manure with earthy smell is an indicator of good quality (Venugopal, 2004)

2.1.6.1.2 Odour of Manure

According to De Bertoldi and Zucconi (1980) this odour is consequence of the excretion of geosmine , a secondary metabolite produced by mesophilic actinomycetes which predominate during the cooling phase of the bio-oxidative period and the maturation period. Mature compost is expected to have only a slight earthy and inoffensive smell (Lekhasi et al, 2001)

2.1.6.1.3 Moisture Content of Manure

Compost with <20-25% moisture is often dusty and difficult to handle. High moisture content is not a desirable attribute and also leads to foul smell during storage of immature compost (Venugopal, 2004)

2.1.6.1.4 C:N ratio as a Factor of Manure Quality

C:N ratio is the criterion traditionally used to determine the degree of maturity and define its agronomic quality. Many authors report that a C:N ratio below 20 is indicative of an acceptable maturity (Poincelot, 1974 and Golueke, 1981). Morel et al (1985) noted that C:N ratio <20 were often found in material not yet degraded, due to the relative N richness of the organic material.

2.1.6.1.5 P^H of Manure

The compost pH is a good indicator of the development of composting (Jimenez and Garcia, 1989). According to Wilson (1989) most well stabilized composts had a P^H between 6.5 and 7.5

2.2 COMMERCIAL ORGANIC MANURES

Commercial organic manures such as stera meal, ecomeal. green rich, karshaka meal etc are available in the market. Constituents of stera meal :– bone meal – 50%, leather meal – 50%, constituents of eco meal – bone meal-50%, leather meal-20%, neem cake -30% (Priya, 2008).

Available N and P contents in soils treated with commercial organic manures increased up to 30-45 days after incubation and decreased thereafter (Priya, 2008). Priya, 2008 reported that highest yield for amaranthus was recorded in plots which received the T4 (NPK fertilizer + Karshaka agromeal grade I). Uptake of N,K and Na were highest in T4 while that of P was highest in T6 (NPK fertilizer + skymeal). Application of COM found to improve the quality aspects of the crop.

2.3 MICROBIAL INOCULANTS

In recent years biofertilizers viz. Azospirillum , Acetobacter, have given good responses in many horticultural crops. As a cost effective supplement to chemical fertilizers and renewable energy source, biofertilizers can help to economize on the high investment needed for fertilizer use as far as N and P are considered (Pandey and Kumar, 2002).

Azospirillum is an associative symbiotic nitrogen fixing bacteria having high potential for nitrogen fixation. They are also known to produce growth promoting substances. Various physico-chemical properties and soil fertility status was considerably improved by residual effect of microbial inoculation (Asha, 2006)

2.3.1 Effect of Azospirillum on Growth and Yield of Vegetables

Azospirillum inoculation gave 15-62 per cent and 25-30 percent increase in yield of brinjal and cabbage respectively (Lehri and Mehrotra, 1972). Manib et al. (1979) reported increased dry weight of tomato plants by 5-12 per cent due to inoculation of Azospirillum. Azospirillum has the ability for better root induction in inoculated plants mainly due to production of hormones like IAA and GA. As a result plants are capable of absorbing more and more available nutrient from the soil which in turn results in better establishment of plant seedlings and subsequent growth (Govindan and Purushothaman, 1989).

Pusa sawani bhindi gave better plant height, plant girth and number of leaves when inoculated with Azospirillum (Parvatham et al., 1989). Paramaguru and Nataraja (1993) reported increased plant height, number of branches and number of lateral roots in chilli when inoculated with Azospirillum. Bhindi gave highest yield when Azospirillum was given as seed and soil treatment along with 30kg N per ha, compared to control (Balasubramani and Pappiah, 1995).

Pot culture experiment with amaranthus showed that, plant height, root biomass, LAI and yield were significantly high in the ttreatment combination of Azospirillum inoculation along with FYM and 75% fertilizer N application (Arunkumar, 1997). Niranjana (1998) reported that, in amaranthus application of Azospirillum with 50 per cent recommended dose of fertilizers produced higher yield than the recommended dose. The highest and significantly higher no: of pods/plant and average fruit wt over control was noticed in bhindi, which was inoculated with Azospirillum and supplied with 75% of the recommended N (Bahadur and Manohar, 2001).

2.3.2 Effect of Azotobacter on Growth and Yield of Vegetables

Lehri and Mehrotra (1972) obtained varying yield increase in cabbage and brinjal with *Azotobacter chroococcum* inoculation. These were 26 to 45 and 15 to 60% for cabbage and brinjal respectively. Badaway and Imam (1975) reported that seed inoculation of cabbage, cauliflower and onion with Azotobacter significantly increased plant growth. Mohandas (1987) found that combined inoculation of tomato with *Azotobacter vinelandii* and *Glomus fasciculatum* under field conditions resulted in significant increase in leaf area, shoot dry weight, N and P content and yield. Dibut et al (1995) and Gupta et al (1995) also reported that in tomato, soil inoculation with *Azotobacter chroococcum* increased seed germination by 33 to 46%. Soil inoculation also increased the no: of flowers and fruits.

2.3.3 Effect of Phosphate Solubilising Bacteria on Growth and Yield of Vegetables

In general phosphate solubilising microbes include different groups of microbes such as bacteria and fungi which convert insoluble organic and inorganic phosphatic compounds into soluble form.

Srivastava and Ahlawat (1995) confined that seed inoculation with rhizobium or PSB alone or in combination resulted in considerable increase in nodulation, nitrogen activity, growth, yield and nutrient uptake by cowpea over uninoculated control. Meena et al (2003) reported that inoculation with PSB significantly increased the grain yield, straw yield and harvest index in chick pea. Tanwar et al (2003) reported that PSB significantly improved yield, N,P content and uptake in both seed and straw in black gram.

Devi krishna (2005) reported that in cowpea, growth characters including height of plant, number and weight of effective nodules, bhusa yield and total dry matter production recorded the highest values with vermicompost and PSM application. Application of 50% recommended dose of P as superphosphate along with PSB and VAM recorded the highest yield during the first years in soybean and during both the years in wheat. (Mahanta and Rai, 2008).

2.3.4 Effect of Microbial Inoculants on the Quality of Crops

Inoculation with Azospirillum increased capsaicin and ascorbic acid contents in chilli (Balakrishnan, 1988). Azospirillum treated plant gave tomato fruits with high TSS (8.86 per cent) and ascorbic acid content (32.91 mg $100g^{-1}$ fresh fruits) (Kumaraswamy and Madalageri, 1990). Keeping quality of the fruits of chilli were significantly high in full dose of VC along with 75% fertilizer N and Azotobacter (Arunkumar, 1997).

Niranjana (1998) observed least fiber content and maximum mineral and protein content in treatment which received Azospirillum inoculation along with 75 per cent of the recommended dose of fertilizers in amaranthus. She reported that ascorbic acid content was maximum with dual inoculation of AMF and Azospirillum and 25 per cent of the recommended fertilizer dose. Sreekala (2004) reported that combined application of FYM, AMF and trichoderma reduced the fiber content and improved the volatile oil content in ginger as compared to that of the recommended dose of fertilizers. The highest protein content , shelf life and the lower fiber content were recorded in cowpea by the application of vermicompost and PSM (Devi krishna ,2005)

2.3.5 Effect of Microbial Inoculants on Nutrient Uptake in Crops.

Azospirillum enhanced the uptake of NO_3, P_2O_5 and K in plants (Sarig et al., 1984). Pacovsky et al., (1985) observed an increase in P and other nutrient concentration in the foliage of Azospirillium inoculated sorghum plants. Parvatham et al., (1989) noted better N and P uptake in bhindi due to Azospirillum inoculation

Materials and Methods

3. MATERIALS AND METHODS

The present investigation entitled "Development and evaluation of bio-organic composite manure for vegetables" was carried out at College of Agriculture, Vellayani during 2009-2011. The main objective of the study was to assess the feasibility of developing good quality bio-organic composite manures for organic vegetable production. The investigation comprises three phases. (1). Formulation and quality evaluation of bio organic composite manures, (2). Mineralization study of bio organic composite manures, (3). Crop response study. Crop response study was conducted as one pot culture investigation and another field investigation. The materials used and the methods adopted for the studies are briefly described in this chapter.

Experiment I

3.1 FORMULATION AND QUALITY EVALUATION OF BIO ORGANIC COMPOSITE MANURES

The study was conducted in the laboratory during January 2010 to January 2011. Organic sources used for the preparation of bio organic composite manures were coir pith compost, poultry manure, neem cake, ground nut cake, ash, rock dust and microbial consortium.

3.1.1 Characterization of raw materials and organic manure mixtures

Raw materials collected from different parts of Kerala were analyzed and best sources were selected for the preparation of mixture. Raw materials were mixed in different proportion to make the respective organic manure mixture. Nitrogen, phosphorous and potassium content of the raw materials are presented in Table 1

Table 1. Nutrient content of raw materials

RAW MATERIALS	N(%)	P(%)	K(%)
Groundnut cake	6.384	0.689	1.36
Neem cake	3.568	0.398	2.2
Rock dust	0.336	0.174	0.62
Coir pith	1.008	0.301	0.46
Ash	0.448	1.01	2.2
Poultry manure	1.464	0.912	2.36

Sixteen organic manure mixtures were prepared as per the treatments. The details of the components are furnished in Table 2

Technical programme

Design - CRD

Treatments - 16 bio-organic composite manures

Replications - 2

Table 2. Components used for organic manure production

Treatment	Organic sources (weight in g)						
	Coir pith compost	Poultry manure	Groundnut cake	Neem cake	Rock dust	Ash	Microbial consortium
OM1	50	_	35	_	15	_	_
OM2	50	_	20	20	10	_	_
OM3	50	_	35	_	_	15	_
OM4	50	_	20	20	_	10	_
OM5	_	50	30	_	20	_	_
OM6	_	50	20	15	15	_	_
OM7	_	50	20	20	_	10	_
OM8	_	50	30	_	_	20	_
OM9	50	_	36	_	13	_	1
OM10	50	_	22	22	5	_	1
OM11	50	_	35	_	_	14	1
OM12	50	_	22	22	_	5	1
OM13	_	50	30	_	19	_	1
OM14	_	50	22	17	10	_	1
OM15	_	50	30	_	_	19	1
OM16	_	50	22	22	_	5	1

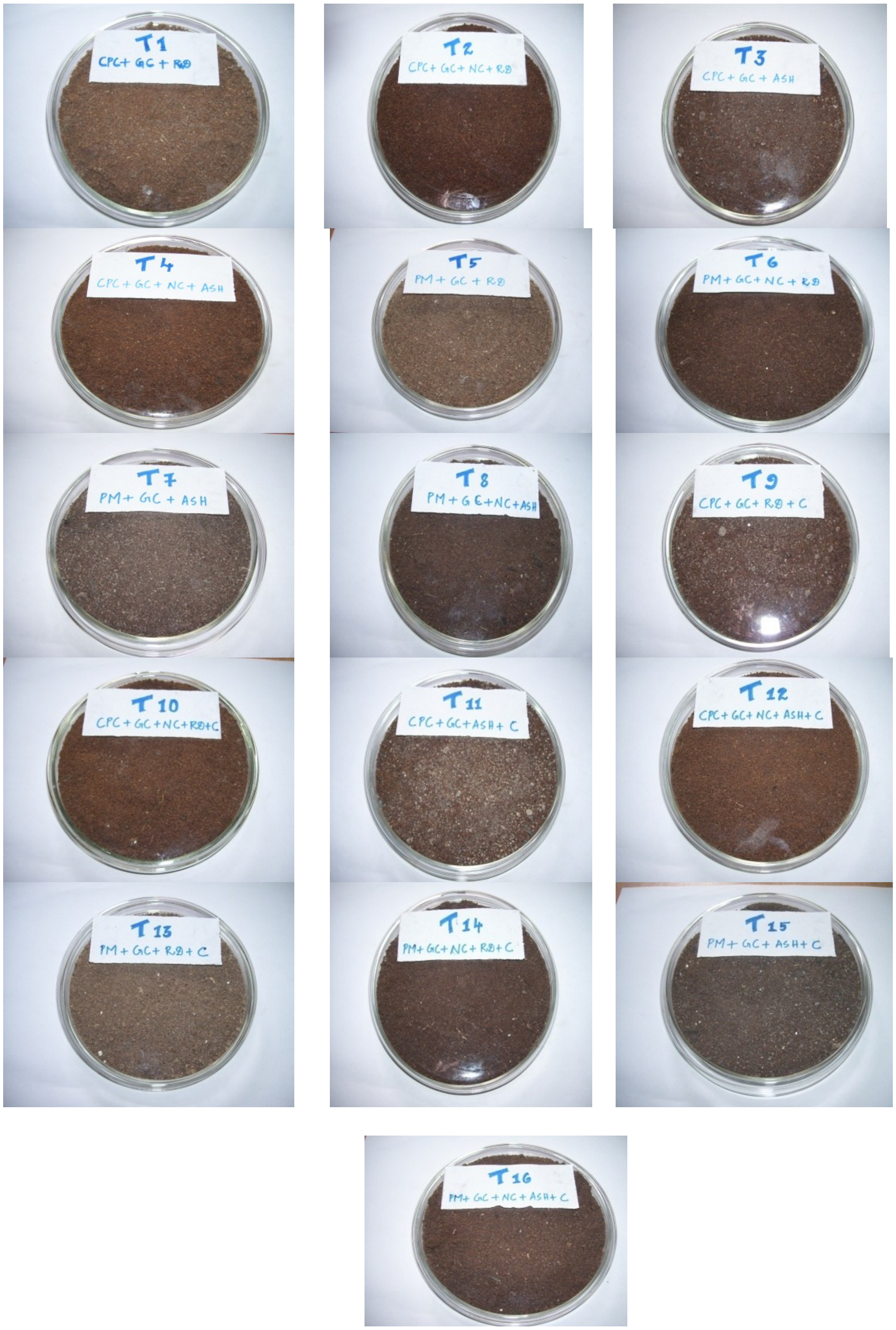

Plate 1. Sixteen bio-organic composite manure

Nutrient content of organic manure mixtures are given in Table 3.

Table 3. Nutrient content of organic manure mixtures

Treatment	N(%)	P(%)	K(%)
OM1	1.79	0.61	0.66
OM2	1.79	0.36	0.77
OM3	3.25	0.87	1.44
OM4	1.79	0.67	1.02
OM5	3.14	1.04	1.32
OM6	2.02	1.24	1.14
OM7	2.63	1.19	1.96
OM8	2.24	1.12	1.70
OM9	3.53	0.27	1.72
OM10	2.29	0.17	2.32
OM11	3.19	0.26	1.24
OM12	2.91	0.24	1.58
OM13	3.08	0.39	0.88
OM14	2.13	0.33	1.24
OM15	2.97	0.45	0.66
OM16	2.24	0.38	0.76

3.1.2 Characterization of selected organic manure mixture

The composite organic manures analyzing at least 3% N and N:K ratio of 1:0.5 were selected for further study. Five mixtures satisfying the selection criteria were identified for the investigation. The nutrient composition of five mixtures are given in Table 4

Table 4 Nutrient composition of selected mixtures

Treatments	N(%)	P(%)	K(%)
OM3	3.25	0.87	1.44
OM5	3.14	1.04	1.32
OM9	3.53	0.27	1.72
OM11	3.19	0.26	1.24
OM13	3.08	0.39	0.88

The selected mixtures were passed through 2mm sieve and ensured that 90% passed through the sieve.

The physical and chemical characters of selected organic manure mixture viz odour, colour , moisture content, bulk density, pH, heavy metals, EC, organic carbon, nitrogen , phosphorous and potassium contents were analyzed following the standard analytical method as adopted for organic manures and are given in Table 5

Table5. Analytical method used for the physico-chemical characterization of composite organic manures

SL NO	Estimated character	Method	Reference
I	**Physical parameters**		
a	Odour	Sensory evaluation	
b	Colour	Visual description	
c	Bulk density (mg m^{-3})	Core method	Gupta and Dakshina moorthi, 1980
d	Moisture content (%)	Gravimetric method	Fertilizer (control) Amendment Order, 2006. Part D, p. 75
II	**Chemical parameters**		
a	Organic carbon(%)	Chromic acid wet digestion method	Walkley and Black, 1934
b	Total N(%)	Modifiedmicrokjeldhal method	Jackson, 1973
c	Total P(%)	Colorimetrically determined by wet digestion of the sample and developing colour by ascorbic acid method and read in a Spectrophotometer.	Bray and Kurtz, 1945
d	Total K(%)	Flame photometer	Jackson, 1973
e	Heavy metals (ppm)	Arsenic, Chromium, Cadmium, Copper,Mercury, Nickel, Lead, Zinc was analyzed by Atomic Absorption Spectrophotometer	Jackson, 1973
f	pH	Ph meter with glass electrode	Jackson,1973
g	EC(dSm^{-1})	Conductivity meter	Jackson,1973

Microbial population (Nitrogen fixers, phosphorous and potassium solubilisers) of selected composite organic manure mixtures were analyzed by serial dilution and plate technique using appropriate medium. For azospirillum-Nitrogen free bromothymol blue medium (Dobereiner et al, 1976), azotobacter-Jensen's medium (Jensen,1942), P solubilisers-Pikovskay's medium (Sundara and Sinha, 1963) and K solubilisers-Nutrient agar medium (Anthoni et al, 2000) were used at dilution of 10^{-5}.

Experiment II

3.2 MINERALIZATION STUDY

Mineralization study was conducted in pots during January 2011 to June 2011. The objective of the study was to assess the nutrient release pattern of different organic manure mixtures.

Five selected mixtures along with KAU POP, KAU Adhoc organic POP and absolute control form the 8 treatments for the mineralization study. Each pot was filled with six kg of soil. The different composite manures were applied as N equivalent basis for the test crop amaranthus. The soil with composite manures was filled in pots of uniform size. Moisture content of the soil was brought to field capacity. These soil samples were kept for 6 months.

3.2.1 Technical programme

Design - CRD

Treatments - 8

Replications - 3

Treatments

T1 - OM3

T2 - OM5

T3 - OM9

T4 - OM11

T5 - OM13

T6 - KAU Adhoc Organic POP

T7 - KAU POP

T8 - Soil alone

3.2.2 Sampling

Sampling was done at monthly interval for a period of six months after incubation. Approximately 500g of soil was taken from each pot and then shade dried, sieved through a 2mm sieve and stored in plastic containers. Part of the processed soil was retained for the analysis of the soil parameters while the remaining was discarded. These samples were then subjected to the analysis of soil parameters

3.2.3 Nutrient analysis

3.2.3.1 Available Nitrogen

Available Nitrogen was determined by Alkaline potassium permanganate method (Subbiah andAsija,1956)

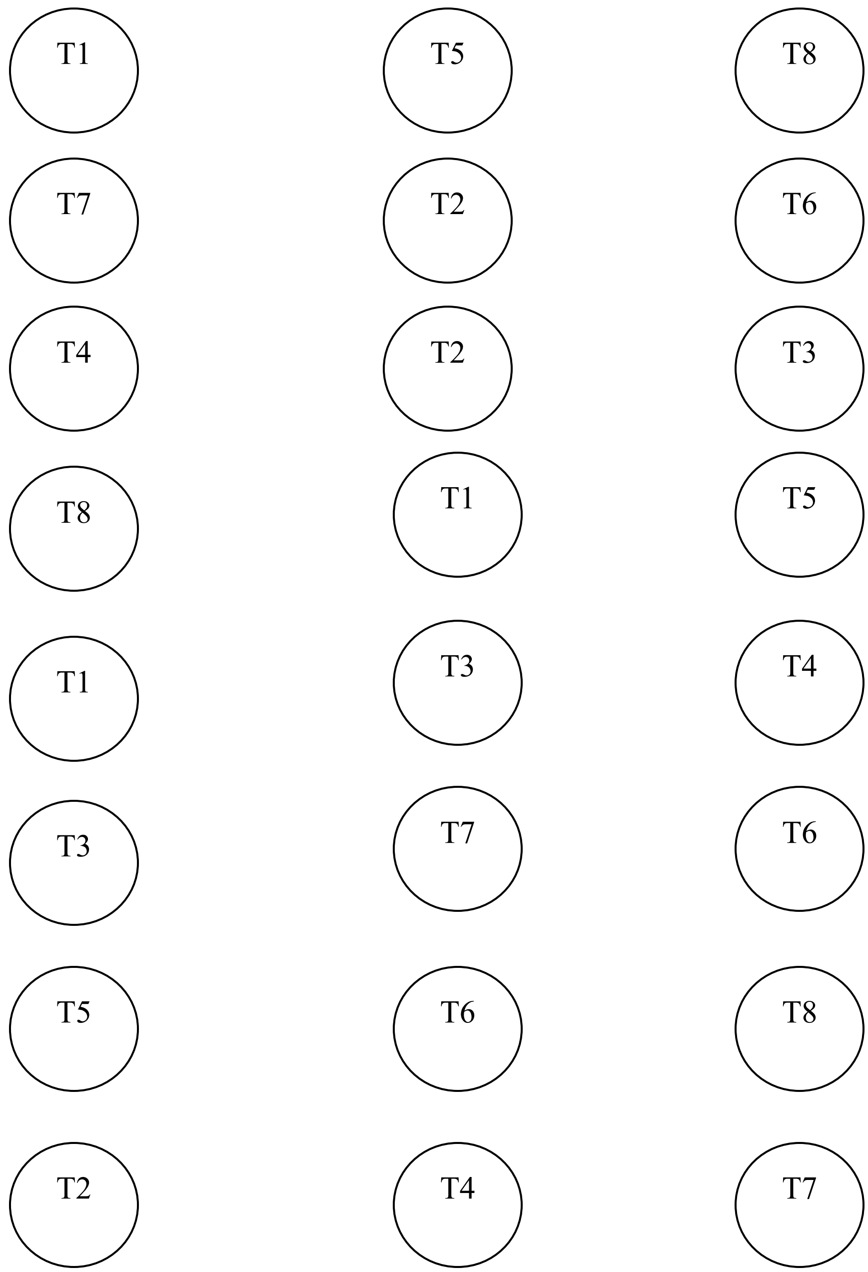

Fig 1. Layout of mineralization study

3.2.3.2 Available phosphorous

Available Phosphorous was determined by Bray colorimeter method (Jackson ,1973)

3.2.3.3 Available Potassium

Available Potassium was determined by Neutral normal ammonium acetate method (Jackson, 1973)

Experiment III

3.3 EVALUATION OF SELECTED COMPOSITE ORGANIC MANURES USING THE TEST CROP AMARANTHUS

In order to study the efficiency of selected COMs on crops, pot and field experiments were conducted using amaranthus as the test crop.

3.3.1 Experimental site

The experiment was carried out at College of Agriculture, Vellayani. The site is situated at 80^0 30' N latitude and 76^0 54' E longitude and at an altitude of 29 m above mean sea level

3.3.2 Soil

Soil of the experimental site was laterite red loam belonging to the order oxisol of Vellayani series.

3.3.3 Weather conditions

Weekly averages of maximum and minimum temperature, relative humidity and rainfall received during the cropping period collected from the observatory of College of Agriculture, Vellayani are given in Appendix 1 and illustrated in Fig.2

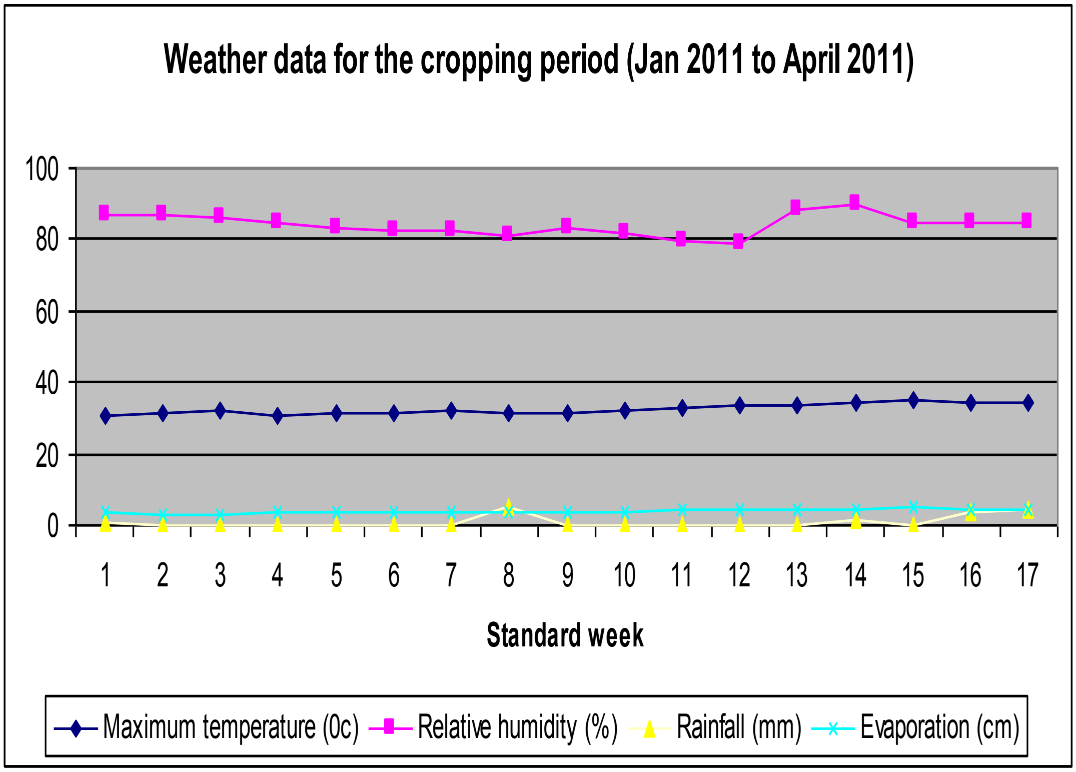

Fig 2. Weather parameters during the cropping period (Amaranthus)

(Jan 2011 to April 2011)

3.3.4 Materials

3.3.4.1 Crop and variety

Amaranthus variety Arun was grown as the test crop.

3.3.4.2 Planting material

Seeds of amaranthus variety Arun were collected from the Department of Olericulture, Vellayani.

3.3.4.3 Manures and Fertilizers

Five composite organic manures, KAU POP, KAU Adhoc Organic POP and microbial consortium were used in the experiment. Composite organic manures selected for the evaluation were applied one week after transplanting on nitrogen equivalent basis of 100kgN/ha as per the POP recommendation of KAU(KAU 2007).

KAU POP – 100:50:50 kg/ha N:P_2O_5:K_2O (50: 50: 50 kg/ha N:P_2O_5:K_2O applied as basal and 50 kg/ha N applied as top dressing after each harvest)

KAU Adhoc Organic POP – Cow's urine @ 500l ha^{-1}(KAU, 2009)

Microbial consortium – Mixture of Azotobacter, Azospirillum, Phosphate solubilising bacteria and Potassium solubilizers obtained from Dept of Agricultural Microbiology, Vellayani was used.

3.3.5 Pot culture experiment

3.3.5.1 Season

The experiment was conducted during January 2011 to April 2011. Crop was transplanted on 27 January 2011.

Important chemical properties of the soil and the methods adopted for analysis are presented in Table 6

Table 6. Chemical properties of the soil at the experimental site

Sl no	Parameter	Content	Rating	Methods adopted
1	pH	6.97	Neutral	pH meter with glass electrode (Jackson,1973)
2	Available N ($kgha^{-1}$)	280.28	Medium	Alkalinepotassium permanganate method (Subbiah and Asija,1956)
3	Available P($kgha^{-1}$)	82.53	High	Bray colorimeter method (Jackson,1973)
4	Available K ($kgha^{-1}$)	110.89	Medium	Neutral normal ammonium acetatemethod (Jackson,1973)
5	Organic carbon (%)	1.46	High	Chromic acid wet digestion method (Walkley and Black, 1934)

3.3.5.2 Materials

Design - CRD

Treatments - 8

Replications - 3

Spacing – 30cm x 20cm

Treatments

T1 - OM3

T2 - OM5

T3 - OM9

T4 - OM11

T5 - OM13

T6 - KAU Adhoc Organic POP

T7 - KAU POP

T8 - Soil alone

All the treatments were given a basal dose of 50 tonnes ha^{-1} FYM

3.3.5.3 Details of cultivation

3.3.5.3.1 Nursery

Amaranthus seedlings were raised in well prepared plots. Seeds were sown on 12 January 2011. Seedlings were irrigated daily

3.3.5.3.2 Transplanting

15 days old robust seedlings were transplanted to pots on 27 January 2011 @ one plant per pot at a spacing of 30cmx20cm. Fertilizers and manures were applied 1 week after transplanting as per the treatments .Crop was irrigated twice daily.

3.3.5.3.3 After cultivation

Unhealthy seedlings were replaced with healthy seedlings. Regular irrigation and weeding were carried out.

3.3.5.3.4 Plant protection

There was no major pest and disease incidence. Mechanical and organic control measures were adopted. The pest or diseased plant portion was removed and destroyed. In order to control leaf blight, Pseudomonas spray was given @ 1%.

3.3.5.3.5 Harvesting

First harvest was done at 30 DAT. Subsequent harvests were done at 15 days interval.

3.3.5.4 Growth characters observed

3.3.5.4.1 Plant height

Height of the plant was measured from base to the growing tip (top most leaf bud) and the mean values were computed and expressed in cm

3.3.5.4.2 Number of leaves

Total number of leaves of the plant per pot was counted.

3.3.5.4.3 Leaf: Stem ratio

Weight of leaves and stem of the plants from each pot were determined and the leaf: stem ratio were calculated.

3.3.5.5 Yield and yield attributes

3.3.5.5.1 Yield per cutting

Weight of leaf and stem portion 15cm above the ground leaving the woody portion were recorded for each pot and expressed in g per pot

3.3.5.5.2 Total yield

The weight of the harvested portion of each observational plant in each pot was recorded for each cutting and the total yield was calculated and expressed in g per pot

3.3.5.5.3 Total dry matter production

Dry matter production per hectare was recorded at each harvest. Fresh weight of the plants was recorded initially after harvest and later oven dried at 70^0c to a constant weight. The dry weight of stem and leaves recorded separately were added together to obtain the total dry matter production and then converted into g per pot.

3.3.5.6 Crop quality attributes

Quality attributes viz beta carotene, oxalate, vitamin C and nitrate content were determined.

3.3.5.6.1 Beta carotene content

Beta carotene content of the plant sample from each treatment was estimated by the method proposed by Srivastava and Kumar 1998 and expressed as µg $100g^{-1}$ fresh leaf sample

3.3.5.6.2 Oxalate content

The oxalate content in the plant sample of each treatment was estimated by the method proposed by AOAC 1984 and expressed as % of dry weight

3.3.5.6.3 Vitamin C content

Vitamin C content of the plant was estimated by titrimetric method (Sadasivam and Manickam, 1996) and expressed in mg/100g fresh leaf sample

3.3.5.6.4 Nitrate content

Nitrate content in the plant sample of each treatment was estimated by the method proposed by Middleton 1958 and expressed as % of dry weight

3.3.5.7 Plant analysis

Sample plants collected from each pot at each harvest were chopped, sun dried and oven dried to a constant weight. Samples were ground to pass through a 0.5 mm mesh in a Willey Mill and the required quantity of samples were digested and N, P and K content were estimated.

3.3.5.7.1 Uptake of nitrogen

Nitrogen content in plant samples was estimated by modified microkjeldhal method (Jackson, 1973) and the uptake of nitrogen was calculated by multiplying the nitrogen content of plant sample with the total dry weight of plants. Uptake values were expressed in kg ha^{-1}.

3.3.5.7.2 Uptake of phosphorus

Phosphorus content in the plant sample was colorimetrically determined by wet digestion of the sample and developing colour by ascorbic acid method and read in a Spectrophotometer (Bray and Kurtz 1945). Uptake of phosphorus was calculated by multiplying the phosphorus content of plant sample with the total dry weight of plants. Uptake values were expressed in kg ha^{-1}

3.3.5.7.3 Uptake of potassium

The potassium content in the plant sample was determined by flame photometer method and the uptake of potassium was calculated by multiplying the potassium content of plant sample with the total dry weight of plants. Uptake values were expressed in kg ha^{-1}.

3.3.5.8 Soil analysis

Soil samples were collected from the experimental site before and after the crop. These soil samples were processed and N,P,K and organic carbon content were analyzed as per the method given in Table 6

3.3.5.9 Microbial Population

Nitrogen fixers, phosphorous and potassium solubilisers in soil samples collected from each treatment were estimated by serial dilution and plate technique using appropriate medium. For azospirillum-Nitrogen free bromothymol blue medium (Dobereiner et al, 1976), azotobacter-Jensen's medium (Jensen,1942), P solubilisers-Pikovskay's medium (Sundara and Sinha, 1963) and K solubilisers-Nutrient agar medium (Anthoni et al, 2000) were used at dilution of 10^{-5}.Microbial Population was estimated from the soil samples collected from each pot before and after the investigation

3.3.5.11 Statistical analysis

Data generated from the investigation were analyzed by applying the analysis of variance technique and significance was tested by F test (Snedecor and Cochran 1975). In the cases where the effects were found to be significant, CD values were calculated by using standard technique.

3.3.6 Field experiment

3.3.6.1 Season

Experiment was conducted during March 2011 to April 2011. Crop was transplanted on 15 March 2011.

Important chemical properties of the soil and the methods adopted for analysis are presented in Table 7

Table 7. Chemical properties of the soil at the experimental site

Sl no	Parameter	Content	Rating	Methods adopted
1	pH	6.83	Slightly acidic	pH meter with glass electrode (Jackson,1973)
2	Available N ($kgha^{-1}$)	301.06	Medium	Alkaline potassium permanganate method (Subbiah and Asija,1956)
3	Available P($kgha^{-1}$)	78.1	High	Bray colorimeter method (Jackson,1973)
4	Available K($kgha^{-1}$)	118.2	Medium	Neutral normal ammonium acetate method (Jackson,1973)
5	Organic carbon (%)	1.62	High	Chromic acid wet digestion method (Walkley and Black, 1934)

3.3.6.2 Materials

Design - RBD

Treatments - 8

Replications - 3

Spacing – 30cm x 20cm

Gross plot size - 0.9m x 2m

Treatments

T1	-	OM3
T2	-	OM5
T3	-	OM9
T4	-	OM11
T5	-	OM13
T6	-	KAU Adhoc Organic POP
T7	-	KAU POP
T8	-	Soil alone

All the treatments were given a basal dose of 50 tonnes ha^{-1} FYM

Replication I

T3	T7	T2	T8	T1	T5	T6	T4

Replication II

T5	T8	T4	T2	T6	T3	T7	T1

Replication III

T7	T2	T8	T3	T5	T6	T4	T1

Fig. 3. Lay out plan of field experiment

3.3.6.3 Details of cultivation

3.3.6.3.1 Nursery

Amaranthus seedlings were raised in well prepared plots. Seeds were sown on 1 March 2011. Seedlings were irrigated daily

3.3.5.3.2 Transplanting

15 days old robust seedlings were transplanted on 15 March 2011 in plots at a spacing of 30cmx20cm. Fertilizers and manures were applied as per treatments 1 week after transplanting. The crop was irrigated twice daily.

3.3.6.3.3 After cultivation

Gap filling was done . Regular irrigation and weeding were carried out.

Plate 2. General view of pot culture study

Plate 3. General view of field study

3.3.6.3.4 Plant protection

There was no major incidence of pest and diseases. Mechanical control measures were adopted.

3.3.6.3.5 Harvesting

Harvesting was done on 11 April 2011 .

3.3.6.4 Growth characters observed

Following growth characters were recorded from 5 randomly selected plants from each plot

3.3.6.4.1 Plant height

Height of plant was measured from base to the growing tip (top most leaf bud) and the mean values were computed and expressed in cm

3.3.6.4.2 Number of leaves

Total number of leaves in each observational plant was counted and the average was recorded for each plot

3.3.6.4.3 Leaf: Stem ratio

The separate weight of the leaves and stem of the observational plants from each plot were determined and the leaf : stem ratio were calculated.

3.3.6.5 Yield and yield attributes

3.3.6.5.1 Total yield

Weight of the harvested portion of each observational plant in each plot was recorded and the total yield was calculated and expressed in tonnes per ha

3.3.6.5.2 Total dry matter production

Dry matter production per hectare was recorded at each harvest. Fresh weight of the plants was recorded initially after harvest and later oven dried at 70^0c to a constant weight. Dry weight of stem and leaves recorded separately were added together to obtain the total dry matter production and then converted into per hectare value.

3.3.6.6 Soil analysis (before and after experiment)

All soil parameters studied under experiment II was repeated for experiment III.

3.3.6.7 Microbial Population

Microbial Population studied under experiment II was repeated for experiment III.

3.6.8 Economics of cultivation

Economics of cultivation of amaranthus was worked out considering the total expenditure and total income of the crop and the BC ratio was calculated as follows

Benefit : Cost ratio = Gross income/ Cost of cultivation

Actual profit obtained for the crop was worked as :

Profit = Gross income - Cost of cultivation

3.6.9 Statistical analysis

Data generated from the investigation were analyzed by applying the analysis of variance technique and significance was tested by F test (Snedecor and Cochran 1975). In the cases where the effects were found to be significant, CD values were calculated by using standard technique.

Results

4. RESULTS

An investigation was conducted to assess the feasibility of developing good quality bio-organic composite manures for organic vegetable production. Three successive experiments as detailed below were conducted to achieve the objectives envisaged.

Experiment 1. Formulation and quality evaluation of bio organic composite manures

Experiment 2. Mineralization study of bio organic composite manures

Experiment 3. Crop response study.

The data on various observations were statistically analyzed and presented in this chapter.

4.1 FORMULATION AND QUALITY EVALUATION OF BIO ORGANIC COMPOSITE

MANURES

4.1.1 Nutrient Content of Composite Organic Manures

Sixteen organic manures were prepared by mixing coir pith compost, poultry manure, ground nut cake, neem cake, ash, rock dust and microbial consortium in required quantity as per the treatments. These manures were analyzed for N,P,K and data are furnished in Table 8. The data revealed that OM9 recorded maximum nitrogen content of 3.53%. OM6 registered maximum phosphorous content of 1.24% and OM10 recorded maximum potassium content of 2.32%. The N content of organic manures ranged from 1.79 to 3.53%, P content ranged from 0.17 to 1.24% and K content ranged from

Table 8. Nutrient content of organic manure mixtures

Composite organic manures	N(%)	P(%)	K(%)	N:K
OM1	1.79	0.61	0.66	2.71
OM2	1.79	0.36	0.77	2.32
OM3	3.25	0.87	1.44	2.26
OM4	1.79	0.67	1.02	1.75
OM5	3.14	1.04	1.32	2.38
OM6	2.02	1.24	1.14	1.77
OM7	2.63	1.19	1.96	1.34
OM8	2.24	1.12	1.70	1.32
OM9	3.53	0.27	1.72	2.05
OM10	2.29	0.17	2.32	0.99
OM11	3.19	0.26	1.24	2.57
OM12	2.91	0.24	1.58	1.84
OM13	3.08	0.39	0.88	3.50
OM14	2.13	0.33	1.24	1.71
OM15	2.97	0.45	0.66	4.50
OM16	2.24	0.38	0.76	2.95
SE	0.129	NS	0.231	-
CD (0.05)	0.386	-	0.694	-

NS – Non Significant

0.66 to 2.32%. N:K ratio ranged from 0.99 to 4.50 %. The criteria fixed for manure selection is a minimum of 3% N and N:K ratio of 1:0.5. OM3, OM5, OM9, OM11 and OM13 registered N content of more than 3% and N:K ratio more than 1:0.5.

4.1.2 Selection of Composite Organic Manures

The composite organic manures analyzing at least 3% N and N:K ratio of 1:0.5 were selected for further study. Five mixtures satisfying the selection criteria were identified for the investigation. The nutrient composition of five mixtures are given in Table 9.

Among the five mixtures N content ranged from 3.53 to 3.08%. Maximum N content was recorded in OM9(3.53%) followed by OM3(3.25%), OM11(3.19%), OM5(3.14%) and OM13(3.08%). P content ranged from 0.26 to 1.04 %. Highest P content was registered in OM5(1.04%) followed by OM3(0.87%), OM13(0.39%), OM9 (0.27%) and OM11(0.26%). K content ranged from 0.88 to 1.72 %. Maximum K content was recorded in OM9(1.72%) followed by OM3(1.44%), OM5(1.32%), OM11(1.24%) and OM13(0.88%). Organic C content ranged from 43.25 to 64.00%. OM11 recorded minimum Organic C content of 43.25% and OM5 recorded maximum Organic C content of 64.00%.

4.1.3 Heavy Metal Content

Data furnished in Table 10 revealed the heavy metal content of composite organic manures. Highest arsenic content was reported in OM9 (0.65 ppm) and lowest content was registered by OM3 and OM11(0.44 ppm). Chromium content ranged from 4.18 to 4.59 ppm. OM5 and OM13 recorded maximum chromium content and OM3 and OM11 recorded lowest content. OM3 and OM11 recorded maximum cadmium content of 0.09 ppm. OM9 registered lowest cadmium content of 0.04 ppm.

Table 9. Nutrient composition of selected composite organic manures

Treatment	N(%)	P(%)	K(%)	Organic C (%)
OM3	3.25	0.87	1.44	62.20
OM5	3.14	1.04	1.32	64.00
OM9	3.53	0.27	1.72	50.00
OM11	3.19	0.26	1.24	43.25
OM13	3.08	0.39	0.88	56.15

Table 10. **H**eavy metal content (ppm) of composite organic manures

Treatment	Arsenic	Chromium	Cadmium	Copper	Mercury	Nickel	Lead	Zinc
OM3	0.43	4.18	0.09	0.08	0.01	0	2.67	0.27
OM5	0.53	4.59	0.06	0.08	0.01	0	2.20	0.62
OM9	0.65	4.38	0.04	0.03	0.01	0	2.21	0.18
OM11	0.44	4.18	0.09	0.08	0.01	0	2.67	0.27
OM13	0.53	4.59	0.06	0.08	0.01	0	2.20	0.62

All organic manures except OM9 registered a copper content of 0.08 ppm and OM9 recorded a copper content of 0.03 ppm. Mercury content was on par for all organic manures (0.01 ppm). Heavy metal nickel was absent in all composite organic manures. Lead content ranged from 2.20 ppm (OM5 and OM13) to 2.67 ppm (OM3 and OM11). Maximum zinc content was reported in OM5 and OM13 and minimum content was recorded in OM9.

4.1.4 Physico Chemical Parameters

Data presented in Table 11 shows the physico chemical characters of composite organic manures. Bulk density ranged from 0.35 to 0.63 mg m^{-3}. OM5 and OM13 recorded the highest bulk density (0.63 and 0.60 mg m^{-3}respectively) followed by OM9(0.47 mg m^{-3}), OM11(0.40 mg m^{-3}) and OM3(0.35 mg m^{-3}). Moisture content of organic manures were less than 1 %. OM9 and OM11 recorded the maximum moisture content (0.61and0.66% respectively) followed by OM3(0.42 %), OM13(0.28 %) and OM5(0.25 %)

Maximum pH was registered by OM5 and OM13 with value 7.98 followed by OM3(6.69) , OM11(6.62), and OM9(5.57). OM5 and OM13 has the pH value in neutral range, OM11and OM3 were slightly acidic and OM9 was medium acidic. Maximum EC was registered by OM5 (18.1 dSm^{-1}) followed by OM13(15.3 dSm^{-1}), OM11(7.1 dSm^{-1}), OM3(6.5 dSm^{-1}) and OM9 (5.1 dSm^{-1})

4.1.5 Microbial Population

Data presented in Table 12 shows the population of N fixers, P solubilisers and K solubilisers of composite organic manures. Nitrogen fixers (Azotobacter and Azospirillum) population was recorded in all organic manures. Highest Azotobacter population was recorded in OM11 (6.0 x 10^{-5}) and OM13 (6.0 x 10^{-5}), followed by OM9 (5.0 x 10^{-5}) , OM5 (3.0 x 10^{-5}) and OM3 (2.0 x 10^{-5}). Azospirillum population

Table 11. Physico chemical parameters of composite organic manures

Treatment	Bulk density (mg m^{-3})	Moisture content (%)	pH	EC (dSm^{-1})
OM3	0.35	0.42	6.69	6.5
OM5	0.63	0.25	7.98	18.1
OM9	0.47	0.61	5.57	5.1
OM11	0.40	0.66	6.62	7.1
OM13	0.60	0.28	7.98	15.3

Table 12. Microbial population of composite organic manures

Treatment	Azotobacter (10^{-5})	Azospirillum (10^{-5})	P solubilisers (10^{-5})	K solubilisers (10^{-5})
OM3	2.0	3.5	2.0	1.0
OM5	3.0	3.0	0	0
OM9	5.0	5.5	4.0	2.5
OM11	6.0	6.0	3.5	4.0
OM13	6.0	4.0	4.5	3.5

ranged from 3.0 to 6.0 x 10^{-5}. OM11 recorded maximum azospirillum population of 6.0 x 10^{-5} and OM5 registered minimum azospirillum population of 3.0 x 10^{-5}.P solublisers were recorded in all organic manures except OM5. Highest P solublisers were recorded in OM13 (4.5 x 10^{-5}) and lowest P solublisers were recorded in OM3 (2.0 x 10^{-5}). K solublisers were reported in all organic manures except OM5. K solublisers ranged from 1.0 to 4.0 x 10^{-5}.

4.2 MINERALIZATION STUDY

Available N, P and K content of the soil as influenced by different bio-organic composite manures were analyzed at 1 month interval up to a period of 6 months and the results are presented below

4.2.1 Available Nitrogen Status

Data on available nitrogen status are presented in Table 13 . T1, T4 and T5,a reduction in available N content was observed during 2MAI and thereafter an increase was observed. For T2,T3 and T6 available N content increased gradually up to 3MAI. For T7 the N content progressively increased up to 2MAI and later declined, whereas for T8 an initial reduction in N status was observed and thereafter increased during 2MAI. From 3MAI onwards all treatments showed a decline in available nitrogen status of soil.

At 1 MAI T5 recorded significantly higher available N content (363.6234 kg ha^{-1}) compared to all other treatments except T7. T1and T2 registered significantly lower N content at 1MAI. At 2MAI T7 recorded significantly higher value (372.04 kg ha^{-1}) compared to all other treatments. The lowest content was recorded in T1(206.98 kg ha^{-1}). At 3 and 4MAI T3 recorded increased N content of 376.32 kg ha^{-}1 and 357.42 kg ha^{-}1 respectively which was significantly different from T5, T6, T7 and T8.

Table 13. Effect of treatments on available nitrogen status of soil (kg ha^{-1})

Treatment	Available nitrogen content in soil (kg ha^{-1})						
	1MAI	2MAI	3MAI	4MAI	5MAI	6MAI	Mean
T1	238.34	206.98	357.51	343.24	324.98	314.32	297.56
T2	280.15	326.15	351.24	335.26	321.16	308.94	320.48
T3	313.60	326.14	376.32	357.42	331.74	314.68	336.65
T4	319.87	307.33	357.51	349.62	342.55	332.02	334.82
T5	363.62	307.33	329.87	319.29	308.92	299.14	321.36
T6	288.52	313.60	319.87	310.88	304.48	298.88	306.04
T7	357.51	372.04	313.60	307.90	301.32	299.76	325.36
T8	288.52	255.06	301.23	242.12	233.12	222.52	257.09
SE	5.63	7.41	10.27	6.22	3.23	4.31	
CD(0.05)	16.87	22.23	30.81	18.66	9.69	12.93	

The lowest content was registered in T8 at 3,4 5and 6 MAI (301.23, 242.12, 233.12 and 222.52kg ha^{-1} respectively).At 5 and 6MAI highest N content was recorded in T4 and was significantly superior to all other treatments.

Among composite organic manures highest available N content was recorded in T3 and lowest content was registered in T1.

The average values showed that the available N was highest (336.65 kg ha^{-1}) with T3 application followed by T4 (334.82 kg ha^{-1}) ,T7 (325.36 kg ha^{-1}), T5(321.36 kg ha^{-1}), T2(320.48 kg ha^{-1}), T6 (306.04 kg ha^{-1}) , T1(297.56 kg ha^{-1}) and the lowest value was shown by T8 (257.09 kg ha^{-1}).

4.2.2 Available Phosphorous Status

Data given in Table 14 represents the effect of various treatments and periods of mineralization on available P_2O_5. There was significant variation among treatments . All treatments registered higher content of available P_2O_5 as compared to T8 (soil alone). For all the treatments the availability was high during Ist month after mineralization and the values gradually declined thereafter.

The available phosphorous content was highest for T2 at 1and 2MAI (138.39 and 125.35 kg ha^{-1} respectively) . At 1MAI T2was significantly superior to all other treatments and at 2MAI it was on par with T1. At 3MAI T7 showed a steady superiority over other treatments and was on par with T1. The lowest P content was recorded in T8 at 1, 2 and 3MAI (98.03,88.19 and 65.54 kg ha^{-1} respectively). At 4, 5 and 6MAI T1 recorded maximum P content of 97.77,84.15 and 80.74 kg ha^{-1} respectively. The lowest content was registered in T4 at 4 and 6MAI. At 5MAI T8 registered the least available P content.

Table 14. Effect of treatments on available phosphorous status of soil (kg ha^{-1})

Treatments	Available phosphorous content in soil (kg ha^{-1})						
	1MAI	2MAI	3MAI	4MAI	5MAI	6MAI	Mean
T1	131.51	124.93	98.47	97.77	84.15	80.74	102.93
T2	138.39	125.35	92.74	88.85	81.99	71.23	99.76
T3	125.85	112.22	93.15	92.04	82.15	78.08	97.25
T4	119.51	113.08	88.48	76.29	69.38	52.43	86.53
T5	131.91	110.03	86.51	83.48	78.34	70.00	93.38
T6	107.16	95.91	77.26	79.31	77.77	76.19	85.60
T7	128.63	114.67	98.57	88.42	80.77	68.60	96.61
T8	98.03	88.19	65.54	84.69	68.85	66.13	78.57
SE	1.95	2.30	1.76	3.59	3.82	2.73	
CD(0.05)	5.84	6.89	5.27	10.77	11.46	8.19	

Comparing the organic manures T1 recorded highest mean value and lowest content was registered in T4.

The mean values showed that the available P_2O_5 was highest (102.93 kg ha^{-1}) in T1 followed by T2 (99.76kg ha^{-1}) ,T3 (97.25kg ha^{-1}), T7 (96.61kg ha^{-1}), T5 (93.38kg ha^{-1}), T4 (86.53kg ha^{-1}), T6 (85.60kg ha^{-1}) and the lowest value (78.57 kg ha^{-1}) was shown by T8 .

4.2.3 Available Potassium Status

The data given in Table 15 revealed the significant influence of various treatments and periods of mineralization on available potassium. In general available K_2O decreased progressively after 1MAI for all the treatments. All treatments showed higher content of available K_2O whereas T8 (soil alone) recorded the lowest value. The potassium mineralization pattern was steady up to 3MAI for T3 and T6 and later declined.

The available K_2O content at 1MAI was highest for T4(180.88 kg ha^{-1}) and was significantly higher for all treatments except T1. The content of K_2O at 2MAI and 3MAI was significantly higher in T1 added soil (163.89 kg ha^{-1} and 147.28 kg ha^{-1} respectively) and was on par with T6. At 4, 5 and 6 MAI T6 recorded maximum available K content of 133.78,121.96 and 115.83 respectively. At 4 and 5 MAI T6 was significantly superior to all other treatments except T1. At 6MAI T6 was significantly higher than all other treatments. The lowest K content was registered in T8 throughout the period of mineralization.

Among composite organic manures T1(139.09 kg ha^{-1}) showed maximum mean value and minimum content was registered in T5(101.36 kg ha^{-1}).

The mean values showed that the available K_2O was highest in T6 and T1 followed by T4 , T7, T3 , T2 , T5 and T8.

Table 15. Effect of treatments on available potassium status of soil (kg ha^{-1})

Treatment	Available potassium content in soil (kg ha^{-1})						
	1MAI	2MAI	3MAI	4MAI	5MAI	6MAI	Mean
T1	174.35	163.89	147.28	131.80	114.24	102.97	139.09
T2	124.88	112.00	108.64	100.07	91.21	86.35	103.86
T3	122.64	128.80	126.56	112.72	99.68	92.22	113.77
T4	180.88	149.71	129.92	116.12	107.55	101.89	131.01
T5	128.43	113.87	100.80	94.79	86.49	83.78	101.36
T6	156.24	156.24	151.20	133.78	121.96	115.83	139.21
T7	138.32	136.64	122.08	109.07	103.73	89.55	116.57
T8	105.28	96.32	99.12	92.89	82.13	66.91	90.44
SE	5.56	4.98	5.37	3.33	3.35	3.09	
CD(0.05)	16.68	14.94	16.11	9.99	10.05	9.27	

4.3 EVALUATION OF SELECTED COMPOSITE ORGANIC MANURES USING THE TEST CROP AMARANTHUS

The present study was conducted to assess the efficiency of selected COMs in improving the growth, productivity and quality of crops. A pot culture and field investigation were conducted for assessing the efficiency of the organic manures. Amaranthus was selected as the test crop and 5 selected organic manures were compared with package of practices (POP) recommendation of Kerala Agricultural University (50 t ha^{-1} FYM + 100:50:50 kg NPK ha^{-1} through chemical fertilizers) on nitrogen equivalent basis, KAU Adhoc Organic POP (cow's urine @ 500L ha^{-1}) and soil alone.

4.3.1Result of Pot Culture Experiment is Indicated Below.

4.3.1.1 Growth characters

4.3.1.1.1 Plant height

The data on plant height of amaranthus recorded at 30,45,60 and 75DAT is presented in Table 16. The data revealed that the treatments caused significant variation in plant height at each harvest. T7 recorded the maximum plant height of 29.67 cm at 30 DAT and was significantly superior to all other treatments. T5 influenced plant height significantly at 45 and 60 DAT (46.50 and 52.00 cm respectively) compared to all other treatments, except T1 which is on par with T5 at 60 DAT. At 75 DAT T8 showed highest plant height of 74.00cm and was significantly different from all other treatments, but was on par with T2. The lowest plant height was recorded by T6 at 30 DAT and 45 DAT (11.33 cm and 17.75 cm respectively). At 60 DAT the lowest value was recorded by T3 (23.5 cm). T4 showed the least value of plant height (38.5 cm) at 75 DAT.

Table 16. Effect of treatments on plant height (cm) of amaranthus

Treatment	Plant height (cm)				
	30DAT	45DAT	60DAT	75DAT	Mean
T1	20.00	20.00	48.00	50.50	34.63
T2	18.33	29.17	36.00	70.50	38.50
T3	16.67	22.50	23.50	61.33	31.00
T4	16.67	24.00	43.50	38.50	30.67
T5	20.50	46.50	52.00	61.00	45.00
T6	11.33	17.75	41.00	61.00	32.77
T7	29.67	18.50	39.00	64.00	37.79
T8	15.67	23.50	40.50	74.00	38.42
SE	2.15	1.83	1.41	1.90	
CD(0.05)	6.45	5.48	4.24	5.71	

Among composite organic manures highest plant height was registered in T5 at 30, 45 and 60 DAT. The lowest height was recorded in T3 and T4 at 30 DAT. At 45 DAT the minimum height was registered by T1(20.00 cm). At 60 DAT lowest plant height was obtained in T3. During the fourth harvest maximum height was registered in T2 and the minimum was recorded in T4.

The average values showed that highest plant height was recorded in T5 and the lowest value was registered in T4.

4.3.1.1.2 No: of leaves per plant

Data furnished in Table 17 indicates significant variation between treatments in the number of leaves per plant. Leaf number increased up to the final harvest. During the first harvest (30 DAT) T3 recorded maximum number of leaves (26.5 $plant^{-1}$) and was significantly superior to all other treatments, where as the lowest value was recorded by T6 (11.33 $plant^{-1}$). T1 registered maximum number of leaves at 45 and 60 DAT (43.5 and 54.82 $plant^{-1}$ respectively) and the lowest values were observed in T4 and T6 (21.33 and 35.58 $plant^{-1}$ respectively). T1 at 60 DAT was on par with T8 and significant with all other treatments. At 75 DAT T8 recorded the maximum value and was significantly higher than all other treatments except T3 and the lowest number of leaves was observed in T4 (38.92 $plant^{-1}$)

Among composite organic manures maximum number of leaves were recorded in T3 at 30 and 75 DAT. At 45 and 60 DAT highest value was registered in T1. At 30 DAT lowest value was recorded in T5. T4 recorded lowest values at 45 and 75DAS. At 60 DAT minimum value was recorded in T2.

The total values showed that highest number of leaves was recorded in T1 (577.53 $plant^{-1}$) and the lowest value was registered in T4 (369.64 $plant^{-1}$).

Table 17. Effect of treatments on no: of leaves per plant

Treatment	No: of leaves plant^{-1}				
	30DAT	45DAT	60DAT	75DAT	Total
T1	21.67	43.50	54.82	72.52	577.53
T2	16.50	22.00	35.90	54.48	386.65
T3	26.50	28.50	43.14	77.27	526.25
T4	17.33	21.33	45.63	38.92	369.64
T5	12.50	35.00	50.92	74.48	518.72
T6	11.33	27.00	35.58	58.72	397.90
T7	21.00	38.00	40.34	53.17	457.51
T8	11.67	34.5	53.77	79.97	539.74
SE	1.51	1.44	1.18	1.07	
CD (0.05)	4.54	4.33	3.53	3.20	

4.3.1.1.3 Leaf : Stem ratio

Leaf : Stem ratio recorded at four harvests is presented in Table 18.At 30, 45 and 60 DAT ,T6 recorded maximum leaf: stem ratio of 6.25, 1.98 and 1.83 respectively and the least values were observed in T7, T5 and T1 (3.04, 0.436 and 1.07 respectively) . At 75 DAT T7 recorded maximum leaf:stem ratio (1.08) which was significantly superior to treatments T2, T8, T5 and was on par with T1, T3, T4 and T6. The minimum value was observed in T5 with the value 0.667.

Among composite organic manures highest leaf : Stem ratio was recorded in T5 at 30 DAT and lowest value was registered in T3. At 45, 60 and 75 DAT maximum ratio was recorded in T3. At 45 and 75 DAT lowest ratio was recorded by T5. At 60 DAT least values were recorded by T1.

4.3.1.1.4 Dry matter production

The data summarized in Table 19 shows the significant difference of all treatments on dry matter production. T8 registered highest dry matter production at 30 DAT (7.25 g pot^{-1}) which was significantly superior to all other treatments. The lowest value was observed in T6. Dry matter production showed maximum value in T5 (11.54 g pot^{-1}) at 45DAT and was significantly different from all other treatments except T2. At 60 DAT T1 recorded maximum dry matter production (13.15 g pot^{-1}) and was significantly superior to T2, T8 and was on par with all other treatments . T8 showed least values at 45 and 60 DAT with the values 5.00 and 8.01gpot^{-1} respectively. Dry matter production was highest in T3 at 75 DAT which was significant from T1, T4, T6, T8 and was on par with T2, T5, and T7. T4 registered the lowest value at 75 DAT compared to other treatments.

Among composite organic manures maximum dry matter production was recorded in T2 at 30DAT and it was on par with T1. The least values were registered in T3 at30 and 45 DAT. At 45 DAT highest value was registered in T5.

Table 18. Effect of treatments on leaf : stem ratio

Treatment	Leaf : stem ratio			
	30DAT	45DAT	60DAT	75DAT
T1	2.97	0.85	1.07	0.96
T2	3.34	0.75	1.45	0.85
T3	2.66	1.11	1.59	1.00
T4	5.13	0.76	1.20	0.97
T5	6.00	0.44	1.51	0.67
T6	6.25	1.98	1.83	1.01
T7	1.53	0.58	1.38	1.08
T8	3.10	1.68	1.29	0.83
SE	0.250	0.108	0.135	6.07
CD (0.05)	0.750	0.324	0.405	0.182

Table 19. Effect of treatments on dry matter production (g pot^{-1})

Treatment	Dry matter production (g pot^{-1})				
	30DAT	45DAT	60DAT	75DAT	Total
T1	5.27	7.02	13.15	11.72	37.16
T2	5.38	10.01	9.42	13.46	38.27
T3	3.60	5.73	11.04	15.96	36.33
T4	3.80	7.00	11.67	10.38	32.85
T5	4.65	11.54	12.93	15.42	44.54
T6	2.97	5.19	11.52	12.69	32.37
T7	5.30	5.66	11.18	14.11	36.25
T8	7.25	5.00	8.01	10.58	30.84
SE	0.306	0.651	0.716	0.869	
CD(0.05)	0.92	1.95	2.15	2.61	

T1 recorded maximum value at 60DAT and lowest value was registered in T2. At 75 DAT highest dry matter production was obtained in T3. The least value was recorded in T4. It was significantly superior to T1 and T4.

The total values showed that highest dry matter production was recorded in T5(44.54 g pot^{-1}) and the lowest value was registered in T8 (30.84 g pot^{-1})

4.3.1.2 Yield and Yield Attributes

4.3.1.2.1 Leaf weight per pot

Leaf weight recorded at four harvests is presented in Table 20. Leaf weight was maximum at 60 DAT. At 30 DAT highest leaf weight was registered by T5 (76.35 g pot^{-1}) and was significantly superior to all other treatments. The least values were observed in T8. At 45 DAT T1 recorded the maximum leaf weight and it was significantly different from all other treatments. At 45 DAT T7 recorded the lowest value (21.87 g pot^{-1}). During the third harvest (60 DAT) T6 registered highest value and was significantly different from T1, T3, T4, T7, T8 and was on par with T2 and T5. At 75 DAT T2 recorded the maximum (59.97 g pot^{-1}) leaf weight and was significantly higher than all other treatments and the lowest value was observed in T4.

Among composite organic manures maximum leaf wt was recorded in T5 at 30 and 60 DAT. At 45 DAT highest value was registered in T1 and at 75 DAT maximum leaf wt was recorded in T2. The lowest leaf wt was reported in T4 at 30 and 75 DAT. At 45 and 60 DAT lowest leaf wt was recorded in T3.

The total values showed that highest leaf wt was recorded in T5 (662.51g pot^{-1}) and the lowest value was registered in T3 (487.06 g pot^{-1})

Table 20. Effect of treatments on leaf wt (g pot^{-1})

Treatment	Leaf wt (g pot^{-1})				
	30DAT	45DAT	60DAT	75DAT	Total
T1	52.90	42.19	61.96	55.13	636.55
T2	53.73	27.05	73.89	59.97	643.92
T3	58.06	23.46	33.21	47.63	487.06
T4	43.26	26.24	56.88	39.81	498.53
T5	76.35	25.21	77.93	41.36	662.51
T6	41.95	30.88	80.55	41.54	584.75
T7	47.08	21.87	52.99	48.92	512.55
T8	39.95	32.05	65.50	43.34	542.53
SE	1.98	2.51	3.03	1.44	
CD (0.05)	5.95	7.53	9.08	4.31	

4.3.1.2.2 Stem weight per pot

The data summarized in Table 21 revealed the significant influence of all treatments on stem weight during four harvests of amaranthus. T7 and T5 observed maximum stem weight at 30 DAT and 45 DAT (30.69 and 57.19 g pot^{-1} respectively). Both the treatments were significantly superior to all other treatments The lowest value was recorded by T6 during first and second harvest (6.74 and 15.9 g pot^{-1} respectively). At 60 DAT T1 registered the highest value (58.04 g pot^{-1}) which was significantly different from T3, T4, T6, T7 and was on par with T2, T5, T8.T2 registered maximum stem weight at 75 DAT which was significantly different from all treatments except T5. At 60 and 75 DAT, the least values were observed by T3 and T4 (21.79 and 41.42 g pot^{-1} respectively).

Among composite organic manures highest stem wt was recorded in T3 at 30 DAT. At 45 DAT highest value was registered in T5 and at 60 DAT maximum stem wt was recorded in T1. At 75 DAT highest value was recorded in T2. The lowest stem wt was reported in T4 at 30 and 75 DAT. At 45 and 60 DAT lowest leaf wt was recorded in T3.

The total values showed that highest stem wt was recorded in T5 (553.36 g pot^{-1}) and the lowest value was registered in T6 (326.28 g pot^{-1})

4.3.1.2.3 Yield per cutting

It is evident from Table 22 that treatments had significant effects on yield in all harvests. At 30 and 60 DAT highest per pot yield was recorded in T5 (89.07 and 129.90 g pot^{-1} respectively). At 30 DAT T5 was significantly superior to all treatments. At 60 DAT T5 was significantly higher than T4, T7 and T3 and was on par with other treatments. At 30 and 60 DAT lowest yield was recorded in T6(48.69 g pot^{-1}) and T3 (55.00 g pot^{-1}) respectively. At 45 DAT T1 registered maximum per pot yield of 92.11 g pot^{-1} and was significantly superior to all treatments except T5.

Table 21. Effect of treatments on stem wt (g pot^{-1})

Treatment	Stem wt (g pot^{-1})				
	30DAT	45DAT	60DAT	75DAT	Total
T1	18.49	49.92	58.04	57.57	552.06
T2	17.01	36.28	51.11	70.72	525.33
T3	21.83	21.04	21.79	47.41	336.18
T4	8.45	34.64	47.76	41.42	396.80
T5	12.73	57.19	51.98	62.56	553.36
T6	6.74	15.90	44.46	41.66	326.28
T7	30.69	37.66	38.68	45.51	457.60
T8	12.89	19.19	51.03	52.19	405.91
SE	1.13	1.89	2.83	2.83	
CD (0.05)	3.38	5.65	8.49	8.49	

Table 22. Effect of treatments on yield (g pot^{-1})

Treatment	Yield (g pot^{-1})				Total yield (g pot^{-1})
	30DAT	45DAT	60DAT	75DAT	
T1	71.39	92.11	120.00	112.70	396.20
T2	70.74	63.32	125.00	130.69	389.75
T3	79.89	44.49	55.00	95.03	274.41
T4	51.70	60.87	104.64	81.23	298.44
T5	89.07	82.40	129.90	103.91	405.29
T6	48.69	46.78	125.00	83.20	303.68
T7	77.76	59.53	91.67	94.43	323.38
T8	52.84	51.24	116.53	95.53	316.15
SE	2.96	4.92	5.75	4.79	6.66
CD(0.05)	8.86	14.76	17.24	14.39	19.97

The minimum yield was recorded in T3(44.49 g pot^{-1}). At 75 DAT highest per pot yield was registered in T2 (130.69 g pot^{-1}) and was significantly superior to all other treatments. The lowest yield of 81.23 g pot^{-1} was recorded in T4.

Comparing the composite organic manures highest per pot yield was recorded in T5 at 30 and 60 DAT. At 45 DAT maximum yield was registered in T1. At 75 DAT maximum yield was recorded in T2. T4 registered lowest yield at 30 and 75 DAT (51.70 and 81.23 g pot^{-1} respectively). At 45 and 60 DAT minimum per pot yield was registered in T3.

Total yield showed that highest yield was recorded in T5 (405.29 g pot^{-1}) and was significantly higher than all treatments except T1 and T2. T3 recorded the lowest yield of 274.41 g pot^{-1}.

4.3.1.3 Quality Attributes of amaranthus

4.3.1.3.1 Beta carotene Content

T7 recorded highest beta carotene content of 3970.00 μg 100 g^{-1} and was significantly superior to all other treatments. Lowest content was registered in T6 (3080.00 μg 100 g^{-1}).

Among composite organic manures T3 recorded maximum beta carotene content of 3478.00 μg 100 g^{-1} and was significantly superior to all other manures. Lowest content was registered in T1.

4.3.1.3.2 Vitamin C content.

Highest vitamin C content was recorded in T1 (23.08 mg 100 g^{-1}) and was significantly higher than T2, T5, T7 and T8. Lowest content was recorded in T8 (7.57 mg 100 g^{-1}).

Among composite organic manures maximum vitamin C content was recorded in T1, which was on par with T3 and T4 and significantly superior to T2 and T5.

4.3.1.3.3 Oxalate Content

Oxalate content was maximum in T4 (1.59 %) and it was on par with all other treatments except T1 and T2. The lowest content was recorded in T2 (0.75 %).

Among composite organic manures highest oxalate content was registered in T4 which was significantly superior to T1 and T2 and was on par with T3 and T5.

4.3.1.3.4 Nitrate Content

T3 recorded highest nitrate content of 1.25 % significantly higher than T2, T6, T8. lowest content was recorded in T6 (0.74 %)

Among composite organic manures maximum content was recorded in T3 and was significantly superior to all other treatments except T2.

4.3.1.4 Uptake of Major Nutrients

4.3.1.4.1 Nitrogen Uptake

The data given in Table 24 revealed that treatments significantly influenced N uptake. T5 registered highest N uptake of 29.53 kg ha^{-1} which was significantly different from T2, T6 and T8 and was on par with T1, T3, T4 and T7. The lowest N uptake was recorded in T8 (17.65 kg ha^{-1}).

Among composite organic manures maximum N uptake was recorded in T5 (29.53 kg ha^{-1}) and minimum uptake was registered in T2 (19.59 kg ha^{-1})

4.3.1.4.2 Phosphorous Uptake

The data given in Table 24 depicts the significant influence of treatments on P uptake. Application of T4 recorded the maximum P uptake of 10.24 kg ha^{-1} and

Table 23. Effect of treatments on quality attributes

Treatment	Beta carotene ($\mu g\ 100\ g^{-1}$)	Vitamin C ($mg\ 100\ g^{-1}$)	Oxalate (%)	Nitrate (%)
T1	3177.67	23.08	0.79	1.11
T2	3277.00	11.72	0.75	0.85
T3	3478.00	19.49	0.80	1.25
T4	3376.67	21.37	1.59	1.07
T5	3431.33	19.04	1.48	1.13
T6	3077.33	20.22	0.84	0.74
T7	3966.00	11.51	1.18	1.19
T8	3275.67	7.57	0.91	0.85
SE	3.02	1.34	0.262	0.104
CD(0.05)	9.07	4.03	0.789	0.313

was significantly superior to all other treatments. The minimum P uptake was registered by T8 (3.87 kg ha^{-1}).

Among composite organic manures highest P uptake was recorded in T4(10.24 kg ha^{-1}) followed by T5 (6.85 kg ha^{-1}), T3 (5.67 kg ha^{-1}), T1 (5.58 kg ha^{-1}) and T2 (4.10 kg ha^{-1}).

4.3.1.4.3 Potassium Uptake

The treatments significantly influenced K uptake at the end of crop growth (Table 24). The highest K uptake was recorded in T3 (58.77 kg ha^{-1}) which was significantly superior to T2, T4, T6, T7 and T8 and was on par with T1 and T5. The lowest uptake was registered in T8 (23.99 kg ha^{-1}).

Among composite organic manures highest K uptake was recorded in T3(58.77 kg ha^{-1}) followed by T5 (48.11 kg ha^{-1}), T1 (46.78 kg ha^{-1}), T4 (45.96 kg ha^{-1}) and T2 (40.04 kg ha^{-1}).

4.3.1.5 Available Nutrient Content in Soil

4.3.1.5.1 Available Nitrogen

The data on available nitrogen content of soil after the four harvests of crop are furnished in Table 25. Various treatments significantly influenced available N content of soil at the end of final harvest. Application of T6 recorded maximum available nitrogen content of 308.00 kg ha^{-1} and was significantly superior to all treatments except T4 (283.36 kg ha^{-1}). The least cotent was registered in T5 (190.96 kg ha^{-1}).

Among composite organic manures highest available nitrogen content was recorded in T4(283.36 kg ha^{-1}) followed by T1(252.56kg ha^{-1}), T2(234.08kg ha^{-1}), T3(201.23 kg ha^{-1}) and T5(190.96 kg ha^{-1}).

Table 24. Effect of treatments on uptake of major nutrients

Treatment	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
T1	23.77	5.58	46.78
T2	19.59	4.10	40.04
T3	27.72	5.67	58.77
T4	24.78	10.24	45.96
T5	29.53	6.85	48.11
T6	17.9	5.87	25.09
T7	23.53	6.35	27.33
T8	17.65	3.87	23.99
SE	2.22	0.833	4.28
CD (0.05)	6.66	2.49	12.81

4.3.1.5.2 Available Phosphorous

The data given in Table 25 clearly depicts the significant influence of treatments on available phosphorous content in soil. T5 recorded the maximum P content (59.45 kg ha^{-1}) in soil and was significantly different from T1, T3 and T8. The minimum content was registered by T3 (44.19 kg ha^{-1}).

Among composite organic manures highest available phosphorous content was recorded in T5(59.45 kg ha^{-1}) followed by T4(56.56kg ha^{-1}), T2(52.45 kg ha^{-1}), T1(49.68 kg ha^{-1}) and T3(44.19 kg ha^{-1}).

4.3.1.5.3 Available Potassium

Various treatments significantly influenced available potassium content of soil at the end of all harvests (Table 25) .Highest available potassium content was recorded in T7 (251.20 kg ha^{-1}) and was significantly superior to T3, T4, T5 and T6 . T3 registered lowest available potassium content of 61.6 kg ha^{-1}.

Among composite organic manures highest available potassium content was recorded in T2 (196.00 kg ha^{-1}) and the lowest content was registered in T3.

4.3.1.5.4 Organic Carbon

Various treatments showed significant influence on the organic carbon content of the soil (Table 25).T8 recorded highest organic carbon content of 1.97% and was significantly superior to all other treatments. The lowest content was registered in T6 (1.34%).

4.3.1.6 Microbial Population in Soil

4.3.1.6.1 Nitrogen Fixers

Data summarized in Table 26 shows the effect of treatments on the population of nitrogen fixers such as Azotobacter and Azospirillum in soil.

Table 25. Effect of treatments on available N,P,K (kg ha^{-1}) and Organic C (%) content in soil.

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Organic C(%)
T1	252.56	49.68	162.40	1.76
T2	234.08	52.45	196.00	1.71
T3	201.23	44.19	61.60	1.71
T4	283.36	56.56	134.43	1.72
T5	190.96	59.45	100.80	1.43
T6	308.00	58.27	100.80	1.34
T7	234.08	58.83	251.20	1.71
T8	240.24	48.60	235.20	1.97
SE	8.37	2.68	36.66	4.63
CD (0.05)	25.10	8.03	109.91	0.139

T5 recorded highest population (6.0 x 10^{-5}) of Azotobacter and lowest population was registered in T8 and T6 (1.0 x 10^{-5}). Azotobacter population was absent in T2 and T7. Maximum Azospirillum population was recorded in T4 (6.0 x 10^{-5}) and minimum population was registered in T7 (1.0 x 10^{-5}). Azospirillum population was absent in T8.

Among composite organic manures highest Azotobacter population was recorded in T5 and maximum Azospirillum population was recorded in T4. The minimum Azotobacter and Azospirillum population were recorded in T1 (2.0 x 10^{-5}).

4.3.1.6.2 Phosphorous solubilisers

Data presented in Table 26 clearly depicts the influence of various treatments on phosphorous solubiliser population. T5 recorded highest P solubliser population of 4.0 x 10^{-5} and lowest population was registered in T1 and T7 (1.0 x 10^{-5}).

Among composite organic manures maximum population was recorded in T5 followed by T3 (3.0 x10^{-5}) , T2 and T4 (2.0 x10^{-5}) and lowest was recorded in T1(1.0 x 10^{-5}).

4.3.1.6.3 Potassium solubilisers

Various treatments shows the influence on population of potassium solubilisers in soil (Table 26). T5 recorded the maximum K solubiliser population of 3.0 x 10^{-5} and minimum population was registered in T2 and T8 (1.0 x 10^{-5}).

Comparing the composite organic manures highest K solubilisers were recorded in T5 followed by T3 and T4 (2.0 x10^{-5}), and , T2 (1.0x 10^{-5}). K solubilisers were absent in T1.

Table 26. Effect of treatments on microbial population in soil

Treatment	N fixers		P solubilisers (10^{-5})	K solubilisers (10^{-5})
	Azotobacter (10^{-5})	Azospirillum (10^{-5})		
T1	2.0	2.0	1.0	0
T2	0	3.0	2.0	1.0
T3	4.0	4.0	3.0	2.0
T4	3.0	6.0	2.0	2.0
T5	6.0	4.0	4.0	3.0
T6	1.0	2.0	3.0	0
T7	0	1.0	1.0	0
T8	1.0	0	0	1.0

4.3.2 Result of Field Experiment is Indicated Below.

4.3.2.1 Growth characters

4.3.2.1.1 Plant height

The data presented in Table 27 showed the effect of different treatments on plant height of amaranthus. The data revealed that the treatments caused significant variation in plant height. T3 recorded maximum plant height of 68.50 cm and it was significantly superior to all other treatments except T4 (60cm). The lowest plant height was registered in T6 (29cm).

Comparing the composite organic manures highest plant height was recorded in T3 (68.50cm) followed by T4 (60.00 cm) ,T2 (54.67cm) , T1(52.00cm) and lowest was recorded in T5 (49.50cm)

4.3.2.1.2 Number of leaves per plant

Data furnished in Table 27 indicates significant variation between treatments in the number of leaves per plant of amaranthus . Highest number of leaves per plant was registered in T1 (25.6 $plant^{-1}$) and was significantly superior to all other treatments. T8 registered minimum number of leaves of 8.40 $plant^{-1}$.

Among composite organic manures maximum number of leaves per plant was recorded in T1 and lowest number of leaves was registered in T3 (14.55 $plant^{-1}$)

4.3.2.1.3 Leaf : Stem ratio

Effect of treatments on leaf : Stem ratio is presented in Table 27. T5 registered highest leaf:stem ratio of 2.47 and was on par with T6 (2.38) and T1(2.29). T5 was significantly superior to all other treatments. T8 recorded lowest leaf:stem ratio of 1.84.

Among composite organic manures highest leaf:stem ratio was registered in T5 followed by T1(2.29) , T2 (2.14) , T3 (2.08) and lowest was recorded in T4 (1.92).

4.3.2.1.4 Dry matter production

The data summarized in Table 27 shows the significant difference of all treatments on dry matter production. Highest dry matter production was recorded in T1 (1481.92 kg ha^{-1}) and was significantly higher than all other treatments. The lowest dry matter production was recorded in T6 (533.34 kg ha^{-1}).

Comparing the composite organic manures maximum dry matter production was registered in T1 and minimum was recorded in T4 (866.68 kg ha^{-1}).

4.3.2.2 Yield and Yield Attributes

4.3.2.2.1 Leaf weight per plant

The data given in Table 28 revealed that treatments significantly influenced per plant leaf weight. T5 registered highest per plant leaf weight of 53.23 g $plant^{-1}$ and was significantly superior to all other treatments except T1 (51.89 g $plant^{-1}$). T8 recorded lowest leaf weight of 22.69 g $plant^{-1}$.

Among composite organic manures maximum per plant leaf weight was registered in T5 followed by T1(51.89 g $plant^{-1}$), T2 (46.32 g $plant^{-1}$) , T4 (42.04 g $plant^{-1}$) and lowest was recorded in T3 (41.72 g $plant^{-1}$).

Table 27. Effect of treatments on growth characters of amaranthus

Treatment	Plant height (cm)	No: of leaves ($plant^{-1}$)	leaf:stem ratio	Dry matter production ($kg\ ha^{-1}$)
T1	52.00	25.60	2.29	1481.92
T2	54.67	16.33	2.14	1022.02
T3	68.50	14.55	2.08	1191.69
T4	60.00	17.27	1.92	866.68
T5	49.50	21.00	2.47	1133.36
T6	29.00	13.80	2.38	533.34
T7	42.00	18.70	1.97	959.24
T8	39.50	8.40	1.84	791.68
SE	3.12	1.42	0.101	87.84
CD (0.05)	9.48	4.30	0.307	265.01

4.3.2.2.2 Stem weight per plant

The data summarized in Table 28 revealed the significant influence of all treatments on stem weight of amaranthus. Highest per plant stem weight was recorded in T2 (23.59 g $plant^{-1}$) and was on par with all others except T3, T6, T7and T8. The lowest stem weight was recorded in T8 (12.32 g $plant^{-1}$).

Comparing the composite organic manures maximum per plant stem weight was registered in T2 (23.32 g $plant^{-1}$) and was on par with all other manures except T3.

4.3.2.2.3 Yield

It is evident from Table 28 that treatments had significant effects on yield of amaranthus. T5 registered highest yield of 12.76 t ha^{-1} was on par with T1 and T2 and was significantly superior to all other treatments. T8 recorded lowest yield of 5.84 t ha^{-1} .

Among composite organic manures maximum yield was recorded in T5 and was on par with T1 and T2.

4.3.2.3 Available Nutrient Content in Soil

4.3.2.3.1 Available Nitrogen

The data on available nitrogen content of soil after the crop harvest is furnished in Table 29. Various treatments significantly influenced available N content of soil . Application of T1 recorded maximum available nitrogen content of 359.59 kg ha^{-1} and was significantly superior to T8 (313.59 kg ha^{-1}) ,T5 (294.79 kg ha^{-1}) and T7 (288.52 kg ha^{-1}). The least content was registered in T7. Among composite organic manures highest available nitrogen content was recorded in T1 followed by T2(359.49 kg ha^{-1}), T3(355.41kg ha^{-1}), T4(351.23kg ha^{-1}) and T5 (294.79 kg ha^{-1}).

Table 28. Effect of treatments on yield and yield attributes of amaranthus

Treatment	Leaf wt(g $plant^{-1}$)	Stem wt(g $plant^{-1}$)	Yield (t ha^{-1})
T1	51.89	22.96	12.48
T2	46.32	23.59	11.65
T3	41.72	20.16	10.31
T4	42.04	22.12	10.69
T5	53.23	23.32	12.76
T6	40.53	17.22	9.63
T7	44.33	20.73	10.85
T8	22.69	12.32	5.84
SE	1.52	1.21	0.566
CD (0.05)	4.61	2.78	1.20

4.3.2.3.2 Available Phosphorous

The data given in Table 29 clearly depicts the significant influence of treatments on available phosphorous content in soil. T1 recorded the maximum P content (61.54 kg ha^{-1}) in soil and was significantly different from all other treatments except T2. The minimum content was registered by T7 (26.94 kg ha^{-1}).

Among composite organic manures highest available phosphorous content was recorded in T1(61.54 kg ha^{-1}) followed by T2(53.55 kg ha^{-1}), T4(49.56 kg ha^{-1}), T5(42.51kg ha^{-1}) and T3(31.58 kg ha^{-1}).

4.3.2.3.3 Available Potassium

Various treatments significantly influenced available potassium content of soil at the end harvest (Table 29) .Highest available potassium content was recorded in T1 (234.47 kg ha^{-1}) and was significantly superior to all other treatments except T4 (209.00 kg ha^{-1}) . T8 registered lowest available potassium content of 71.79 kg ha^{-1}.

Among composite organic manures highest available potassium content was recorded in T1 (234.47 kg ha^{-1}) and the lowest content was registered in T3 (128.13 kg ha^{-1}).

4.3.2.3.4 Organic Carbon

Various treatments showed significant influence on the organic carbon content of the soil (Table 29). T2 recorded highest organic carbon content of 1.89% and was significantly superior to all other treatments except T6 (1.81%). The lowest content was registered in T7 (1.16%).

Among composite organic manures T2 recorded maximum organic C content and lowest content was registered in T3 (1.35%).

Table 29. Effect of treatments on available N,P,K (kg ha^{-1}) and Organic C (%) content in soil

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Organic C(%)
T1	359.59	61.54	234.47	1.58
T2	359.49	53.55	192.86	1.89
T3	355.41	31.58	128.13	1.35
T4	351.23	49.56	209.00	1.60
T5	294.79	42.51	177.97	1.43
T6	351.23	35.96	106.57	1.81
T7	288.52	26.94	115.11	1.16
T8	313.59	31.53	71.79	1.29
SE	11.92	2.67	9.07	4.78
CD (0.05)	36.17	8.11	27.52	0.145

4.3.2.4 Microbial Population in Soil

4.3.2.4.1 Nitrogen Fixers

Data summarized in Table 30 shows the effect of treatments on the population of nitrogen fixers such as azotobacter and azospirillum in soil. T4 recorded highest population (5.0×10^{-5}) of azotobacter and lowest population was registered in T1 and T7 (1.0×10^{-5}). Azotobacter population was absent in T6 and T8. Maximum azospirillum population was recorded in T4 (6.0×10^{-5}) and minimum population was registered in T6 and T8 (1.0×10^{-5}). Azospirillum population was absent in T2, and T7 .

Among composite organic manures highest azotobacter population was recorded in T4 and maximum azospirillum population was recorded in T4. The minimum azotobacter and azospirillum population were recorded in T1 (1.0×10^{-5} and 2.5×10^{-5}) respectively.

4.3.2.4.2 Phosphorous solubilisers

Data presented in Table 30 clearly depicts the influence of various treatments on phosphorous solubiliser population. T5 recorded highest P solubiliser population of 5.0×10^{-5} and lowest population was registered in T4 (1.0×10^{-5}).

Among composite organic manures maximum population was recorded in T5 (5.0×10^{-5}) followed by T3 (3×10^{-5}), T2 (2.0×10^{-5}), T4(1.0×10^{-5}) and absent in T1.

4.3.2.4.3 Potassium solubilisers

Various treatments shows the influence on population of potassium solubilisers in soil (Table 30). T3 recorded the maximum K solubiliser population of 4.0×10^{-5} and minimum population was registered in T2 (1.0×10^{-5}).

Table 30. Effect of treatments on microbial population of soil.

Treatment	N fixers		P solubilisers (10^{-5})	K solubilisers (10^{-5})
	Azotobacter (10^{-5})	Azospirillum (10^{-5})		
T1	1.0	2.5	0	0
T2	2.0	0	2.0	1.0
T3	4.0	4.0	3.0	4.0
T4	5.0	6.0	1.0	2.0
T5	3.0	4.0	5.0	3.0
T6	0	1.0	2.0	0
T7	1.0	0	2.0	0
T8	0	1.0	0	0

Comparing the composite organic manures highest K solubilisers were recorded in T3 followed by T5 (3.0×10^{-5}) , T4 (2.0×10^{-5}), T2(1.0×10^{-5}) and absent in T1.

4.4. Economics of cultivation

The data on economics of cultivation is presented in Table 31.

Highest net returns was recorded in T5 (Rs 130800/-) and lowest net returns was registered in T8 (Rs 22200/-).

T5 showed maximum B:C ratio of 2.2 compared to all other treatments and lowest ratio was reported in T8 (0.6). Among manures highest B:C ratio was reported in T5 followed by T2, T1, T3 and T4. T6 and T7 recorded a B:C ratio of 1.8 and 1.9 respectively.

Table 31. Effect of treatments on economics of cultivation of amaranthus

Treatment	Cost of cultivation (Rs)	Gross returns (Rs)	Net returns (Rs)	B:C
T1	66000	187200	121200	1.8
T2	60600	174750	114150	1.9
T3	60200	154650	94450	1.6
T4	63600	160350	96750	1.5
T5	60600	191400	130800	2.2
T6	35000	96300	61300	1.8
T7	36200	108500	72300	1.9
T8	36200	58400	22200	0.6

Discussion

5. Discussion

An experiment was conducted at College of Agriculture , Vellayani during 2009- 2011 to assess the feasibility of developing good quality bio-organic composite manures for organic vegetable production. The investigation comprises three phases. (1). Formulation and quality evaluation of bio organic composite manures,

(2). Mineralization study of bio organic composite manures,

(3). Crop response study. Crop response study was conducted as one pot culture investigation and another field investigation. The results obtained are discussed below.

5.1 Formulation and quality evaluation of bio-organic composite manures

Sixteen manures were prepared by mixing different organic amendments in different ratios. Among the sixteen manures, five promising manures (OM3, OM5, OM9, OM11 and OM13) were selected based on the nutrient content and N:K ratio. These manures were prepared by mixing coir pith compost, poultry manure, ground nut cake, rock dust, ash and microbial consortium. Ground nut cake analyzing 7 % N is a major constituent of these manures and this resulted in a better N status of the organic composite manure. Microbial consortium was also used for the preparation of OM9, OM11 and OM13 which leads to the increase in N %. Remaining 11 manures analyzed a N status < 3% may be due to the difference in the components used for the preparation of manures. Addition of microbial consortium also did not improved the N status of these 11 manures to the desirable level. This shows the differential response to substrate by microorganisms.

The selected manures were analyzed for heavy metals content. The content is in the desirable range. So this shows that the constituent used for the preparation of manures were safe for bio-organic composite manure production. The shelf life of the manure was studied and it was observed that the nutrient content remains somewhat constant till 3 months thereafter a reduction was observed. This reduction in nutrient status with time may be due to microbial transformation. pH of the manures was estimated. Neutral pH of OM5 and OM13 may be due to higher content of rock dust in the mixture. OM3 and OM11 constituents are same. OM3 registered a neutral pH which may be due to the presence of ash. OM11 registered acidic pH and this may be due to the release of some organic acids by microorganisms.

5.2 Relative performance of bio –organic composite manures on growth and productivity and quality of amaranthus

5.2.1 Yield

Among the manures T1, T2 and T5 recorded maximum yield. Yield is a function of leaf weight and stem weight. T1, T2 and T5 recorded higher leaf and stem weight which cumulatively resulted in better yield. T1, T2 and T5 recorded higher plant height compared to T3 and T4. This must have resulted in better leaf production and higher stem weight. Gianquinto and Borin (1990) observed an increase in plant growth and yield of tomato plants by the addition of organic manures. T1, T2 and T5 pH was neutral where as T3 and T4 they are acidic in nature. This investigation was taken up in acid soil. The neutral nature of T1, T2 and T5 must have promoted the availability and absorption of native and added nutrients and this may be one of the reasons for obtaining higher productivity in T1, T2 and T5. Better content of Zn and Cu was also observed in these treatments and this better availability of Zn might have also contributed to higher yield. Nair (2003) reported that, poultry manure recorded the highest availability of nutrients N,P,K. Superiority of T1, T2 and T5 compared to T3 may be due to

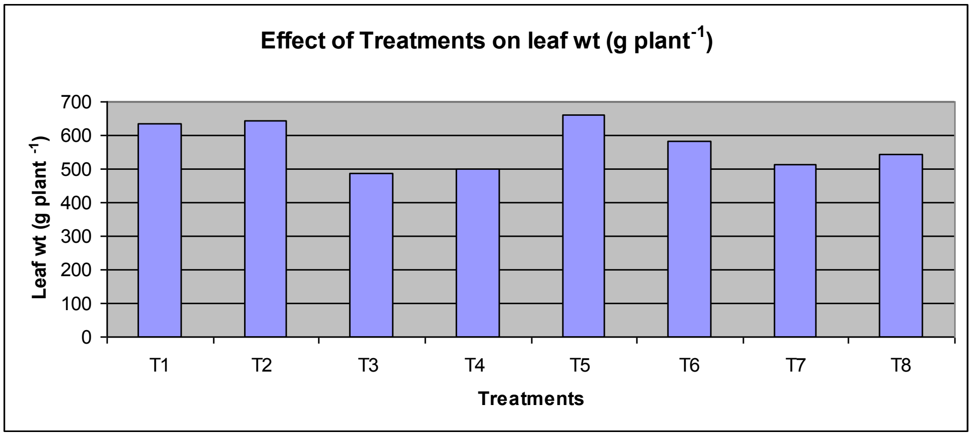

Fig 4. Effect of treatments on leaf weight of amaranthus

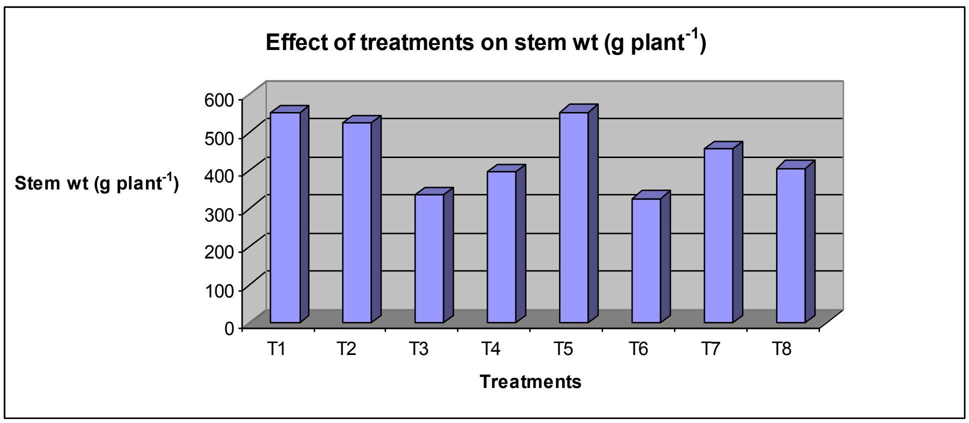

Fig 5. Effect of treatments on stem weight of amaranthus

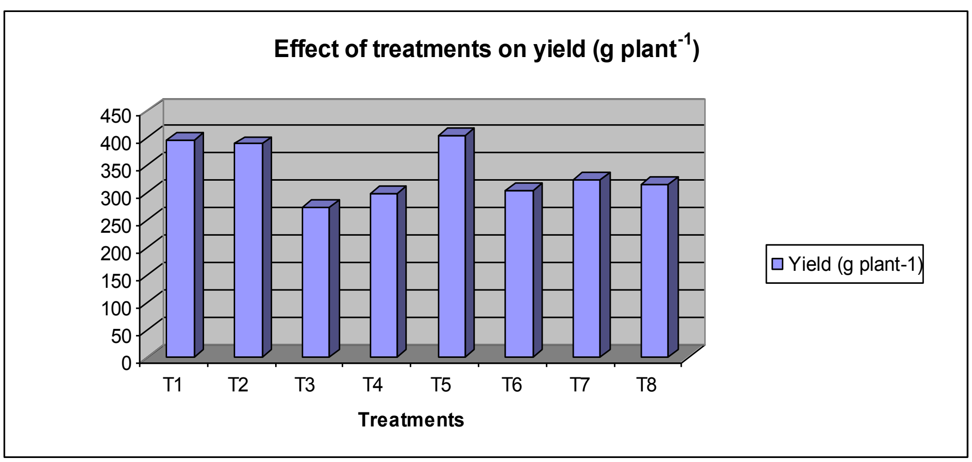

Fig 6. Effect of treatments on yield of amaranthus

good N:K ratio which resulted in better supply of potassium. As coir pith is rich in potash and being acidic, its application can enhance the release of fixed and mineral potassium in soil and hence the quantity of potash fertilizers can be reduced in agriculture (Savithri et al., 1993)

Manures vs POP and Adhoc organic POP

Compared to KAU POP, T1, T2 and T5 recorded higher leaf and stem weight which cumulatively resulted in higher yield. Awodun (2007) reported that , in fluted pumpkin, poultry manure application increased no: of leaves and branches, length of internodes compared to NPK fertilizers. It was observed that population of all beneficial organisms was higher in organic manure applied pot compared to KAU POP. Result of the mineralization study was also proved that all organic manure applied pots maintained better nutrient status to meet the amaranthus requirement. All these resulted in better performance of T1, T2 and T5 compared to KAU POP.

In Adhoc organic POP FYM was applied as basal dose and cows urine 8 times dilution was given as foliar spray after each harvest. C:N ratio of the FYM applied was 25:1, since the ratio was > 20:1 nutrients were released slowly. The nutrient schedule adopted in Adhoc organic POP might not have satisfied the nutrient requirement of the crop. So this must have resulted in low yield of T6.

5.2.2 Quality

Among composite organic manures T3 recorded maximum beta carotene content and was significantly superior to all other manures. Lowest content was registered in T1. Maximum vitamin C content was recorded in T1, which was on par with T3 and T4 and significantly superior to T2 and T5. Highest oxalate content was registered in T4 which was significantly superior to T1 and T2 and was on par with T3 and T5. T3 recorded higher nitrate content and was significantly superior to all other treatments except T2. Sheeba (2004) showed that the treatments with organic sources of plant nutrients recorded the highest value for beta carotene content, protein content and the lowest fiber and oxalate content in amranthus.In general compared to control beta carotene content was higher in T3, T4 and T5. Organic manure addition increased the vitamin C content compared to control. Oxalate content of T4 and T5 was higher compared to control. An increasing trend was observed on nitrate content among manures compared to control due to supply of more nitrogen by the addition of manures. Anitha (1997) observed that chilli plants treated with poultry manure recorded the maximum ascorbic acid content of fruit as compared to vermicompost and control treatments. Arunkumar (2000) reported that in amaranthus maximum protein content was obtained with poultry manure application

Manures vs POP and Adhoc organic POP

Compared to KAU POP all organic manure mixtures showed significantly lower beta carotene content. Higher vitamin C content was recorded in all manures except T2 compared to POP. All organic manure mixtures showed same trend compared to POP on oxalate content. POP was significantly superior to T2 and was on par with other manures on nitrate content due to supply of more nitrogen.

KAU Adhoc organic POP when compared with manures showed that, beta carotene content was higher in organic manure mixtures. KAU Adhoc organic POP was superior to T2 and was on par with other manures on vitamin C content. Oxalate content showed same trend in organic manures and KAU Adhoc organic POP . T2 was on par with KAU Adhoc organic POP and all other manures were superior on nitrate content.

5.2.3 Uptake of Major Nutrients

All manures were on par on nitrogen uptake except T2. Superiority of phosphorous uptake was seen by T4 on all other manures. In the case of potassium uptake T2 and T4 recorded lower uptake and T1, T3 and T5 were on par. Abusaleha (1992) observed an increased uptake of N,P,K,Ca and Mg in bhindi when 40kg N was supplied through poultry manure compared to the application of the same quantity through farm yard manure or ammonium sulphate on equivalent nitrogen basis. Meena et al (2007) observed that the total nutrient uptake also increased significantly in organic treatments compared to control and was highest with application of 150% RND as PM in green peas. In general compared to control organic manure addition increased nitrogen, phosphorous and potassium uptake by amaranthus. Uptake is a function of dry weight and nutrient content. Better nutrient content or better dry matter production resulted in better nutrient uptake by manures.

Manures vs POP and Adhoc organic POP

All organic manures were on par with KAU POP on nitrogen uptake. Phosphorous uptake showed that, T4 was superior and all other manures were on par with KAU POP. Potassium uptake showed that, T2 was on par and all other manures were superior to KAU POP.

T1 and T2 were on par and all other manures were higher than KAU Adhoc organic POP on nitrogen uptake. Phosphorous uptake showed that, T4 was superior and all other manures were on par with KAU Adhoc organic POP. Manures recorded superiority on potassium uptake compared to KAU Adhoc organic POP.

5.3 Available Nutrient Content in Soil

Compared to initial value available N status decreased in all treatments. It may be due to nutrient removal, immobilization of microbes and other reasons. Lowest available N status observed in T5 due to higher nitrogen removal. Humus by virtue of its chelating properties increases the availability of N, P, S and other nutrients to plants growing in humus rich soils (Gaur, 1994). Nair (2003) reported that among FYM, poultry manure and vermicompost, poultry manure recorded the highest availability of nutrients N,P,K. Among composite organic manures T4 was superior to all other manures on available nitrogen content in soil. Available phosphorous content showed that T5 was higher than T1 and T3 and all others were on par. T2 was superior to all other treatments except T3 which was on par for available potassium content. T1 was superior to T5 on organic carbon content.

Available N status showed that, T4 was higher, T1 and T2 was on par and other manures were inferior compared to control. In general except T1 and T3 available P status was found to be higher. In general except T7 available K status was found to be lower compared to control.

Manures vs POP and Adhoc organic POP

Manures compared with KAU POP it was observed that available nitrogen content shows the same trend as that of control. Except T1 and T3 available P status of KAU POP was on par with manures. Available potassium content showed that, T1 and T2 were on par and all other manures were inferior to KAU POP.

All manures were inferior except T4 which was on par with KAU Adhoc organic POP on available N status. Available phosphorous content showed that all manures were on par with KAU Adhoc organic POP except T3. Compared to Adhoc POP it was observed that all manure mixtures were on par for available K status.

5.4. Mineralization study

5.4.1 Available Nitrogen Status

An initial increase in available N content was observed in T1, T4 and T5 is due to the mineralization of nutrients from the organic manures. This mineralization was occurred due to safe C: N and C: P ratio of the manures. Later a reduction was observed during 2MAI and thereafter an increase was observed. For T2, T3 and T6 available N content increased gradually up to 3MAI. For T7 the N content progressively increased up to 2MAI and later declined, whereas for T8 an initial reduction in N status was observed and thereafter increased. From 3MAI onwards all treatments showed a decline in available nitrogen status of soil. In an incubation study conducted with FYM, poultry manure and vermicompost, Nair (2003) reported that there was a progressive increase in the availability of N and P_2O_5 till the 90^{th} day for all the three manures. The average values showed that the available N was highest by T3 application followed by T4, T7, T5, T2, T8 ,T6 and the lowest value was shown by T1. Among composite organic manures highest available N content was recorded in T3 and lowest content was registered in T1. Compared to control except T1 all other manures recorded maximum available N content. Compared to KAU Adhoc organic POP similar trend was seen as that of control. T3 and T4 showed higher available N compared to POP and all other manures were inferior.

5.4.2 Available Phosphorous Status

All treatments registered higher content of available P as compared to T8 (soil alone). For all the treatments the availability was high during Ist month after mineralization and the values gradually declined thereafter. The mean values showed that the available P was highest in T1 followed by T2 ,T3 ,T7 ,T5 ,T4 ,T6 and the lowest value was shown by T8 .Comparing the organic manures T1 recorded highest mean value and lowest content was registered in T4.It was observed that available P content of all manures were higher than control. Comparing KAU Adhoc organic POP with manures, same trend was seen as that of control.T4 and T5 recorded lower P content and all other manures registered higher mean value of P compared to POP.

5.4.3 Available Potassium Status

In general available K_2O decreased progressively after 1MAI for all the treatments. All treatments showed higher content of available K whereas T8 (soil alone) recorded the lowest value. Nair (2003) reported that there was a progressive increase in the availability of K_2O for organic manures FYM, poultry manure and vermicompost, up to the 60^{th} day and there after decreased. Among the three organic manures, poultry manure showed higher availability of the nutrients. The mean values showed that the available K was highest in T6 and T1 followed by T4 , T7, T3 , T2 , T5 and T8.Among composite organic manures T1 showed maximum mean value and minimum content was registered in T5. Compared to control mean value showed that available K content was higher for all manures. T1 and KAU Adhoc organic POP shows same value of available K content and all other manures were inferior to Adhoc organic POP. Compared to POP T4 and T1 recorded higher K content and all other manures were inferior. Sheeba (2004) inferred from an incubation experiment that available N, P_2O_5 and K_2O content of the soil increased up to 45 days of incubation, and then the availability slowly declined.

Summary

6. SUMMARY

The present investigation entitled "Development and evaluation of bio-organic composite manure for vegetables" was carried out at College of Agriculture, Vellayani during 2009-2011. The main objective of the study was to assess the feasibility of developing good quality bio-organic composite manures for organic vegetable production. The investigation comprises three phases. (1). Formulation and quality evaluation of bio organic composite manures, (2). Mineralization study of bio organic composite manures, (3). Crop response study. Crop response study was conducted as one pot culture investigation and another field investigation.

1. Formulation and quality evaluation of bio organic composite manures

The study was conducted in the laboratory during January 2010 to January 2011. Organic sources used for the preparation of bio organic composite manures were coir pith compost, poultry manure, neem cake, ground nut cake, ash, rock dust and microbial consortium.

Raw materials collected from different parts of Kerala were analyzed and best sources were selected for the preparation of mixture. Raw materials were mixed in different proportion to make the respective organic manure mixture. Sixteen organic manure mixtures were prepared as per the treatments. The experiment was laid out in completely randomized design with 16 treatments and two replications. The nutrient content of the manure mixtures were analyzed. The objective of the study was to select composite organic manures analyzing at least 3% N and N:K ratio of 1:0.5. Five mixtures (OM3 - coir pith compost – 50g, ground nut cake – 35g and ash – 15g , OM5- poultry manure- 50g, ground nut cake – 30g, rock dust- 20g, OM9 - coir pith compost – 50g, ground nut cake – 36g ,rock dust – 13g and microbial consortium – 1g, OM11 - coir pith compost – 50g, ground nut cake – 35g

, ash – 14g and microbial consortium – 1g, OM13- poultry manure- 50g, ground nut cake – 30g, rock dust- 19g and microbial consortium – 1g) satisfying the selection criteria were identified for the investigation and selected for further study. The physical and chemical characters of selected organic manure mixture viz odour, colour , moisture content, bulk density, pH, heavy metals, EC, organic carbon, nitrogen , phosphorous and potassium contents were analyzed.

The results revealed that among the 16 manure mixtures maximum N content was obtained in OM9, highest P content was registered in OM6 and maximum K content in OM10. Among the five mixtures maximum N content was recorded in OM9, highest P content was registered in OM5 and maximum K content was recorded in OM9 . OM11 recorded minimum Organic C content and OM5 recorded maximum Organic C content . Shelf lives of these manures were also assessed. It was observed that theses manures retain the initial nutrient status up to 3 months and there after a reduction was observed in nutrient status.

Highest arsenic content was reported in OM9 and lowest content was registered by OM3 and OM11. OM5 and OM13 recorded maximum chromium content and OM3 and OM11 recorded lowest content. OM3 and OM11 recorded maximum cadmium content. OM9 registered lowest cadmium content. All organic manures except OM9 registered a copper content of 0.08 ppm. Mercury content was on par for all organic manures . Heavy metal nickel was absent in all composite organic manures. Maximum zinc content was reported in OM5 and OM13 and minimum content was recorded in OM9. Heavy metal content of organic manure mixtures were within the permissible limit only.

OM5 and OM13 recorded the highest bulk density followed by OM9, OM11and OM3. Moisture content of organic manures were less than 1 %. OM9 and OM11 recorded the maximum moisture content . OM5 and OM13 has the pH value in neutral range, OM11and OM3 were slightly acidic and OM9 was medium acidic. Maximum EC was registered by OM5 and minimum by OM9.

Nitrogen fixers (Azotobacter and Azospirillum) population was recorded in all organic manures. Highest Azotobacter , Azospirillum and K solubilisers population were recorded in OM11 .OM5 registered minimum azospirillum population .P solubilisers were recorded in all organic manures except OM5. Highest P solubilisers were recorded in OM13 and lowest P solubilisers were recorded in OM3. K solubilisers were reported in all organic manures except OM5.

2. Mineralization study

Mineralization study was conducted in pots during January 2011 to June 2011. The objective of the study was to assess the nutrient release pattern of different organic manure mixtures. The experiment was laid out in completely randomized design with 8 treatments and three replications. Five selected organic manures were compared with package of practices (POP) recommendation of Kerala Agricultural University (50 t ha^{-1} FYM + 100:50:50 kg NPK ha^{-1} through chemical fertilizers) on nitrogen equivalent basis, KAU Adhoc Organic POP (cow's urine @ 500L ha^{-1}) and soil alone form the 8 treatments. The different composite manures were applied on N equivalent basis for the test crop amaranthus. The soil with composite manures was filled in pots of uniform size. These soil samples were kept for 6 months.

The studies indicated that T1(OM3), T4(OM11) and T5 (OM13),a reduction in available N content was observed during 2MAI and thereafter an increase was observed. For T2 (OM5) ,T3 (OM9) and T6 (Organic POP) available N content increased gradually up to 3MAI. For T7 (KAU POP) the N content progressively increased up to 2MAI and later declined, whereas for T8(soil alone) an initial reduction in N status was observed and thereafter increased during 2MAI. From 3MAI onwards all treatments showed a decline in available nitrogen status of soil.

At 1 MAI T5 (OM13) recorded significantly higher available N content compared to all other treatments except T7 (KAU POP) . T1(OM3) and T2 (OM5) registered significantly lower N content at 1MAI. At 2MAI T7 (KAU POP) recorded significantly higher value compared to all other treatments. The lowest content was recorded in T1(OM3). At 3 and 4MAI T3 (OM9) recorded increased N content which was significantly different from T5 (OM13), T6 (Organic POP), T7 (KAU POP) and T8(soil alone). The lowest content was registered in T8 at 3,4 5and 6 MAI .At 5 and 6MAI highest N content was recorded in T4(OM11) and was significantly superior to all other treatments. Among composite organic manures highest available N content was recorded in T3 (OM9) and lowest content was registered in T1(OM3) .The average values showed that the available N was highest with T3 (OM9) application and the lowest value was shown by T8(soil alone).

There was significant variation among treatments on available P content in soil. . All treatments registered higher content of available P_2O_5 as compared to T8 (soil alone). For all the treatments the availability was high during Ist month after mineralization and the values gradually declined thereafter. The available phosphorous content was highest for T2 (OM5) at 1and) . At 1MAI T2 (OM5)was significantly superior to all other treatments and at 2MAI it was on par with T1(OM3). At 3MAI T7 (KAU POP) showed a steady superiority over other treatments and was on par with T1(OM3). The lowest P content was recorded in T8(soil alone) at 1, 2 and 3MAI. At 4, 5 and 6MAI T1(OM3) recorded maximum P content. The lowest content was registered in T4(OM11) at 4 and 6MAI. At 5MAI T8(soil alone) registered the least available P content. Comparing the organic manures T1(OM3) recorded highest mean value and lowest content was registered in T4(OM11). The mean values showed that the available P_2O_5 was highest in T1(OM3) applied soil and the lowest value was shown by T8(soil alone) .

In general available K_2O decreased progressively after 1MAI for all the treatments. All treatments showed higher content of available K_2O whereas T8 (soil alone) recorded the lowest value. The potassium mineralization pattern was steady up to 3MAI for T3 (OM9) and T6 (Organic POP) and later declined. The available K_2O content at 1MAI was highest for T4(OM11) and was significantly higher for all treatments except T1(OM3) . The content of K_2O at 2MAI and 3MAI was significantly higher in T1(OM3) added soil and was on par with T6 (Organic POP). At 4, 5 and 6 MAI T6 (Organic POP) recorded maximum available K content . At 4 and 5 MAI T6 (Organic POP) was significantly superior to all other treatments except T1(OM3). At 6MAI T6 (Organic POP) was significantly higher than all other treatments. The lowest K content was registered in T8(soil alone) throughout the period of mineralization. Among composite organic manures T1(OM3) showed maximum mean value and minimum content was registered in T5 (OM13). The mean values showed that the available K_2O was highest in T6 (Organic POP) and T1(OM3) and lowest in T8(soil alone).

3. Evaluation of selected composite organic manures using the test crop amaranthus

Crop response study was conducted as one pot culture investigation and another field investigation with 8 treatments and 3 replications using amaranthus as the test crop. Treatments were same as the mineralization study. Design adopted was completely randomized design for pot culture study and randomized block design for field investigation.

Pot culture and field study revealed that growth response of amaranthus to various treatments indicated that application of organic manure mixtures favoured crop growth conditions by producing longer plants, more no: of leaves and recording the maximum dry matter production as compared to other treatments.

Yield attributes like leaf wt, stem wt and total yield were also significantly higher than the application of organic POP, KAU POP and soil alone. Among the treatments maximum yield was obtained for the treatment T5 (poultry manure- 50g, ground nut cake – 30g, rock dust- 19g and microbial consortium – 1g) and it was on par with T1 (coir pith compost – 50g, ground nut cake – 35g and ash – 15g) and T2 (poultry manure- 50g, ground nut cake – 30g, rock dust- 20g). Organic POP as well as KAU POP was significantly inferior to the best treatments. The results were same for both pot and field investigation. Maximum yield obtained under pot study was 405.29 g pot^{-1}. Maximum yield registered in field investigation was 12.76 t ha^{-1}.

Pot culture study revealed that T7 recorded highest beta carotene content and was significantly superior to all other treatments. Lowest content was registered in T6. Organic manures in general recorded highest vitamin C, oxalate and nitrate content compared to other treatments.

Nutrient uptake by plants varied significantly with respect to various treatments. T5 registered highest N uptake. Among composite organic manures maximum N uptake was recorded in T5. Application of T4 recorded the maximum P uptake .The highest K uptake was recorded in T3.

Various treatments significantly influenced available nutrient content of soil. Application of T6 recorded maximum available nitrogen content . Among composite organic manures highest available nitrogen content was recorded in T4. T5 recorded the maximum P content. Highest available potassium content was recorded in T7. T8 recorded highest organic carbon content

T5 recorded highest population of Azotobacter, P solubiliser and K solubiliser population. Maximum Azospirillum population was recorded in T4 .

Field study showed that available nutrient content was maximum in manure applied soils compared to organic POP, KAU POP and soil alone. N,P, and K content in soil was maximum in T1 and organic content was maximum in T2. Microbial population study indicated that maximum population was observed in manure applied plots compared to other treatments. Maximum N fixers were recorded in T4, Psolubilisers in T5 and K solubilisers in T3.

The study on economics shows that T5 registering net returns of Rs 130800/- was the most economical treatment with B:C ratio 2.2. The lowest net returns of Rs. 22200 was obtained in treatment T8 (soil alone) with B:C ratio 0.6.

Future line of work

- Substrate preference for assessing the performance of microbial consortium.
- Using of different types of containers for improving the shelf life of manures and also for increasing the activity of microbial consortium should be studied.
- Possibility of developing quality organic manures by mixing other organic materials can be studied.
- In organic farming most important nutrient for which alternate nutrient sources are not available at present is potassium. So the possibility of producing manure rich in K also should be assessed.

References

7. REFERENCES

Abusaleha, S. 1992. Effect of different sources and forms of nitrogen on the uptake of major nutrients of okra. *S. Indian Hort*. 49:192-196

Ahmed, S.R. 1993. Influence of composted coconut coir dust on soil physical properties, growth and yield of tomato. *S. Indian Hort*. 41: 264-269

Allison, F.E. and Klein, C.J. 1945. Role of immobilization and release of nitrogen following additions of carbonaceous materials and nitrogen to soils. *Soil Sci.* 93: 383-386

Angeles, D., Seurynck, K.K. and Mead, M.N.1997. The effect of minerals and trace elements on soybean growth and rhizobial activity. Remineralize the Earth. 10: 54-63

Anitha, V.1997. Nitrogen management in vegetable chilli grown in pots with modified drip irrigation system. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 140p

Anthoni, R.S., Subramanian, S and Subramanian, P. 2000. Biodissolution of nutrition in rice ecosystem. Dept of Microbiology and Dept of Soil Science and Agricultural Chemistry, Agriculture College and Research Institute, Madhurai, Tamilnadu.

AOAC. 1984. Official and Tentative method of analysis. Association of Official Agricultural Chemists, Washington D.C. 156 p

Appavu, K., Poongothi, S. and Savithri, P. 2001. Effect of different organic manures, tillage methods and crop residue management on the availability of micronutrients. Madras Agric. J. 87: 414-417

Arunkumar , K.R. 2000. Organic nutrition in amaranthus. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 123p

Arunkumar,S. 1997. Azotobacter and Azospirillum inoculants for Nitrogen Economy in Vegetable Cultivation. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 130p

Asha , K.R.2006. Ecofriendly production of slicing cucumber (*Cucumis sativus* L.) through organic sources. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 125p

Asha, K.R. 1999. Organic nutrition in okra (*Abelmoschus esculentus*). M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 166p

Awodun, M.A. 2007. Effect of poultry manure on the growth, yield and nutrient content of fluted pumpkin (*Telfaria occidentalis* Hook F). *Asian J. Agric. Rese*. 1(2): 67-73

Badawy,F.H. and Imam,M.K. 1975. Effect of seed inoculation with Azotobacter on growth and yield of some vegetable crops. *Libyan.J.Agric*.4:69-78

Bahadur, A. and Manohar, R.K. 2001. Response of okra to biofertilizers. *Veg Sci.* 28(2): 197-198

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

Balasubramani, P. and Pappiah, C.M. 1995. Effect of nitrogen and Azospirillum inoculation on the yield and quality of bhindi. *Material Symposium on Organic Farming, Oct 27-28*, TNAU, Madurai, pp. 42-46

Balasubramanian, A., Siddaramappa, R. and Rangaswami, G. 1972. Effect of organic manuring on the activities of enzymes hydrolyzing sucrose, urease on soil aggregation. *Plant and Soil* 14: 327-328

Barker , A.V., Brien, T.A. and Campe, J. 1998. *Soil mineralization and sustainable crop production*. In : Beneficial co utilization of agricultural , municipal and industrial products. Kluwer. 405-413

Becker, B. 1995. USDA begins field demonstration for SR. Remineralization the Earth. 7: 17-18

Bhowmic, B.B. and Debnath, C.R. 1985. Coir Fiber , Part II. Potentiality of coir fiber products, *Indian Cocon. J.* 16:7-10

Biswas, T.D., Ingole, B.N. and Jha, K.K. 1969. Changes in the physical properties of the soil by fertilizer and manure. *Fertil. News* 14:23

Bray, R.H. and Kurtz, L.T. 1945. Determination of total organic and available forms of phosphorous in soils. *Soil Sci*., 59: 39-45.

Chang , A.C., Lund, L.J., Page, A.L. and Warneke, J.E. 1977. Physical properties of fly ash-amended soils. *J. Environ. Qual.* **6**: 267–270.

Channabasavanna, A.S. and Biradar, D.P. 2002. Poultry by product to avoid pollution. *Kisan Wld.* 29(5): 52-53

Chinnaswamy, K.N. 1967. A note on the effect of organic manures on the earliness and fruiting in tomatoes. *Madras Agric. J.* 54 : 144-146

Clapham, W.M. and Zibilske, L.M. 1992. Wood ash as a liming amendment. *Commun. Soil. Sci. Plant Anal.* **23**: 1209–1227.

De Bertoldi,M. and Zucconi,F. 1980. Microbiologia della transformazione deirifiuti solidi urbani in compost and Ioro utilizzozione in agricoltura. Ingegneria ambientale,9:209-216

Devi krishna. 2005. Impact of organic farming on soil health, yield and quality of cowpea. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 132 p

Dibut,B., Martinez,K and Gonzalez,R. 1995. Stimulation of tomato development and yield by inoculation with *A.chroococcum*. *Memorias de XI Congress Latinanmericano dela Cinencia de suelo y II.* 1995

Divya, S.S.R. 2008. Rock dust as a nutrient source for coleus (*Solenostemon rotundifolius* (POIR) MORTON) . M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 72 p

Dobereiner, J., Marriel, I.E. and Nery, M. 1976. Ecological distribution of *Spirillum lipoferum*, Beijerinck. *Can. J. Microbiol*., 22, 1464-1473.

Eghball, B.,Wienhold, B. J.,Gilley, J. E. and Eigenberg, R. A. 2002. Mineralization of manure nutrients. *J. Soil. Water Consrv Nov/Dec 2002,* 57 (6): 470-473

Erich, M.S. 1991. Agronomic effectiveness of wood ash as a source of phosphorus and potassium. *J. Environ. Qual.* 20: 576–581.

Etiegni, L. and Campbell, A.G. 1991. Physical and chemical characteristics of wood ash. *Biores. Technol.* 37:173–178

Etiegni, L., Campbell, A.G. and Mahler, R.L. 1991a. Evaluation of wood ash disposal on agricultural land. I. Potential as a soil additive and liming agent. *Commun. Soil Sci. Plant Anal.* 22: 243–256.

Etiegni, L., Mahler, R.L., Campbell, A.G. and Shafii, B, 1991b. Evaluation of wood ash disposal on agricultural land. II. Potential toxic effects on plant growth. *Commun. Soil Sci. Plant Anal.* 22: 257–267.

Ewulo, B.S., Ojeniyi, S.O. and Akanni, D.A. 2008. Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato. *African J. Agric. Rese* 3(9): 612-616

Ferm, A., Hokkanen, T., Moilanen, M. and Issakainen, J. 1992. Effects of wood bark ash on the growth and nutrition of a Scots pine afforestation in central Finland. *Plant and Soil* 147: 305–316

Fertilizer (control) Amendment Order. 2006. Government of India, Ministry of Agriculture, Department of Agriculture and Co-operation, The Gazette of India: Extraordinary, Part II- Sec. 3(ii), pp 72-79.

Fragstein,P.V. and Vogtmann,A,1987. Organic extracts for the treatment of Rock powder Fertilizers in Biological , Agriculture and Horticulture,1:169-180

Gaur, A.C. 1994. Bulky organic manure and crop residues. *Fertilizers, Organic Manures, Recyclable Wastes and Biofertilizers* (ed. Tandon, H.L.S.). Fertilizer Development and Consultation Organization, New Delhi, 205 p.

Gaur, A.C. and Mathur, R.S. 1979. Note on the effect of straw, neem cake and FYM on yield and nitrogen uptake by maize crop. *Indian J. Agron*. 24:449-450

Geetha, D., Jane, M.M., Suharban M., and Sajitharani T. 2004. Comparative efficiency of coir pith based biomanures. *Proc. Coir Board Golden Jubilee Celebrations, 11-13 August 2004*, Central Coir Research Oinstitute, Allepey, pp. 1-4

Geetha, D., Suharban, M., Vijayan, M. and Pramod, R. 2005. Coir pith compost for increasing banana crop production efficiency. *Ind. Cocon. J*. 35(9): 7-9

Gianquinto, G. and Borin, M. 1990. Effect of organic and mineral fertilizer application and soil type on the growth and yield of processing tomatoes. *Rev. Agron.* 24:339-348

Golueke, C.G. 1981. Principles of biological resource recovery. Biocycle, 22: 36-40

Govindan, M. and Purushothaman, D. 1989. Production of phytohormones by the nitrogen fixing bacteria Azospirillum. *Agric. Rese. J. Kerala* 22: 133

Gupta, R.P. and Dakshinamoorthi, C. 1980. Procedures for physical analysis of soil and collection of agro meteorological data, IARI, New Delhi.

Gupta,S., Arora,D.K and Srivastava,A.K. 1995. Growth promotion of tomato plants by rhizobacteria and imposition of energy status on *Rhizoctonia solani. Soil Biol.Biochem*.27(8):1051-1058

Hamaker, J.D. and Weaver, D.A. 1982. Three problems threatening our existence. *The survival of utilization*. Hamaker – Weaver Publishres, Michigan, California, 376p.

Huang, H., Campbell, A.G., Folk, R. and Mahler, R.L. 1992. Wood ash as a soil additive and liming agent for wheat. Field studies. *Commun. Soil Sci. Plant Anal.* 23: 25–33.

Hulagur, B.F. 1996. Use of different oilcakes or fertilizers- comparison of processes of immobilization, mineralization and nitrification inhibition in soil and nitrogen uptake. Neem and Environment-Vol. II (eds. Singh, R.P., Chari, M.S., Raheja, A.K. and Kraus, W.). Oxford and IBH Publishing Co., Pvt. Ltd., New Delhi, pp. 835-846

Jackson, M.L. 1973. *Soil chemical analysis*. 2nd edition. Prentice Hall of India (Pvt) Ltd. New Delhi.

Jensen, H.L. 1942. Nitrogen fixation in leguminous plants. General characteristics of root nodule bacteria isolated from species of Medicago and Trifolium in Australia. *Proc. Linn. Soc., N.S.W.*66; 98-108.

Jimenez,E.I. and Garcia,V.P. 1989. Evaluation of city refuse compost maturity : a Review. Biological wastes. 27:115-142

Jose, D., Shanmughavelu, K. And Thamburaj, S. 1988 . Studies on the efficacy of organic vs inorganic form of nitrogen in brinjal. *Indian J. Hort*. 5: 100-103

Julia, M., Hallorans, A., Munoz, M. And Colberg, O. 1993. Effect of chicken manure on chemical properties of a mollisol and tomato production. *J. Agric. Univ. P.R.* 77: 181-190

Kahl, J.S., Fernandez, I.J., Rustad, L.E. and Peckenham, J. 1996. Threshold application rates of wood ash to an acidic forest soil. *J. Environ. Qual.* 25: 220–227.

Kansal, B.D., Singh, B., and Kaur, G. 1981. Effect of organic and inorganic sources on the yield and quality of spinach. *Qualitas Pl*. 31 : 163-170

KAU. 1987. *Research Report 1984-85*. Directorate of Research, Kerala Agricultural University, Thrissur, 307 p.

KAU. 2007. *Package of Practices Recommendations: Crops* (12th Ed). Directorate of Extension, Kerala Agricultural University, Thrissur, 334 p.

KAU. 2009. *Package of Practices Recommendations (Adhoc) for Organic Farming*. Directorate of Extension, Kerala Agricultural University, Thrissur, 200 p.

Krejsl, J.A. and Scanlon, T.M. 1996. Evaluation of beneficial use of wood-fired boiler-ash on oat and bean growth. *J. Environ. Qual.* 25: 950–954.

Kulvinder, K., Krishan, K. K. and Anand, P.G. 2005. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *J. Plantt .Nutri. Soil. Sci.* 168: 117–122

Kumaraswamy, D. and Madalageri, B.B. 1990. Effect of Azotobacter inoculation on tomato. *S.Indian Hort*. 38:345-346

Lal, J.K., Mishra, b. And Sarkar, A.K. 2000. Effect of plant residue incorporation on specific microbial group and availability of some plant nutrients in soil. *J. Indian Soc. Soil Sci.* 48(1): 67-71

Lampkin. 1990. Vermiculture biotechnology. *Organics in Soil Health and Crop Production* (ed. Thampan, P.K.). Peekay Tree Crops Development Foundation, Cochin, pp. 78-79

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

Lekhasi,J.K.,Tanner,J.C., Kimani,S.Kand Harris,P,J,C. 2001. Managing manure to sustain small holder Livelihoods in the East African High lands. DFID-Natural Resource Systems Programme HDRA, Conventry, United Kingdom

Leonardos,O.H., Imana,J.E., Flor,H.M., Kronberg.B.I. and Fyte,W.S.1982. Nutrient recharge of laterites using basalt powder (abstract) . II International Seminar on Laterisation Process IUGS/UNESCO, Sao Paulo, 66p

Lerner, B.R. and Utzinger, J.D. 1986. Wood ash as soil liming material. *Hort Science* 21 :76–78.

Loganathan, S. 1990. Effect of certain tillage practices and amendments on physico chemical properties of problem soils. *Proc. Soil Sci. Soc. Am*. 33: 62-68

Luchnik, N.A. 1975. Sborrik Nauchnykh Statez Karagand, Gos, S. Kn. Opydnor Stantrii. *Hort. Abstract* 46(6): 168-175.

Mahanta, D and Rai, R.K. 2008. Effects of sources of phosphorous and biofertilizer on productivity and profitability of soybean-wheat system. *Ind. J. Agron* 53(4):279-284.

Maheswarappa , H.P., Hedge, M.R., Dhanapal, R. And Biddappa, C.C. 1998. Mixed farming in coconut garden, its impact on soil physical and chemical properties, coconut nutrition and on yield. *J. Pln. Crops* 26:139-143

Manib, M., Add-el-Malak, Y., Hosney, I. And Fayez, M. 1979. Effect of Azospirillum inoculation on plant growth and soil nitrogen. *Zentralbl Baketeriol. Parasitenkd. Infektionsk. Hyg.* 136(7): 555-559

Manickam , T.S. 1993. *Organics in Soil Health and Crop Production* (ed. Thampan, P.K.). Peekay Tree Crops Development Foundation, Cochin, pp. 87-104

Mapa, R.B. and Kumara, G.K.K.P. 1995. Potential of coir dust for agricultural use. *Sri Lankan J. Agric. Sci*. 32:161-164

Marderosian,A.D., Bentler,J., Ptender,W and Chambers,J.1980. Nitrate and Oxalate content of vegetable amaranth. *Proc.Second Amaranth Conf.,Sep 2-8, 1980 eds.Yoder,R.,Weinsteiger,E and Sheft,J.* Rodale Press Inc.,Emmaur,pp. 31-40

Meena , L.R., Singh, R.K. and Gautam, R.C. 2003. Yield and nutrient uptake of chickpea (*Cicer arietinum*) as influenced by moisture conservation practices. *Legume Res*. 26(2): 109-112

Meena, R,N., Yogeshwa, S., Singh, S.P. and Singh, K. 2007. Effect of sources and level of organic manures on yield, quality and economics of garden pea in Eastern U.P. *Veg Sci.* 34(1): 60-63

Meerabai, M. and Raj, A.K. 2001. Biofarming in vegetables. *Kisan Wld*. 28:15-16

Meerabai, M., Jayachandran, B.K., Ann, N. And Sudha, B. 2003. Biofarming in chilli (*Capsicum annuum* L*.). Proc. 15th Kerala Sci. Congress 29-31 Jan.2003* (eds. Prakashkumar, R., Prabhakumari, P. And Kokkal, K.). State Committee on Science, Technology and Environment, Thiruvananthapuram.pp. 780-783

Meiwes, K.J. 1995. Application of lime and wood ash to decrease acidification of forest soils. *Water Air Soil Pollut.* 85: 143–152.

Middleton, K.R. 1958. A new procedure for rapid determination of nitrate and a sudy of the preparation of phenol-sulphonic acid reagent. *J. Appl. Chem*. 8: 505-508.

Miller, R.W. and Donahue, R.L. 1992. *Soils- An Introduction to Soils and Plant Growth.* Prentice Hall of India Pvt. Ltd., New Delhi, 95p.

Mohandas,S. 1987. Field response of tomato to inoculation with VAM fungus Glomus fasciculatum and with *Azotobacter vinelandii*. *Pl.Soil*.98(2):295-297

Moorthy, V.K. and Rao, K.B. 1997. Recycling of coir pith – a successful VRF experience. *Coir News* .26:21-24

Morel,J.L. Colin,F., Germon,J.C., Godin,P. and Juste,C.1985. Methods for the evaluation of the maturity of municipal refuse compost. *In composting of Agricultural and other wastes,ed. Gasser,J.K.R.* Elsevier Applied Science Publisher, London and Newyork, pp 56-72

Nagarajan, R., Ramasamy, K., Savithri, P. Nad Manickam, T.S. 1990. *Coir waste in crop production*. Agricultural College and Research Institute, Madurai and Central Coir Research Institute, Coir Board, Kalavoor, 39 p.

Nair, R.C. 2003. Sustainable nutritional practices for bittergourd- amaranthus intercropping system. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 97 p.

Nambiar , C.K.B., Khan, H.H., Joshi, O.P. and Pillai, N.G. 1983. A rational approach to management of coastal sands for establishment and production of coconuts. *J. Plantn. Crops* 11: 24-32

Niranjana, N.S. 1998. Biofarming in vegetables – 1) Effect of biofertilizers in amaranth (*Amaranthus tricolor* L.). M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 148p

Ohno, T. and Erich, M.S., 1990. Effect of wood ash application on soil pH and soil test nutrient levels. *Agric. Ecosyst. Environ.* 3**:** . 223–239.

Ohno, T. 1992. Neutralization of soil acidity and release of phosphorus and K by wood ash. *J. Environ. Qual.* 2**:**. 433–438.

Ohno, T. and Erich, M.S. 1993. Incubation-derived calcium carbonate equivalence of paper mill boiler-ashes derived from sludge and wood sources. *Environ. Pollut.* 79: 175–180.

Pacovsky, R.S., Paul, E.A. and Bethlen falvay. 1985. Nutrition of sorghum plants fertilized with nitrogen or inoculated with *Azospirillum brasiliense. Pl. and Soil* 85: 145-148

Pandey, V. and Kumar, D. 2002. Biofertilizers for sustainable agriculture. *Agric. Today* 5: 44-47

Paramaguru, P. and Nataraja, S. 1993. Effect of Azospirillum on the growth and yield of chilli (*Capsicum annum* L.). grown under semidry condition. *S. Indian Hort*. 41: 80-83

Parvatham, A., Vijayan, K.P. and Nazar, A. 1989. Effect of Azospirillum on growth and nutrient uptake of Pusa Sawani bhindi (*Abelmoscus esculentus* L.*). S. Indian Hort*. 37: 227-229

Pietikäinen, J. and Fritze, H. 1995. Clear-cutting and prescribed burning in coniferous forest: comparison of effects on soil fungal and total microbial biomass, respiration activity and nitrification. *Soil Biol. Biochem.* 27: 101–109

Pimpini, F., Giardini, L., Borin, M. and Gianquinto, G. 1992. Effects of poultry manure and mineral fertilizers on the quality of crops . *J.Agric. Sci*. 118: 215-221

Poincelot,R.P. 1974. A scientific examination of the principles and practice of composting. Compost.Sci.,15:24-31

Prabhu, S.R. and Thomas, G.V. 2002. Biological conversion of coir pith into a value added organic resource and its application in agri-horticulture: Current status, prospects and perspective. *J. Plantn. Crops* 30: 1-17

Priya, G. 2008. Development of protocol for quality control of commercial organic manures and their evaluation. Ph. D. thesis, Kerala Agricultural University, Thrissur, 259p.

Rajasree, G. 1999. Standardization of organic and inorganic fertilizer combinations for maximizing productivity in bittergourd (*Momordica charanbntia* L.). Ph.D. thesis, Kerala Agricultural University, Thrissur, 102 p

Rani, P.J., Kannan, M. And Thamburaj, S. 1997. Nutritive value of vegetables. *Kisan Wld*. 24(2): 53-54

Rao, S.S. and Shaktawat, M.S. 2002. Effect of organic manures, phosphorous and gypsum on groundnut production under rainfed condition. Indian . J. Agron. 47(2): 234-241

Reddy, R.N.S. and Prasad, R. 1985. Studies on the mineralization of urea, coated urea and nitrification inhibitors treated urea in soil. *J. Soil Sci*. 26:304

Reeja, R.S. 2002. Comparative efficiency of lignocellulolytic fungi for bioconservation of coir pith. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 97 p

Renu, C.N. 2003. Sustainable nutritional practices for bittergourd-amaranthus intercropping system. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 97 p

Sadanandan, A.K. and Hamza, S. 1998. Effect of organic farming on nutrient uptake, yield and quality of ginger. *Proc. Nat. Sem. Water and Nutrient Management for sustainable Production and Quality of Spices. Oct. 5-6, 1997* (eds. Sadanandan, A.K., Krishnamoorthy, K.S., Kandiannan, K. And Korikanthinath, V.). Indian Institute of Spices Research, Calicut pp. 89-94

Sadanandan, N. and Iyer, R. 1986. Effect of organic amendments on rhizome rot of ginger. *Indian Cocoa Arecanut Spices J*. 9: 94-95

Sadasivam, S. and Manickam, A. 1996. *Biochemical Methods for Agricultural Sciences*. Wiley Eastern Ltd., New Delhi, 246p.

Sahrawat, K.L. and Mukherjee, S.K. 1997. Nitrification inhibitors II. Studies with furano compounds. *Pl. Soil* 47: 687-691

Sarig , S., Kalpulnik, V. And Okon, Y.I. 1984. Response of non-irrigated sorghum to Azospirillum inoculation. *Exp. Agric*. 20: 59-66

Sathianathan, K.N. 1982. Increasing nitrogen use efficiency in upland soils. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 110 p.

Savithri, P., Murugappam, M. And Nagarajan, R. 1993. Possibility of economizing potassium fertilization by composted coir pith application. *Fert. News* 38: 39-40

Sharu, S.R. 2000. Integrated nutrient management in chilli (*Capsicum annum* L.). M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 108 p.

Sheeba, P.S. 2004. Vermicompost enriched with organic additives for sustainable soil health. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 110 p

Shehana,R.S., Regeena.S., Ravi, S., and Kishorekumar,N.2006. Effect of partial or full substitution of chemical fertilizer with petrofertilizer (Khondalite powder) on the yield of cassava(Manihot esculents) in laterite soils:- *In : Root and tuber crop in nutrition food security and sustainable environment.* Regional Centre CTCRI (ICAR) Bhubaneshwar, Orissa. Editors. Nasker, S.K., Nedumchezhiyan, Rajashekhar. Rao., Sivakumar, P.S. and Misra, R.S. 148-152.

Shehana,R.S.2006. Nutrient release from petrofertilizer Khondalite in laterite soil of south Kerala, India. 18th World Congress of Soil Science. July 9-15, Philadelphia, Pennsylvania, USA.

Shiyam, J.O. and Binang, W.B. 2010. Effect of poultry manure and urea-n on flowering occurrence and leaf Productivity of *Amaranthus cruentus.*

Singh , K., Gill, I.S. and Verma, O.P. 1970. Studies on poultry manure in relation to vegetable production. *Indian J. Hort*. 27: 42-47

Singh, K., Minhas, M.S. and Srivastava, O.P. 1973. Studies on poultry manure in relation to vegetable production potato. *Indian J. Hort*. 30: 537-541

Singh, R.S. and Sitaramaiah, K. 1963. Control of plant parasitic nematodes with organic amendments in soil. *Final Technical Report*. Research Bulleting Experimental Station No.6, G.B. Pant University of Agriculture and Technology, Pantnagar, pp. 256

Singh,M. 2005. Influence of organics on soil chemical processes-nutrient transformation. *Proceedings of winter school on " Efficient composting techniques for production of nutrient enriched composts from agro, industrial and city wastes and standardization methods".* Dec1-21,2005. at Division of Soil Biology, Indian Institute of Soil Science, Bhopal. ICAR

Snedecor, G.W. and Cochran, W.G. 1975. *Statistical methods* (16th Ed.). Oxford and IBH publishing Co., Calcutta, pp. 349-351.

Som, M.G., Hashim, H., Mandal, A.K. and Maity, T.K. 1992. Influence of organic manures on growth and yield of brinjal (*Solanum melongena* L.). *Crop Res*. 5(1): 80-84

Sreekala, G.S. 2004. Effect of organic manures and microbial inoculants on growth , yield and quality of ginger. Ph. D. thesis, Kerala Agricultural University, Thrissur, 258 p.

Srivastava, R.P. and Kumar, S. 1998. *Fruit and Vegetable Preservation – Principles and Practices*. Second edition. International Book Distributing Co., Lucknow, 444p.

Srivastava, T.K. and Alawat, I.P.S. 1995. Response of pea (*Pisum sativum*) to phosphorous and molybdenum fertilizers. *Indian J. Agric*. 40(4): 630-635

Subbaraj, D. and Ramaswami, P.P. 1992. Influence of organic amendments on highly permeable soils of Typic Ustipsamments. *Nat. Sem. on Development in Soil Sci. 57th Annual Convention.* Indian Society of Soil Science. Nov. 2

Subbiah, B.V. and Asija, L.LK. 1956.A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci*., 25: 259-260.

Suharban, M., Geetha, D. And Nair, M.C.1997. Degradation of coir pith by Oyster mushroom (*Pleurotus* sp.) and its effect on yield of bhindi. *Mushroom Res.* 6: 101-102

Suja, G. 2001. Resource management for intercropping white yam (*Dioscorea rotundata* Poir) in coconut garden. Ph. D. thesis, Kerala Agricultural University, Thrissur, 195p

Sundara Rao, W.V.B and Sinha, M.K. 1963. Phosphate dissolving organisms in the soil and rhizosphere, *Ind. J. Agri. Sci*., 33, 272-278.

Tanwar, S.P.S., Sharma, G.L. and Chahur, M.S. 2003. Effect of phosphorous and biofertilizer on yield , nutrient content and uptake by black gram (*Vigna mungo* (L) Hepper). *Legume Res*. 26(1): 39-41

Thamburaj, S. 1994. Tomato responds to organic gardening. *Kisan Wld.* 21(3): 49

Troeh, F.R. and Thompson, L.M. 1993. *Soils and Soil Fertility* (fifth ed.), Oxford University Press, Oxford.

Tusneem, M.E. and Patrick, W.H. 1971. Nitrogen transformation in water logged soils. In: *Bulletin No. 657*. Lousiana State University, USA

Ulery, A.L., Graham, R.C. and Amrhein, C. 1993. Wood-ash composition and soil pH following intense burning. *Soil Sci.* 156 :358–364.

Unger, Y.L. and Fernandez, I.J. 1990. The short-term effects of wood-ash amendment on forest soils. *Water Air Soil Pollut.* 49: 299–314.

Vance, E.D. 1996. Land application of wood-fired and combination boiler ashes: an overview. *J. Environ Qual.* 25: 937–944.

Venkitaswamy, R. 2003. Integrated nutrient management in coconut with composted coir pith. *Madras Agric. J.* 90: 54-56

Venugopal,V.K. 2004. Quality control of organic manures . Proceedings of the Winter School on Organic farming for sustainable agriculture, Nov 17-Dec 7, 2004, ICAR, KAU, COA, Vellayani, TVMP.pp 323-328

Verhagen, J.B.G.M. and Papadopoulos, A.P. 1997. CEC and the saturation of the adsorption complex of coir dust . *Acta Horticulturae* 481: 151-155

Vimala, P., Illias, M.K. and Salbiah, H. 2006. Effect of rates of organic fertilizer on growth, yield and nutrient content of cabbage (*Brassica oleracea* var. *capitata*) grown under shelter. *Acta Horticulturae 710*

Voundi, J.C., Demeyer, A. and Verloo, M.G. 1997. Chemical effects of wood ash on plant growth in tropical acid soils. *Biores. Technol.* 6**3**: 251–260.

Walkley, A. and Black, I.A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*., 39: 29-38.

Williams, T.M., Hollis, C.A. and Smith, B.R. 1996. Forest soil and water chemistry following bark boiler bottom ash application. *J. Environ. Qual.* 25: 955–961

Wilson, G.B. 1989. Combining raw materials for composting. Biocycle, 30:80-85

Yarrow, D. 1997. Forests of champions. Remineralize the Earth. 10-11: 21-32

Yarrow, D. 1998. Milarch tests trace element fertilizer in green house trials. Remineralize the Earth. 13: 70-74

Appendices

APPENDIX – I

Weather parameters during the cropping period (Amaranthus) (Jan 2011 to April 2011)

Standard week	Maximum temperature (^0C)	Rainfall (mm)	Relative humidity (%)	Evaporation (mm/week)
1	31.00	0.86	86.64	3.29
2	31.06	0	86.93	3.07
3	31.80	0.19	86.21	3.03
4	30.80	0	84.57	3.31
5	31.20	0	83.21	3.43
6	31.71	0	82.14	3.51
7	31.86	0	82.43	3.66
8	31.60	5.03	81.07	3.40
9	31.66	0	82.86	3.60
10	32.08	0	81.71	3.83
11	32.60	0	79.86	4.06
12	33.94	0	78.64	4.43
13	33.60	0	88.30	4.70
14	34.10	1.30	89.70	4.70
15	34.80	0	84.60	4.80
16	34.50	3.30	85.00	4.50
17	34.40	4.20	84.90	4.60

Appendix II

Average input costs and market price of produce

Sl No.	Items	Cost
	INPUTS	
a	**Labour**	
1	Man labourer	Rs 175.00 day^{-1}
2	Women labourer	Rs 175.00 day^{-1}
b	**Cost of manures and fertilizers**	
1	Coir pith compost	Rs 500 t^{-1}
2	Poultry manure	Rs 2000 t^{-1}
3	Ground nut cake	Rs 35 kg^{-1}
4	Ash	Rs 0.50 kg^{-1}
5	Urea	Rs 6 kg^{-1}
6	Rock phosphate	Rs 6 kg^{-1}
7	Muriate of potash	Rs 6 kg^{-1}
8	Microbial consortium	Rs 70 kg^{-1}
	OUTPUT	
	Market price of amaranthus (organic)	Rs 15 kg^{-1}
	Market price of amaranthus (inorganic)	Rs 10 kg^{-1}

DEVELOPMENT AND EVALUATION OF BIO-ORGANIC COMPOSITE MANURE FOR VEGETABLES

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ABSTRACT

An investigation entitled " Development and evaluation of bio-organic composite manure for vegetables" was taken up at College of Agriculture, Vellyani during the period 2009-2011 . the main objective of the experiment was to assess the possibility of developing good quality bio-organic composite manure for organic vegetable production. The investigation was taken up in three stages namely, formulation and quality evaluation of bio organic composite manures, mineralization study of bio organic composite manures and crop response study.

In the first experiment, study was conducted in the laboratory. Organic sources used for the preparation of bio organic composite manures were coir pith compost, poultry manure, neem cake, ground nut cake, ash, rock dust and microbial consortium. Raw materials collected from different parts of Kerala were analyzed and best sources were selected for the preparation of mixture. Raw materials were mixed in different proportion to make the respective organic manure mixture. Sixteen organic manure mixtures were prepared as per the treatments. The experiment was laid out in completely randomized design with 16 treatments and two replications. The results revealed that composite organic manures analyzing at least 3% N and N:K ratio of 1:0.5 were selected for further study. Five mixtures (OM3, OM5, OM9, OM11, 0M13) satisfying the selection criteria were identified for the investigation.

The physical and chemical characters of selected organic manure mixture viz odour, colour , moisture content, bulk density, pH, heavy metals, EC, organic carbon, nitrogen , phosphorous and potassium contents were analyzed. The results revealed that the selected five organic manure mixtures were good quality with high N, P,K content. Shelf lives of these manures were also assessed. It was observed that theses manures retain the initial nutrient status up to 3 months and there after a reduction was observed in nutrient status.

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In the second experiment mineralization study was conducted in pots. The objective of the study was to assess the nutrient release pattern of different organic manure mixtures The experiment was laid out in completely randomized design with 8 treatments and three replications..Five selected mixtures along with KAU POP, KAU Adhoc organic POP and absolute control form the 8 treatments . The different composite manures were applied as N equivalent basis for the test crop amaranthus. Sampling was done at monthly interval for a period of six months after incubation. Results of the study shows that nitrogen status of all treatments in general increased up to 3 months and there after the status decreased. In general phosphorous and potassium status increased initially and then decreased.

Crop response study was conducted as one pot culture investigation and another field investigation with 8 treatments and 3 replications using amaranthus as the test crop. Treatments were same as the mineralization study. Design adopted was completely randomized design for pot culture study and randomized block design for field investigation. The results revealed that among the treatments maximum yield was obtained for the treatment T5 (poultry manure- 50g, ground nut cake – 30g, rock dust- 19g and microbial consortium – 1g) and it was on par with T1 (coir pith compost – 50g, ground nut cake – 35g and ash – 15g) and T2 (poultry manure- 50g, ground nut cake – 30g, rock dust- 20g). Organic POP as well as KAU POP was significantly inferior to the best treatments. The results were same for both pot and field investigation. Maximum yield obtained under pot study was 405.29 g pot^{-1}. Maximum yield registered in field investigation was 12.76 t ha^{-1}.

The study on economics shows that T5 registering net returns of Rs 130800/- was the most economical treatment with B:C ratio 2.2. The lowest net returns of Rs. 22200 was obtained in treatment T8 (soil alone) with B:C ratio 0.6.