SOIL PROPERTIES AND PRODUCE QUALITY OF CARDAMOM (*Elettaria cardamomum* Maton) UNDER ORGANIC FARMING

By

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THESIS

submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled "Soil properties and produce quality of cardamom (*Elettaria cardamomum* Maton) under organic farming" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award tome of any degree, diploma, fellowship, associate ship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled "Soil properties and produce quality of cardamom (*Elettaria cardamomum* Maton) under organic farming" is a record of research work done independently by Shri. Arun G., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

1. INTRODUCTION

Organic agriculture is a set of strict rules and complicated practices that allow marketing of certified food products. Although traditional farming systems such as the agri-horti-silvi-pisi-pastural homestead systems of Kerala, which apply soil-building practices and avoids synthetic inputs, qualify as organic by default, they are not considered "organic" in this context. Organic farming emphasizes management practices involving substantial use of organic manures, green manures, organic pest management practices, and so on. It is a system of farming that prohibits the use of artificial fertilizers and synthetic pesticides. Thus *organic* is a process claim rather a product claim. (GoI, 2001b). According to the *Codex Alimentarius* (The Codex Alimentarius Commission is a joint FAO [Food and Agricultural Organization]/ WHO [World Health Organization] Food Standards Programme that sets international food standards) Guidelines for Organic Food, "*organic agriculture*" is a holistic production management system that promotes and enhances ecosystem health, including biological cycles and soil biological activity. The primary goal of organic agriculture is to optimise the health and productivity of inter-dependent communities of soil life, plants, animals and people. Thus, organic agriculture is not only based on minimising the use of external inputs and avoiding the use of synthetic fertilizers and pesticides, but follows a system and process oriented approach that suits the current focus on resource based development in rural India.

The FAO World Food Summit in Rome in June 2002 and the World Summit for Sustainable Development in Johannesburg in September 2002 were platforms where organic agriculture could position itself as a significant contribution to sustainability as well as food security. Also, the IFOAM (International Federation of Organic Agriculture Movements) Organic World Congress in August 2002 in Canada, with its 1,300 participants from about 100 countries, was a mirror of the dynamic development of organic farming initiatives around the world.

Mahatma Gandhi pioneered organic agriculture through adopting holistic traditional practices in several locations in India. As a protagonist of self-reliance, he taught his fellow workers about composting and farming based on local inputs. Even now, in marginal regions, many small farmers are *de facto* organic producers. Out of necessity they have turned degraded lands into productive organic systems that meet local needs. Surpluses are sold in village "green shops" at prices often equal to (sometimes lesser than) conventional products.

Organic agriculture is frequently understood as a system of food production and consumption to the health conscious people of the developed world. Current drive of many developing countries to produce organic food and fibres is triggered by different objectives such as securing a place on international markets, export promotion, economic self-reliance, finding alternatives to decreased access to agricultural inputs, natural resource conservation, food self-sufficiency, and rural and wider social development (Alam and Shah, 2003).

Kerala state is blessed with all the factors conducive to organic farming, marketing and exports stipulated under the NPOP (National Programme of Organic Production). Being located in the high rainfall tropical region (between 4 and 12 degree North latitude), the state falls in one of the regions in the world with high incidence of solar radiation round the year, warm temperature and high rainfall with average annual precipitation of 300 cm; all congenial for high biological activity which is manifested in our rich biodiversity. The existing cropping patterns and farming systems in many parts of Kerala (the homesteads/farmsteads) are the results of cumulative effort of several generations of farmers who have evolved a system based on the natural resource endowments. Optimum blending of crop growth requirements and land qualities is distinguishable in the cropping patterns, resulting in the maintenance of productivity and better exploitation of the land capability over the years. Thus Kerala state is the best candidate to lead organic farming initiatives in India. Examples of organic farming in Kerala include the initiatives of Peermade Development Society, Wyanad Social Service Society, POABS Biodynamic Farms, etc.

One of the major crops grown under organic farming in Kerala is Cardamom (*Elettaria cardamomum* Maton). Cardamom is the dried fruit of a herbaceous perennial and in India. It is mainly grown in Kerala, Tamil Nadu and Karnataka, on the shady slopes of the Western Ghats. Warm humid climate, loamy soil rich in organic matter, distributed rainfall, special cultivation and processing methods all combines to make Indian cardamom truly unique in aroma, flavour, size and colour. Production in 1999-2000 was 9300 tonnes, as compared to about 7170 tonnes in 1998-99.

Indian cardamom is among the most exotic and highly prized spices in the international markets. India has been an exporter of cardamom from time immemorial. The competition from countries like Guatemala in recent years poses a major threat to Indian cardamom in the international market. Today less than four per cent of India's total output of cardamom is exported as compared to Guatemala's 100 per cent. India will be able to compete effectively with Guatemala, only by offering cardamom of higher quality at competitive prices. Organic farming of the crop offers increased export opportunities and internal markets for cardamom.

However, studies on the effect of organic farming on the characteristics of soils, crops and produces are scanty in the state. Therefore, an exploratory investigation was conducted in the cardamom farms around Peermade with the objective to compare the soil properties, crop nutrient concentrations and quality of cardamom (*Elettaria cardamomum* Maton) under organic and conventional farming.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Agricultural production systems have been evolving over ages. The basic concepts of some of the recognized farming practices are depicted in Fig. 1. Organic farming and its variations have been in vogue in rural India and elsewhere in the world. However, certified organic farms and produces are most popular in developed nations such as European countries, USA and Australia. Research on the effect of organic farming practices on different components of the production system is also predominant in these countries. Literature from India, though scanty, also is available. A review of literature relevant to the study under report is presented hereunder.

2.1. DEFINITIONS OF ORGANIC AGRICULTURE

Organic farming system solely depends on the use of crop residues, animal manures, green manures, off-farm organic wastes, crop rotations incorporating legumes, biological pest control etc., to maintain soil productivity (Lampin, 1990, Palaniappan and Annadurai, 1999). With these considerations, some of the attempts made to define organic agriculture follow.

A. Organic agriculture is a production system, which avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives (Lampin, 1990).

B. The definition of organic farming given by the International Federation of Organic Agriculture Movements (IFOAM), which follows that, organic agriculture includes all agricultural systems that promote the environmentally, socially and economically sound production of food and fibers. It also follows that in organic agriculture systems local soil fertility is the key to successful production. By respecting the natural capacity of plants, animals and landscape, it aims to optimize quality in all aspects of agriculture and the environment (Nguyen, 1998).

C. Organic agriculture is a crop production method respecting the rules of the nature. The main objective is to achieve a sustainable farming system that preserves the environment and soil fertility for our off spring too (Spices Board, 2001).

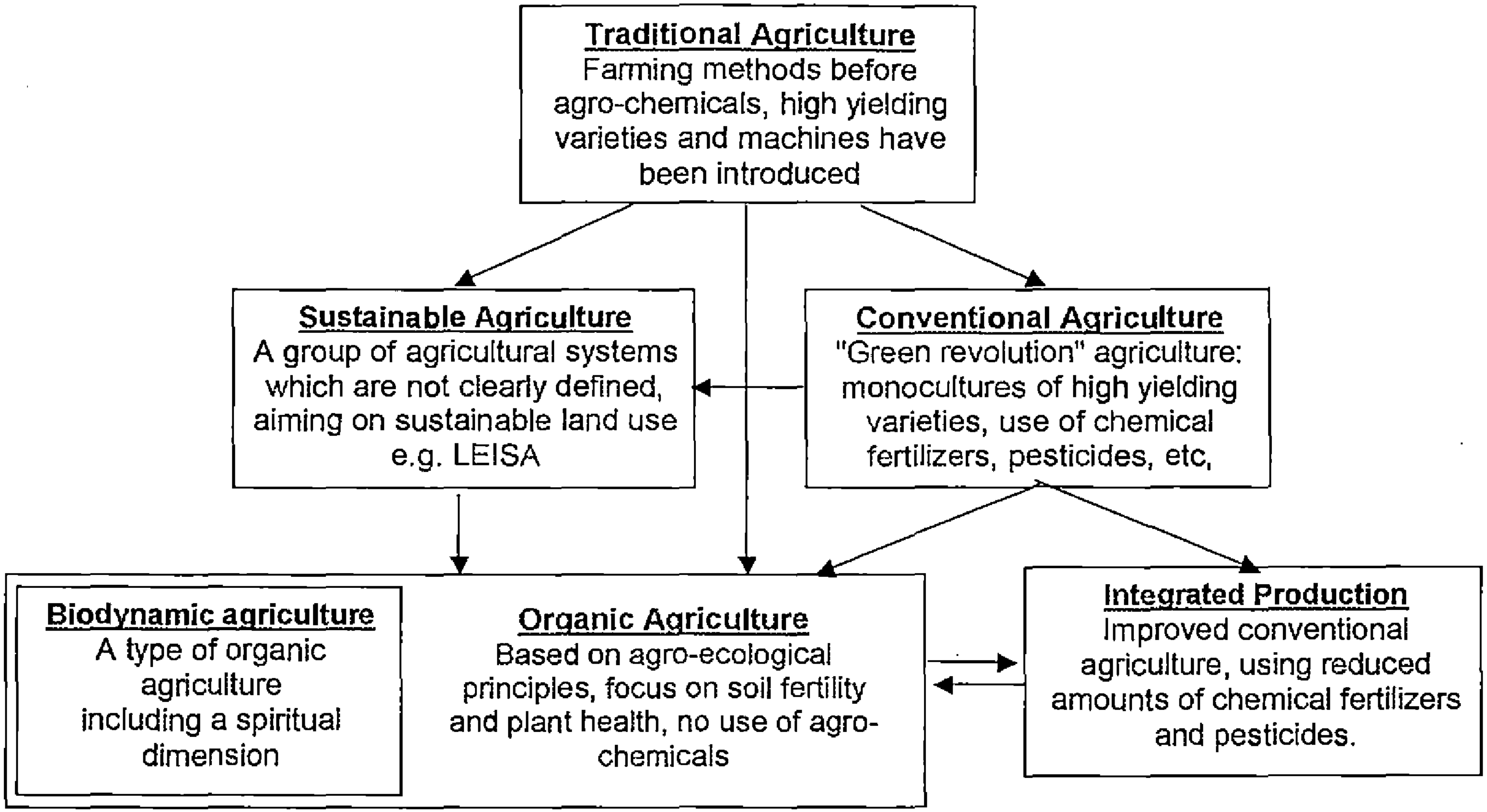

Fig.1. Definition of some farming systems (adapted from Eyhorn *et al.*, 2002)

D. Organic farming is a holistic way of farming besides production of goods of high quality - an important aim is the conservation of natural resources, fertile soil, clean water and rich biodiversity. The art of organic farming is to make the best use of ecological principles and processes (Eyhorn *et al.*, 2002).

E. Organic agriculture stresses careful management to meet crop needs and avoid excess application of manure and other organic matter that could cause nitrate leaching and causing ground water pollution (Alam and Wani, 2003).

F. According to the Codex Alimentarius Commission of the United Nations, the organic agriculture is viewed as a holistic production management system, which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (Sharma, 2003).

A range of farming systems comes under the purview of organic agriculture. They are permaculture, nature farming, natural farming, *Rishi krishi* etc., that cannot be defined, as they lack specific standards of production. But they fulfill the minimum requirement of organic farming (Eyhorn *et al.*, 2002). Among the variants of organic farming, biodynamic farming and natural farming need special mention.

2.1.1. **Biodynamic Farming**

Biodynamic farming is a special type of organic agriculture. It fulfills all the principles and standards of organic farming, and even goes a step beyond. It includes a spiritual component in agricultural practices. An Austrian Philosopher Rudolf Steiner developed biodynamic farming during 1920's. The basic foundations of this special type of organic agriculture as described by Eyhorn *et al.*, 2002 are listed below.

1. Cosmic rhythms: the rhythms of sun, moon, planets and stars, influence the growth of plants. So by timing the agricultural operations, the farmer can make use of this influence to improve his crops.
2. Vitality: besides the physical and chemical characteristics, matter has a vital quality, which influences the organisms.

3. Biodynamic preparations: certain naturally occurring plants and animal materials are combined in specific preparations and applied at homeopathic dilutions to compost piles, to the soil or directly to the plants.
4. The farm organism: the farm is considered as a whole organism integrating plants, animals and humans.

2.1.2. Natural Farming

Natural farming is the second most important variant of organic farming advocated by the reputed Japanese, Fukuoka. It is based on four basic principles (Fukuoka, 1978).

1. No cultivation: This means, no ploughing or turning of the soil. The earth cultivates naturally by means of penetration of plant roots and activity of microorganisms, small animals and earthworms.
2. No chemical fertilizer or prepared compost: This is based on the fact that the soil has the innate capacity to maintain its fertility naturally, in accordance with the orderly cycle of plant and animal life.
3. No weeding by tillage or by herbicides: The fundamental principle is that weed should only be controlled and not eliminated.
4. No dependence on chemicals: This is based on the principle that, nature when left alone is in perfect balance between harmful pests and their natural enemies.

In the Indian context an alternative system called Eco-technological farming has often been equated to organic farming. This system is an effective blend of traditional practices of wisdom with appropriate modern advances of science (GoI, 2001b).

2.2. PRINCIPLES AND CONCEPTS OF ORGANIC FARMING

Unlike the principle of conventional chemical based agriculture in which crop yields are increased by nutrient inputs and reduced through pest, diseases and weeds (Eyhorn *et al.*, 2002), organic agriculture views the farm as a holistic unit biologically complete, balanced, living and dynamic which is ecologically stable and sustainable.

The fundamental and guiding principles of organic farming, as described by Spices Board (2001) are listed below.

1. To produce food of high nutritional quality in sufficient quantity.
2. To encourage and enhance biological cycles within the farming system involving microorganisms, soil flora and fauna, plants and animals.
3. To maintain or to increase long-term fertility of the soils.
4. To promote the healthy use of water, water resources and all its life therein.
5. To help in the conservation of soil and water.
6. To use as far as possible on-farm resources.
7. To provide live stock living conditions which allow them to perform the basic aspects of their innate behavior.
8. To minimize all forms of pollutions resulting from agriculture.
9. To maintain a genetic diversity of the agricultural system and it surroundings.
10. To preserve and enhance traditional and indigenous knowledge in farming.
11. To ensure a quality of life conforming to the UN human rights charter.

Thus organic farming principles aim at attaining sustainability in all aspects of agricultural production. Sustainability in organic farming must be seen in a holistic sense, which includes, ecological, economic and social aspects. Only then the agricultural system can be called sustainable. The ecological sustainability in organic farming is achieved by recycling the nutrients instead of applying external inputs, avoiding chemical pollution of soil and water, promotion of biological activity, improvement of soil fertility and buildup of humus, prevent soil erosion and compaction, animal friendly husbandry and by using renewable energy. Social sustainability can be achieved through sufficient production for subsistence and income, safe nutrition for family with healthy food, good working condition for both men and women and building on local knowledge and tradition. Economic sustainability is achieved by satisfactory and reliable yields, low cost on external inputs and investments, crop diversification to improve income safely and value addition through quality improvement (Eyhorn *et al.*, 2002).

Unlike conventional agriculture there are no diminishing returns to the continued use of production inputs in organic farming. On the other hand, the productivity increases on a long-term basis (Sharma, 2003). However, Hegde *et al.*, (1995) cautioned against total exclusion of synthetic chemicals in agriculture through extremism of organic farming, rightly termed as ecological fundamentalism, which may be avoided.

2.3. HISTORY AND GROWTH OF ORGANIC AGRICULTURE IN INDIA

Organic manure and its importance in agriculture find mention in the ancient Hindu religious scriptures such as Rigveda and Atharva veda (Chonkar, 2003). In ancient India, Agnihothra (ashes left after performing Yagna) was touted as complete plant food (Pathak and Ram, 2003). The Holy Quran also mentions that at least one third of what you take out from the soil must be returned to it implying recycling of the post harvest residues. As early as 1937, Rao Bahadur. B. Vishwanath mentioned in his presidential address at the 24th Indian Science Congress held at Madras (now Chennai) that, organic matter is the life of the soil and if neglected the fertility of the soil would be lost. The great Indian thinker Acharya Vinoba Bhave experimented with *Rishi Krishi* at his *ashram* and advocated tilling the land with bare hands, as India's ancient *Rishis* (hermits: Sages who wrote the Vedas) did for meeting their requirement of food and fiber (Chonkar, 2003). In modern India, the work of Sir Albert Howard mentions that a shift from nature's method of crop production to adoption of newer methods in India leads to the loss of soil fertility and related problems (Howard, 1940).

The pioneering organic producers in the country are Shri. Jain (for last 60 years), of Karanja Lad (Maharashtra), M. V. Wankhede, S. P. Wankhede, R. S. Wankhede (from 1978 onwards), of Amaravati district (Maharashtra), and Anantrao Subhedar, Om Prakash Mor and Tukaram Bhimsingh Jadhav of Yavatmal district (Maharashtra) (from 1990 onwards). All of them were influenced by the natural farming propagated by Fukuoka (GoI, 2001b). Commercial Indian organic cotton cultivation started for the first time in the state of Maharashtra in early 1990s. The initiatives taken by Bombay Burma trading corporation to convert *Singampatti* group estates in southern India to market organic tea internationally is the first of a few efforts for commercial organic agriculture in India. New ventures include bio-villages of M.S. Swaminathan Research Foundation Tamil Nadu, Gloria farm, Aurovilla and Annapurna farms, Government agricultural farm, Bhopal and Kshama farm, Rajastan (Sharma, 2003).

Organic farming has greater significance in the dry-land agriculture of India, as 65 per cent or more of the total arable land in the country is under rain fed farming (GoI, 2001b). India can play a major role in the world organic spice market, if part of the large tracts of land in the tribal belts of Orissa, North Eastern states, Nilgiri hills and Andaman and Nicobar Islands, where traditional practices are still in vogue, are converted to organic spice areas. Realizing the situation, the Spices Board of India has published the national standards of organic spice production, which received approval from the national standard committee of IFOAM (International Federation of Organic Agricultural Movements), the umbrella organization of organic farming associations worldwide.

According to Alam and Shah (2003), almost 23 million hectares are managed organically world wide, and the major part of which is located in countries like Australia (10.65 m. ha.), Argentina (3.2 m. ha.), and Italy (more than 1.2 m. ha.). Total organic area in Asia is almost 6 lakh hectares, of which only 41 000 hectares are in India, which account for only 3 per cent of the total agricultural land of the nation (Fig.2.).

The main agricultural produces traded in the organic markets of Asia are tea, cotton and spices from India, coffee, herbs and spices from Indonesia, grains, herbs, spices, fruits and nuts from Pakistan, pineapple, sesame, oils, and dried coconuts from Sri Lanka and vegetables, fruits, tea, spices and cashew nut from Thailand (GoI, 2001b).

India offers a variety of organic agricultural commodities that are sold at domestic and world markets. These include cereals (rice, wheat, paddy, jowar, bajra and maize), pulses (pigeon pea, chick pea, green gram, black gram and bengal gram), oil seeds (ground nut, castor, mustard and seasame), spices (ginger, turmeric, chilies, cumin, black pepper, white pepper, vanilla, tamarind, clove, cinnamon, nutmug and mace), plantation crops (tea, coffee and cardamom), fruits (banana, sapota, custard apple, papaya, pineapple, passion fruit and orange), vegetables (tomato, okra, onion,

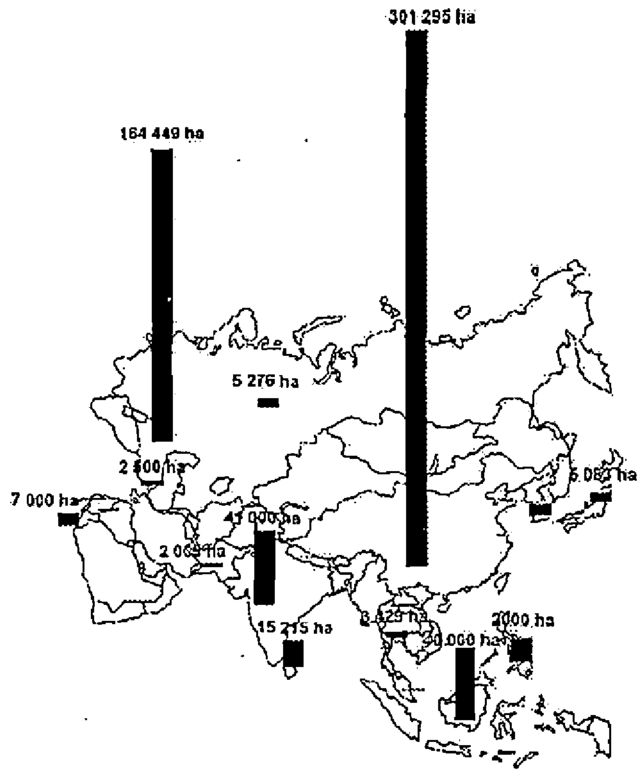

Fig.2. Area under organic farming in Asia (SOEL, 2003)

potato, brinjal, cucurbits, cole crops and leafy vegetables) and others (cotton and sugarcane) (GoI, 2001a).

Major organic products exported from India (in tonnes) are, tea (30 000), coffee (9550), spices (700), rice (2500), wheat (1150), pulses (300), oil seeds (100), fruits and vegetables (1800), cashew nut (375), cotton (1200) and herbal products (250) (Kolunu and Kumar, 2003).

2.4. CERTIFICATION OF ORGANIC FARM

Certification is mandatory for selling agricultural produce as organic products. Organic certification provides an identifiable label for organic food and assure consumers that, foods bearing such a label are truly organic throughout the journey from plough to plate (Ilyas and Goyal, 2003). Certification system ascertains that the products meet the standards set by private or public institutions. A certification system should be objective, independent, transparent, competent, credible, voluntary, nondiscriminatory, confidential, cost effective, goal oriented and easy to communicate (Alam and Wani, 2003). Certification of the organic agriculture focuses on the production system rather than the product (Rundgren and Hagenfors, 1999). This system includes standard setting (developing rules or standards), inspection (verification and evaluation of the performance against the standards) and certification (recognition of producers who have successfully met the standards (Blake, 1990).

Accordingly the certification program should ascertain that,

a) biological potential of the soil has been upgraded through incorporation of composts, green manure, legumes, cultivation etc.,
b) the organic manures are well composted before use,
c) the mineral supplements like rock phosphate, limestone, chalk, gypsm, clay etc., have been used on a limited level and
d) pest and disease control is done by the integration of various components like crop rotation, choice of local varieties, mechanical control and use of natural enemies.

The development of any inspection and certification programme should be equivalent to the European Council Regulation, in order to get competence in the international market (Alam and Shah, 2003).

2.4.1. Organic Standards

Organic standards aims at maintaining natural ecological balances in production system through crop rotations, recycling of crop residues, composting, raising of legumes and biological control of pest and diseases etc. (Sharma, 2003). At least hundred regional or national organic production standards have been developed so far, which belong to organic farmer organizations or to certification agencies and are adapted to local, social, cultural, economic and ecological conditions (Rundgren and Hagenfors, 1999). A joint venture of FAO (Food and Agricultural Organization), WHO (World Health Organization) and the Codex Commission of the United Nations has set up organic standards which are the basis for many national standards (Alam and Wani, 2003).

The national steering committee, Ministry of Commerce, Govt. of India had prescribed national standards for organic production for crops based on three international regulations namely, IFOAM (International Federation for Organic Agricultural Movements) standards, Codex Alimentarius standards of United Nations and EC 2091/92 regulations of the European Council (Sharma, 2003). The dominance of European Union in the organic market resulted in the acceptance of European Union regulation (EEC 2091/92) for international trade. Standards proposed at the federal level in the United States for organic production and processing have proved to be highly controversial and have yet not been approved (Rundgren and Hagenfors, 1999).

2.4.2. **Inspection and Certification Agencies**

There are many agencies involved in the organic certification business around the world such as Organic Crop Improvement Association (OCIA), International Federation of Organic Agricultural Movement (IFOAM), Ecocert, BCS Oeko Garantie GmbH, Skal International, Institute of Market Okology (IMO), Farm Verified Organic (FVO), Quality Assurance International (QAI), Oregon Tilth and National Association for Sustainable Agriculture Australia (NASAA) (Sharma, 2003).

The organic certification movement in India was spearheaded by the members and associates of IFOAM, Germany. Its member in India is, All India Federation of Organic Farming (AIFOF). The certification is done by an agency accredited by any of the accreditation bodies authorized by the Govt. of India. Ministry of Commerce, Govt. of India, has designated five accreditation agencies namely Agricultural and Processed food products Export Development Authority (APEDA), Coffee Board, Spices Board, Tea Board and Coconut Board. It has also recognized three private certification agencies for certification of organic products namely Institute of Market Okology (IMO), Banglore; Skal India, Banglore; Ecocert International, Germany, which are already approved by European Union so that their certification will be accepted by importing countries (Sharma 2003). The organic inspections cover agricultural production, transactions between participants in the chain, storage and processing labels and certificates and documentations. Producers will normally be inspected at least once a year. (Rundgren and Hagenfors, 1999).

2.5. IMPACT OF ORGANIC FARMING

Reports on the impact of organic farming on soil quality, crop health and produce quality from round the world are not conclusive. Results are often contradictory, rather than being confirmatory. Literature on various soil quality attributes namely soil physical properties, chemical characteristics and biological behavior are reviewed.

2.5.1. **Soil Quality**

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries and to positively interact with the environment external to that, to sustain plant growth and animal productivity, maintain or enhance water and air qualities, and support human health and habitation (Karlen *et al.*, 1994). There are several indicators used for the measurement of different soil quality attributes. Indicators for soil physical properties include bulk density, aggregate stability etc. and chemical properties are indicated by soil nutrient status, organic matter content etc. Soil biological quality is often indicated by soil enzyme activity, microbial count and so on.

2.5.1.1. *Soil Physical Properties*

Literature on soil physical properties namely bulk density, water holding capacity, aggregate stability, porosity and soil structure are reviewed below.

2.5.1.1.1. Bulk Density

Liebig and Doran (1999) reported that soils under organic farms had lower bulk density compared to conventional farms. In a comparison of organic and conventional farming practices, Blakemore (2000) also reported the same result.

2.5.1.1.2. Water Holding Capacity

According to Robertson and Morgan (1996), no significant change in the water holding capacity of the soil was observed after 18 months of conversion of a conventional farm to organic agriculture. Liebig and Doran (1999) observed that available water holding capacity was higher in organically farmed soils compared to conventionally farmed soils.

2.5.1.1.3. Aggregate Stability

Organic farms were reported to have coarser and better-developed aggregates than the conventional farms (Gerhardt, 1997). Siegrist *et al.* (1998) reported that the aggregate stability of the organic plots, when determined by means of percolation, was significantly better than conventional plots and concluded that erosion susceptibility was greater on plots farmed conventionally than plots farmed organically. Albiach *et al.* (1999) arrived at the conclusion that soil aggregate stability was high in the organic management practices than under conventional management. In a long-term experiment done in Switzerland, it was observed that soil aggregate stability as assessed by the percolation method and the wet sieving method was 10 to 60 per cent higher in the organic plots than in the conventional plots (Mader *et al.*, 2002).

2.5.1.1.4. Porosity

A study conducted by Gerhardt (1997) in USA comparing the soil structures of organically managed farms and conventional farms revealed that the organic farms had significantly high porosity than the conventional farms. Moreover, the conventional farms also suffered from compaction and erosion.

2.5.1.1.5. Soil Structure

Over a long-term, organic management methods were able to maintain and improve the structure of soils (Gerhardt, 1997). Sadanandan *et al.* (1990) reported an improved soil physical condition with the application of organic manures compared to chemical fertilizers in ginger. Blakemore (2000) also reported similar results that organically managed soils had good crumb structure whereas the conventional farming soil was cloddy and subject to puddling.

2.5.1.2. ***Soil Chemical Properties***

The chemical properties that are reviewed in this study comprise cation exchange capacity, soil pH, total N, available N, organic N, mineral N, potentially mineralisable N, soluble P, plant available P, soil K, available K, soluble K, exchangeable K, mineral K, soil Ca and Mg, minor plant nutrients, soil organic C, total C, microbial biomass C, soil organic matter status and nutrient leaching from soil.

2.5.1.2.1. Cation Exchange Capacity (CEC)

Sadanandan *et al.* (1990) reported that the CEC of cardamom tracts in Kerala varied from (8.6 to 58.5) cmols (p+) kg^{-1} of soil. He also observed that the CEC was positively correlated with the organic matter content of the soil.

2.5.1.2.2. Soil Nitrogen

The soil N fractions that are reviewed in this study comprise total N, plant available N, organic N, mineral N and potentially mineralisable N.

2.5.1.2.2.1. *Total Nitrogen*

In a long term experiment initiated in 1978 the effects of different farming systems (biodynamic, organic-biological and conventional) on the soil properties were studied (Fliessbach *et al.*, 1997). The highest soil total N content was found in the biodynamic treatment, while the lowest values were found in the treatments given no organic fertilizers. Loes and Ogaard (1997) reported that total N increased in the subsoil after converting to an organic system from a conventional farm. Murata and Goh (1997) reported that the total N content in the soils of biodynamic (organic) mixed cropping farms was decreasing with time. At the same time this was not found in soils from the conventional farm. He explained that this trend was probably due to N fertilizer additions. Liebig and Doran (1999) opined that 20 per cent more total N was found on organic farms than conventional farms in the surface 30.5 cm. He concluded that the capacity of organic production practices to improve soil total N under the conditions of this study might be due to the use of more diverse crop sequences, application of organic amendments and less frequent tillage. Breland and Eltun (1999) reported that the total N remained similar in both organic and other farming systems (conventional and integrated) irrespective of whether arable or pasture. Soil total N was reported to be high in the organically managed soils than from conventional farm soils (Albiach *et al.*, 1999 and Blakemore, 2000). Korsaeth and Eltun (2000) found that both organic and conventional arable systems show similar reduction in the total soil N pool.

2.5.1.2.2.2. *Plant Available Nitrogen*

A field experiment conducted in Sweden revealed that the nutrient balance of N was higher in the conventional farms than organic ones (Fagerberg *et al.*, 1996). An experiment conducted at Kerala Agricultural University on eight year old pepper vines (Panniyur-1 and Panniyur-2) during 2000-2001 revealed that treatment including completely organic source of plant nutrients (50 per cent as FYM and the rest as *Azospirillum*) exhibited higher values of soil available N (Stephen and Nybe, 2003).

2.5.1.2.2.3. *Organic Nitrogen*

Robertson and Morgan (1996) reported that the conversion from conventional agriculture to organic farming had no effect on the microbial biomass N in the soils. Whereas, Liebig and Doran (1999) in their investigation on soil quality found that organic N content was higher in the organic farms compared to conventional farms.

2.5.1.2.2.4. *Mineral Nitrogen*

Willumsen and Kristensen (2001) reported that the soil mineral N was higher in organic fields compared to conventional fields. They concluded that the inclusion of legumes and green-manuring crops helped to bring these changes.

5.1.2.2.5. *Potentially Mineralizable Nitrogen*

Liebig and Doran (1999) observed that organic farms often had more potentially mineralizable N relative to nitrate N in the surface 30.5 cm. Jessica and Daniel (2002) reported that the nitrate N content in the soils of the organic farm increased over time during the period of investigation.

2.5.1.2.3. Soil Phosphorus

The soil P fractions that are reviewed in this study comprise soluble P and plant available P.

2.5.1.2.3.1. *Soluble Phosphorus*

Clark *et al.* (1998) observed that after four years of conversion from conventional farming to organic farming, the soluble P content of the soil was increased. In an experiment, soluble fractions of P was analysed in the organic and conventional farming systems (Mader *et al.*, 2002). It was reported that soluble P was lower in the organic soils than in the conventional soils.

2.5.1.2.3.2. *Plant Available Phosphorus*

An investigation on the effect of organic cultivation of cotton on soil fertility was carried out at the Central Institute of Cotton Research, Nagpur, India. The results showed that the available P content in the organic soil increased with time, whereas that of the conventional fields remained almost constant over the years (Tarhalkar *et al.*, 1996). Available P (kg ha^{-1}) in organic and conventional farms were 12.1 and 12.1, during June 1993 which changed to 12.6 and 12.0 in February 1994 to 14.5 and 12.9 in February 1995 and 15.0 and 12.0 in February 1996 respectively. Fagerberg *et* *al.* (1996) reported that P balance was higher in the conventional farms than organic farms. Hsieh *et al.* (1996) and Blakemore (2000) compared the available P content of organic and conventional farms. They reported that the organic farms had higher available P levels compared to conventional farms. Loes and Ogaard (1997) reported that while converting from conventional farming system to organic farming methods, the average plant available P concentration was reduced in the topsoil. An experiment conducted by Warman and Havard (1998) for three years in a sandy loam soil proved that extractable P content was higher in the organically fertilized potato plots than conventional plots. Asdal *et al.* (1999) arrived at the conclusion that soil P shows a negative balance in the organic farms, leading to deficiency symptoms.

Mader *et al.* (2000) reported that P content in the soil showed no significant temporal trends in the organic farms. In another experiment on a demopodzolic soil, Bundiniene (2000) observed that the available soil P increased in the treatment with mineral fertilizers compared to organic fertilizers. Pil-Joo *et al.* (2001) observed that Bray-2 extracted P values were higher in the organic farm soils than in conventional farm soils. Soil test data from twelve fields (17 to 50 acres in size) was compiled and analysed for changes over time in soil chemical properties for ten soil fertility components. It was found that the available P reached a level that could be an environmental risk if soils are not managed carefully (Jessica and Daniel, 2002). Stephen and Nybe (2003) reported that organic source of plant nutrients (P solubilizers and Arbuscular Mycorhizal Fungi) resulted in high available P content of the soil.

2.5.1.2.4. Soil Potassium

Soil K fractions that are reviewed in this study comprise available K, soluble K, exchangeable K and mineral K.

2.5.1.2.4.1. *Available Potassium*

Bundiniene (2000) reported that the available K status of the soil was increased in the treatment with mineral fertilizers compared to organic treatments. In an experiment, possible changes over time in soil chemical properties were investigated from twelve fields (17 to 50 acres in size) in Central Great Plains in Northern Colorado. It was reported that the available soil K in the experimental organic farms increased over the time of research (Jessica and Daniel, 2002).

2.5.1.2.4.2. *Soluble Potassium*

A long-term experiment for a period of sixty years investigated the soil quality change resulted from the conversion of a conventional crop management system to organic management practices. It revealed that soluble K in the soil showed a temporal decrease in the organic farms (Mader *et al.*, 2000). Soluble K fraction was reported to be lower in the organic farming system than in the conventional farming system (Mader *et al.*, 2002).

2.5.1.2.4.3. *Exchangeable Potassium*

Clark *et al.* (1998) reported that exchangeable K content of the soil increased after four years of conversion from conventional farming practices to organic farming practices. Stephen and Nybe (2003) reported that the application of 100 per cent K through organic source (wood ash) yielded high soil exchangeable K.

2.5.1.2.4.4. *Mineral Potassium*

The results of a comparative experiment of organic and conventional farming showed that the nutrient balance of K in the organic farms was almost on par with the conventional farms (Fagerberg *et al.*, 1996). Loes and Ogaard (1997) reported that the average plant available K concentration had reduced in the conversion of conventional farming practices to organic farming practices. Asdal *et al.* (1999) reported that K shows a negative balance in the organic farms, leading to deficiency symptoms. In a comparison experiment Blakemore (2000) reported that mineral K content was higher in the organically managed soil than in soil from the conventional stockless field.

2.5.1.2.5. Soil Ca and Mg

In an organic-conventional comparative experiment, where the conventional plots followed a soil test and provincial recommendations for the addition of pesticides, lime and NPK fertilizer and in the organic plots, applications of lime, composted manure and insect control were done according to the guidelines of the "Organic Crop Improvement Association". The results showed that extractable Mg was affected by treatments in the sweet corn, with the Mg content higher in the organic plots (Warman and Havard, 1998). They also accounted that Ca and Mg contents were higher in organically fertilized potato plots than conventional plots. Mader *et al.* (2000) reported no significant temporal variations of Ca and Mg in the soils of the organic farms. An experiment conducted at Kerala Agricultural University on eight year old pepper vines (Panniyur-1 and Panniyur-2) during 2000-2001 revealed that the exchangeable Ca and Mg showed an increment in the organic treatment (Stephen and Nybe, 2003). Soluble Ca and Mg were found to be higher in the organic farming system than in the conventional farming system (Mader *et al.*, 2002).

2.5.1.2.6. Minor Plant Nutrients

Hsieh *et al.* (1996) mentioned that the microelements concentration in the organic farms were higher than that of the conventional farms. Jessica and Daniel (2002) reported the interpretations of soil test data from twelve organic fields (17 to 50 acres in size), which showed changes over time in soil micronutrient content. The micronutrient elements namely Zn, Fe, Mn and Cu showed a positive change over time in the organic farms. The increased acidity of the soil was cited as the reason for the high availability of these elements.

2.5.1.2.7. Soil Carbon

Soil C fractions that are reviewed in this study comprise of organic C, microbial biomass C and total C.

2.5.1.2.7.1. *Soil Organic Carbon*

The effect of organic cultivation of cotton on improvement of soil fertility was investigated at the farm of Central Institute of Cotton Research, Nagpur, India. The results indicated that the organic C content increased with time in the soils of organic field. Organic C content (percentage) in organic and conventional farms were 0.38 and 0.38, during June 1993 which changed to 0.40 and 0.36 in February 1994 to 0.46 and 0.35 in February 1995 and 0.53 and 0.38 in February 1996 respectively (Tarhalkar *et al.*, 1996). Soil chemical properties during the transition from conventional to organic farming practices were studied over 8 years in California's Sacramento Valley (Clark *et al.*, 1998). After 4 years, soils in the organic system had higher soil organic C content compared to the conventional system. Liebig and Doran (1999) reported that there was 22 per cent more organic C in the soils of organic farms compared to conventional farms, at four of five locations of study. The report of Breland and Eltun (1999) follows that there were no detectable differences between organic and conventional farming systems in terms of total soil organic C. Blakemore (2000) reported that organic C was found to be higher in the organically managed soil than in soil from the conventional stockless field. Mader *et al.* (2000) reported that organic C content of the soil showed no significant temporal trends in the organic farms.

2.5.1.2.7.2. *Total Carbon*

An investigation of cropping systems on soil quality in a pair of conventional and biodynamic (organic) mixed cropping farms revealed that in the biodynamic farm, total C content of the soil was decreasing over time (Murata and Goh, 1997).

2.5.1.2.7.3. *Microbial Biomass Carbon*

Robertson and Morgan (1996) observed no significant change in the status of the soil microbial biomass C after 18 months of conversion to organic farming from a previously conventional organic agricultural system. Liebig and Doran (1999) also reported higher amount of microbial biomass C from organic farms compared to conventional farms.

2.5.1.2.8. Soil Organic Matter Content

Brown *et al.* (1995), Hsieh *et al.* (1996) and Gerhardt (1997) reported that organic arable and horticultural farms tended to have higher organic matter levels than conventional farms. A comparative study of organic and conventional management on soil properties were conducted in Spain (Albiach *et al.*, 1999). Thirteen pairs of citrus orchards were selected for the study. Both orchards in each pair shared similar characteristics, but one was managed under organic practices and the other under conventional management practices. The results indicated that organic husbandry gave rise to significantly higher contents of organic matter, humified substances and humic acids. Condron (2000) reported that soil organic matter content was higher under organic and biodynamic systems than under conventional system of New Zealand. Temple *et al.* (2000) reported that soil organic matter content increased in the organic system over time. An experiment conducted in Korea reported that organic husbandry gave rise to significantly higher contents of soil organic matter compared to conventional management (Pil-Joo *et al.*, 2001). A study comparing conventional and organic farms under similar climatic and pedologic conditions in Estonia reported that organic matter content was higher in the organic farms irrespective of the soil types (calcic Cambisols, calcic Gleysols and haplic Podzols) (Geherman, 2002). Soil organic matter content of the organic farms showed a positive trend over the time of investigation (Jessica and Daniel, 2002).

2.5.1.2.9. Nutrient Leaching from Soil

An experiment carried out at three locations in Germany investigated the uptake of atmospheric and soil N by legumes (Schmidtke, 1997). The results suggested that in contrast to conventional agriculture, there is no increased risk of N leaching with increasing animal stocking rate in ecological (organic) agriculture. It is concluded that there is a self-regulation of N supply via symbiotic N fixation by legumes and soil N availability. With higher N supply from the soil, the legumes took a lesser proportion of their N from the atmosphere. This had the effect of reducing the soil N to a minimum level and decreasing the risk of N leaching, which in turn protects groundwater quality.

Clark *et al.* (1998) reported that the organic system appeared to be much efficient in its capacity of storing excess N and the conventional system were the least efficient, making the conventional system more susceptible to N leaching.

In an experiment, intensively cultivated farmland in Germany with a mean annual N input of 177 kg ha^{-1} was converted to organic agriculture and examined by means of large test plots (Kolbe *et al.*, 1999). It was concluded that organic agriculture practices increased the soil's ability to conserve nutrients in the top layer, thus considerably decreasing risks of leaching. Askegaard (1999) observed no differences in nitrate leaching between the two systems (organic and conventional).

Eriksen and Askegaard (2000) reported that sulphate leaching was independent of the farming practice (organic or conventional) and varies with the type of crops grown and the drainage volume.

2.5.1.2.10. Soil pH

Mader *et al.* (2002) reported that soil pH was slightly higher in the organic system than the conventional chemical based farming system.

2.5.1.3. ***Soil Biological Properties***

The biological soil properties that are reviewed in this study comprise earthworm count, microbial count and soil enzyme activity. Mader *et al.* (2002) reported that organically managed soils exhibited greater biological activity than the conventionally managed soils.

2.5.1.3.1. Earthworm

Gerhardt (1997) reported that the soils of organically managed farm had significantly high earthworm abundance compared to conventional land-use management. Siegrist *et al.* (1998) observed greater earthworm biomass and density as well as the population diversity in the organic plots than in the conventional plots. In a long-term trial, the earthworm population of two organic farming systems, two conventional systems and one control treatment were compared in a seven year crop rotation on a Luvisol from loess in Switzerland (Pfiffner and Mader, 1998). The earthworm biomass and density and the number of juveniles were significantly higher in the organic than in the conventional or unfertilized plots. In addition, more earthworm species were found in the organic plots. It was concluded that plant protection management seems to be the main factor responsible for the differences in earthworm population. Blakemore (2000) concluded that earthworm biomass and density and the number of juveniles were significantly higher in the organic than in the conventional plots. He cited the reason for this as the high organic matter content in the organic farms. Jossi *et al.* (2001) accounted that though there was little difference in the earthworm population with different farming systems, earthworms of endogenic species were present more in organic farming system than in intensive farming system.

2.5.1.3.2. Soil Microbes

Robertson and Morgan (1996) reported that a conversion period of 18 month from conventional to organic farming of vegetable crop doesn't improve the soil bacterial count and fungal hyphal length (microscopic observation). In a field experiment, conventionally and organically managed grasslands on silt, loamy and sandy soils were sampled and analysed to assess effects of management and soil texture on soil fauna and microorganisms. Bacterial phospholipid fatty acids (PLFA) predominated in all the farming systems and unaffected by the farming system management except in silty soils. In silty soils PLFA was found more in organic land. Fungal PLFA on the other hand was found greater under organic management in all soils (Yeates *et al.*, 1997).

A field experiment conducted in Austria revealed that microbial biomass of the organic vegetable plots remained constant with time while that of conventional plots showed high seasonal fluctuations (Meissner and Fokkema, 1998). Carpenter *et al.* (2000) reported that there were no major observed effects of the biodynamic preparations over organic manures. Organically and biodynamically managed soils had similar microbial status and were more biotically active than soils that did not receive organic fertilization. So they concluded that organic management enhanced soil biological activity, but additional use of the biodynamic preparations did not significantly affect the soil biotic parameters tested.

2.5.1.3.3. Soil Enzymes

Chao and Chao (1996) reported that the nitrification activities of alluvial and clayey soils of Taiwan managed under organic farming practices had improved markedly compared to the conventional practices after one year of study. They also found that after five years, the nitrifying activities in clay samples, which had been managed under organic and conventional practices, were not significantly different, but in the alluvial soil nitrification activities were higher under organic than under conventional practices. An experiment conducted in Switzerland by Oberson *et al.* (1996) proved that the biological soil parameters like the level of phosphatase activity and mineralization of organic C in the bio-dynamic and bio-organic systems were higher than the conventional farming system. They explained this trend as because of the greater importance given to the manuring and the different plant protection strategies adopted in the above alternate systems compared to the conventional farming system.

Albiach *et al.* (1999) mentioned that organic farms possessed high levels of soil enzyme activities compared to conventional farms. Liebig and Doran (1999) reported higher microbial mineralization rates of C and N in organic farming system, which was an indicator of higher availability of nutrients enhanced by microbial activity. They also reported that soil respiration activities were highest in the organic farms. A study was carried out to investigate whether biodynamic compost or field spray preparations affect the soil biological community in the short term, beyond the effects of organic management (Carpenter *et al.*, 2000). Four fertilizer options namely composted dairy manure and bedding, the same material composted with biodynamic compost preparations, mineral fertilizers and no fertilizer were investigated with and with out the biodynamic field spray preparations. Both biodynamic and non-biodynamic composts increased soil dehydrogenase activity. No significant differences were found between soils fertilized with biodynamic vs. non-biodynamic compost. Temple *et al.* (2000) observed that soil biological activity increased over time in the organic system. Condron (2000) reported higher soil biological activity in organic and biodynamic systems compared to conventional system. In soils of the organic system, Mader *et al.* (2002) found that dehydrogenase, protease and phosphatase activities were higher than in the conventional system, indicating a higher overall microbial activity and a higher capacity to cleave protein and organic P. P flux through the microbial biomass was faster in organic soils and more P was bound in the microbial biomass. Evidently, nutrients in the organic system are less dissolved in the soil solution and microbial transformation processes may contribute to the plant's P supply.

2.5.1.3.4. Others

Comparisons of Danish and British organic and conventional farmland had revealed evidence that bird populations were generally higher on the organic-farm land (Fuller, 1997). However, the studies to date do not pinpoint which of the potential mechanisms underpin these differences. Yeates *et al.* (1997) reported that nematode populations were greater under organic management in all soils under study. Bacterial-feeding nematodes were most common under organic grassland in silt soils. Fungal-feeding nematodes were twice as abundant under organic managements at all sites. Plant-feeding nematodes were more abundant under organic management at all sites. It was concluded that it might be due to changes in soil nutrient cycling and diversity of soil biota. In an experiment done by Reddersen (1997), the arthropod fauna was studied in 21 and 17 matched pairs of organic and conventional cereal fields in Denmark. It was found that the total density, species diversity, total biomass and number of bird food items were consistently and often significantly higher in organic than conventional cereal fields. A study carried out by Fujita and Fujiyama (2001) in the crop fields of central Japan indicated that the abundance and diversity of soil mesofauna (enchytraeid worms and oribatid mites) were greater in the organic farming fields than those in conventional farming fields. Root length colonized by mycorrhizae in organic farming system was 40 per cent higher than in conventional system (Mader *et al.*, 2002).

2.2.5.2. **Crop Health Parameters**

Crop health parameters that are reviewed in this study comprise subdivisions namely yield, plant nutrient content and biometric observations.

2.5.2.1. *Yield*

The yield changes due to the difference in the farming practices are classified on the basis of crop types. The crops that are reviewed in this study comprise vegetables, fruit crops, cereals, pulses, spices, cash crops, cotton and other general crops.

2.5.2.1.1. Vegetables

Hsieh *et a.l* (1996) conducted a field experiment on a slate alluvial neutral sandy loam soil in which broccoli was grown using conventional farming and organic farming methods. He reported that yield of broccoli in the organic treatments was greater than in the conventional one. It was concluded that the better soil fertility factors in the organic treatments caused the higher yield. A seventeen year old field experiment in Germany comparing the effects of mineral fertilizers and organic manures revealed that yield of potatoes was greater with mineral fertilizers compared to organic fertilizers (Raupp and Lockeretz, 1997). Divis and Vodicka (1998) observed that organic farm had 30 to 40 per cent lower potato yields compared to conventional farm. He concluded that it might be due to poor nutrition and earlier termination of growth by late blight (*Phytophthora infestans*) in the organic farms. An experiment conducted by Warman and Havard (1998) for three years in a sandy loam revealed that potato yield was not affected by treatments (organic or conventional). Schulzova *et al.* (1999) reported that yield of potato was about twice as high in conventional farming compared to that of organic farming.

Neuhoff *et al.* (1999) studied the influence of biodynamic preparations over 'conventional organic' farming on potato yield. The result of the field trial indicated that yield in the biodynamic farms was slightly higher than that of 'conventional organic' farming system. Rembialkowska and Alfoldi (2000) reported that yield of conventionally grown vegetables was 25 to 37 per cent higher than organic ones. Fjelkner *et al.* (2000) reported that yield was lower by 65 to 90 per cent for organically grown vegetables compared to integrated grown vegetables. Mader *et al.* (2002) reported that potato yield in the organic system was 58 to 66 per cent of those in the conventional plots, mainly due to low K supply and the infeststion of *Phytophtora infestsans.*

2.5.2.1.2. Fruit Crops

Hui-Lian *et al.* (2000) reported that the fruit yield was 62 per cent higher for organically farmed pear orchard compared to conventional chemical based farms. Reganold *et al.* (2000) reported that after two years of establishment, fruit yields were higher in organic production of apples compared to conventional farming system.

2.5.2.1.3. Cereals

Wheat production levels on eight paired-adjacent-fields, managed organically and conventionally in Western Australia were monitored and compared in three years (Deria *et al.*, 1996). Sites were paired to ensure similar soil types, crop history before conversion to the organic farming, so that the management system was the primary object of difference. At four sites the grain yield of organic and conventional wheat was comparable, but grain yield of organic wheat was significantly depressed at the other four sites. The yield depression in the organic plots was most likely related to the lower pre-sowing P level in the soil, late sowing and low N supply. Raupp and Lockeretz (1997) accounted that yield of rye was higher with mineral fertilizers. Granstedt *et al.* (1997) reported that organic fertilization generally increased yields of spring wheat. Warman and Havard (1998) found out that yield of sweet corn was more in the conventionally grown than the organically grown ones. In a field trial conducted in Iran, a rotation of wheat, sugar beet and maize was planned at different levels of management namely conventional, integrated and organic farming (Faizabady *et al.*, 1998). Compared to other systems the yield of all the crops was significantly lower in the organic system. Bartosova *et al.* (2000) observed that in the ecological (organic) system, yield was lower for crops like wheat and maize compared to conventional intensive system. Mader *et al.* (2000) also reported that wheat grain yield was lower on organic farms than on integrated farms. Winter wheat yield in the third crop rotation period of a long-term experiment reached an average of 4.1 metric tons per hectare in the organic system. This corresponds to 90 per cent of the grain harvest of conventional system, which is similar to yields of conventional farms in the region (Mader *et al.*, 2002).

2.5.2.1.4. Pulses

Leon and Cortes (1998) reported that yield of common bean (*Phaseolus vulgaris)* was not at all affected by the farming practices (organic and conventional), but sorghum yield was greater under organic practices in the second cropping season, probably due to edaphic effects. Bartosova *et al.* (2000) reported that yields of pea and other legume crops were significantly lower in the organic system compared to conventional farming system.

2.5.2.1.5. Spices and Other Cash Crops

Sadanandan *et al.* (1990) observed increased yields of rhizome and oleoresin of ginger when cultivated using organic manures compared to chemical fertilizers. Stephen and Nybe (2003) reported that the dry yield of pepper was highest in the organic treatments compared to treatments involving chemical fertilizers.

2.5.2.1.6. Cotton

A long term experiment conducted at the Central Cotton Research Institute, India reported that from the third year of production onwards the yield of organically produced cotton equaled to that of the conventionally produced ones, with the bonus of increased soil quality in the organically managed plots (GoI, 2001b).

2.5.2.1.7. General

Granstedt *et al.* (1997) reported that organic fertilization increased yields of beet. A farming systems research done at Grastorp, Sweden, to compare an Ecological Arable Farming System (organic) and an Integrated Arable Farming System, with a Conventional Arable Farming System as a reference for a period of four years showed lower yields in the organic farming system compared to the others, which it was thought were mainly due to N deficiency in the early part of the growing season (Helander, 1997). Thorup and Grevsen (1999) reported that the organically produced crops showed reasonable yields and more than half of the experimental crops produced yields comparable with similar conventional crops. Mader *et al.* (2002) reported no marked differences in grass clover yields between organic and conventional systems.

2.5.2.2. ***Biometric Observations***

Hsieh *et al.* (1996) reported that growth of broccoli in the organic treatments was greater than the conventional one. The results of a field experiment comparing natural (organic) and conventional agriculture production systems in USA showed that natural farming rice retained proportionately more tillers and had a higher proportion of mature seeds than conventionally grown rice (Andow and Hidaka, 1998). Fertilizer trials involving application of P as both rock phosphate and super phosphate were conducted on adjacent organic and conventional farms in SE-Australia (Derrick and Ryan, 1998). The origin of the seed, (whether it was produced on an organic or conventional farm), the year it was harvested, and the fertilizer treatment (the parent crop had received), did not significantly affect seedling growth. But heavier seeds had a higher P content and were found more likely to have germinated after 48 hours. Seedling shoot dry mass and root dry mass after three weeks of germination were positively correlated with seed P content and seed mass. It is concluded that enhanced early growth of seedlings may be particularly important on organic farms where herbicides are not applied and seedlings may face increased weed competition. It is suggested that organic farmers may benefit from grading out heavier seeds for sowing. Schulzova *et al.* (1999) compared the conventional and organic methods of cultivation. He reported that tuber size was higher for conventionally grown potatoes than organically grown ones.

A study was conducted in a greenhouse in Yugoslavia (Momirovic, 2000) to compare the effects of different organic substrates on the characteristics and quality of sweet pepper (*Capsicum annuum* cv. Macvanka). The organic substrates used were: (1) cattle manure + soil from a deciduous forest + sand (40:40:20), (2) hotbed compost + peat (60:40), (3) AMS humus (microbial culture of wood chips) + hotbed compost (60:40), (4) AMS humus + soil (60:40) and (5) lumbri-humus + soil (40:60). Substrate had significant effects on plant height, number of leaves and shoot biomass. Considerable differences in plant height were observed for variants 2, 3, and 5 (14.62, 13.79 and 14.14 cm respectively) compared with the values obtained for variants 1 and 4 (11.95 and 9.02 cm respectively). No significant differences in number of leaves were observed between variants 1, 2, 3 and 5 (ranging from 6.1 to 6.7 leaves per plant), but a significantly lower number of leaves were observed for variant 4 (4.8

leaves per plant). The highest shoot biomass was obtained from variant 5 (3.7 g), while the lowest was observed for variant 4 (1.41 g). The highest total leaf area was obtained for variant 5 (83.4 cm^2), while the lowest was observed for variant 4 (28.2 cm^2). The highest values for number of fruits (9.12), average fruit weight (109.16 g) and total yield (49.59 Mg ha^{-1}) was observed for variant 5. The lowest values for number of fruits (96.6) and total yield (35.26 Mg ha^{-1}) were observed for variant 4, whereas the lowest average fruit weight (94.47 g) was observed for variant 1.

Blakemore (2000) reported that winter wheat grown in the organic field had significantly longer shoots and roots than that grown in conventional fields. Slight growth lag was reported by Reganold *et al.* (2000) in the apple trees grown under organic management in the initial stages of orchard establishment. In another organic-conventional comparison experiment, Srivastava *et al.* (2002) reported that the use of organic materials especially Vesicular Arbuscular Mycorrhizal fungi enhanced plant growth of citrus trees.

2.5.2.3. *Plant Nutrient Contents*

The plant nutrient contents that are reviewed in this study comprise N, P, K, Ca, Mg and micronutrients.

Enrique (2001) observed no relationship among leaf nutrient levels, growth, yield and fruit quality parameters in his study comparing organically grown banana with conventionally grown bananas.

2.5.2.3.1. Nitrogen

Warman and Havard (1998) reported a lower N content in the organically produced wheat compared to conventional wheat. Stalenga and Alfoldi (2000) reported N deficiency in spring barley produced under organic system of crop management compared to conventional management system. Quite similar to the above findings, Worthington (2001) reported that organic crops (fruits, vegetables and grains) have fewer nitrates than conventional crops.

Enrique (2001) reported that concentration of N in the leaf dry matter was almost similar for both organically grown and conventionally grown bananas and fell in the normal range.

2.5.2.3.2. Phosphorus

In an experiment conducted in Denmark, the findings showed significantly higher levels of P in organically grown peas compared to conventionally grown peas (Gundersen *et al.*, 2000). Stalenga and Alfoldi (2000) observed no significant difference in the P status of the spring barley crop, grown both organically and conventionally. Enrique (2001) reported that the P concentration of organic banana was similar and was in normal range to that of conventional banana. A comparison of nutrient content of organic and conventional crops (fruits, vegetables and grains) showed that organic crops contained significantly more P than conventional crops (Worthington, 2001).

2.5.2.3.3. Potassium

Stalenga and Alfoldi (2000) reported K deficiency in spring barley produced under organic system of crop management compared to conventional management system. Enrique (2001) reported that foliar concentration of K was low in the organically grown banana compared to the conventional one, but not deficient.

2.5.2.3.4. Calcium

Enrique (2001) reported that foliar concentration of Ca was high in the organically grown banana compared to the conventional one.

2.5.2.3.5. Magnesium

Warman and Havard (1998) observed that organic wheat contained less Mg in leaves compared to conventional wheat. Worthington (2001) observed that the Mg content of organic crops (fruits, vegetables and grains) was significantly higher than the conventional crops. Enrique (2001) found that the Mg concentration of the organic and conventional banana leaves were in the normal range.

2.5.2.3.6. Micronutrients

Warman and Havard (1998), while comparing organically grown and conventionally grown wheat plants reported that the Fe content was low in the organic wheat than in conventional wheat. Worthington (2001) reported that organic crops (fruits, vegetables and grains) contained significantly more Fe than conventional crops. Enrique (2001) reported that leaf contents of micronutrients such as Cu, Fe, Mn and Zn of the organically grown bananas fell within the normal range related to conventionally grown bananas.

2.5.3. **Produce Quality**

Produce quality assessments that are reviewed in this study comprise aromatic contents, vitamins, heavy metals, nitrite and nitrate, amino acids/ proteins, sugar, TSS (total soluble salts), dry matter, phenol and P

2.5.3.1. ***Aromatic Contents***

Gutierrez *et al.* (1999) reported that while comparing the quality of oil extracted from organically cultivated olives (cv. *Picual*) with oil extracted from olives cultivated using conventional methods, it was found that the virgin olive oil produced by organic culture was of superior quality to the conventional virgin olive oil for all the quality parameters analysed (acidity value, peroxide index, ultraviolet absorption at 232 and 270 nm, stability to oxidation, sensory analysis, fatty composition and contents of tocopherols, phenolic compounds and sterols). Lavender (*Lavendula officianalis syn.* L. *angustifolia*) is a fragrant herb, which is cultivated in the Jammu and Kashmir state of India. The herbs cultivated under organic production system were marked with a high percentage of linalyl acetate (more than 44 per cent) which is an indicative of its international quality, and thereby fetches a premium price in the international market (Shawl and Kumar, 2003). The organically produced geranium (*Pelargonium graveolens* Lin.) yielded good quality essential oil with L-citronellol (35.7 per cent), geraniol (21.3 per cent), linalool (3.8 per cent), isomethone (6.15 per cent), cis-3-hexanol (0.29 per cent) and rose oxide (0.72 per cent), which essentially meets the international standards (Tajuddin *et al.*, 2003).

2.5.3.2. *Vitamin*

Velisek *et al.* (1995) reported that grain thiamin and riboflavin (water-soluble vitamins) contents were lower from organic than from conventional wheat and barley grain samples on a clay loam soil near Prague. They also found that lipid-soluble vitamin contents were unaffected by farming methods. This was explained by the location of the vitamins, since the lipid-soluble vitamins are found mainly in the embryo, which is less likely to be affected by any nutrient imbalances resulting from organic farming than the water-soluble vitamins which are found in the endosperm and surface layers of the seed. Schulzova (1999) accounted that ascorbic acid (vitamin C) content was not significantly different between the conventionally grown and organic potatoes. Rembialkowska and Alfoldi (2000) observed a 30 per cent increase in the vitamin C content in organic cabbage compared to the conventionally grown ones. Worthington (2001) also reported the same results.

2.5.3.3. *Heavy Metals*

Rembialkowska and Fiedorow (1998) reported that carrots from organic farms had higher Cd content than conventionally grown carrots. A study conducted by Petr *et al.* (1999) in Czech Republic on wheat, barley, rye, millet, buckwheat and peas grown organically according to the IFOAM regulations showed that the Cd, Pb and Hg contents were within permissible limits for foodstuffs as defined by the Czech Republic and European Union. In conventional intensive agriculture, the content of these elements were found higher than in organically grown grain crops. Prugar (1999) reported that residues of pesticides and heavy metals were lower in organic produce.

In an experiment, Schulzova *et al.* (1999) reported that the contents of most metals analysed were higher in organically grown potatoes (Mn, Fe, Co, Cu, Zn, Se and Ni) compared with conventionally grown potatoes except Cd, which was lower. Nakagawa (2000) reported that organically grown rice had higher Mg and Zn content than conventionally grown rice. Jorhem and Slanina (2000) reported that no significant difference in the concentrations of Cd, Pb, Cr and Zn in rye, carrots and potatoes were detected between the cultivation systems (organic farming and conventional farming).

2.5.3.4. *Nitrite and Nitrate*

Yun *et al.* (1998) reported that the concentration of Kjeldahl-digested N was significantly higher in milled rice grains cultivated under conventional farming practices than in those grown organically. Rembialkowska and Fiedorow (1998) reported that carrots and white cabbages from organic farms had lower nitrite compared to conventional farms. Divis and Vodicka (1998) and Schulzova (1999) reported that potatoes from the organic farm had lower nitrate levels compared to the conventional farms. Prugar (1999) reported that organically grown potatoes and vegetables had lower mineral (especially N) contents compared to conventionally grown one. Nyanjage *et al.* (2000) found that the peel of non-organic banana fruits had higher N content than organic fruits.

2.5.3.5. *Amino Acids / Proteins*

Granstedt *et al.* (1997) reported that in potatoes and wheat, crude protein content was higher in the inorganic, but protein quality was better in the organic treatments. Yun *et al.* (1998) reported that concentrations of the free amino acids, aspartic acid, glutamic acid, glutamine and asparagine were significantly higher in milled rice grains from organically grown rice than in those from conventionally farmed rice. Prugar (1999) reported that organically produced wheat and barley generally had lower grain protein contents compared to conventional ones.

2.5.3.6. *Sugar*

Divis and Vodicka (1998) reported that potatoes from the ecological farm had higher starch content than conventional ones. Yun *et al.* (1998) reported that the amylose content showed no differences between organic and conventional cultivation methods.

2.5.3.7. *TSS (Total Soluble Salts)*

Nyanjage *et al.* (2000) reported that organic and non-organic Cavendish bananas had no significant difference in total soluble salt contents.

2.5.3.8. ***Dry matter***

Divis and Vodicka (1998) reported that potatoes from the ecological farm had higher dry matter content compared to conventional ones. Rembialkowska and Fiedorow (1998) reported that carrots and white cabbages from organic farms had higher dry matter compared to conventional farms. Rembialkowska (1999) and Schulzova *et al.* (1999) reported that the content of dry matter was significantly higher in organically produced potatoes than conventionally produced potatoes. Rembialkowska and Alfoldi (2000) observed that organic cabbages contained 15 per cent more dry matter than conventional ones.

2.5.3.9. ***Phenol***

Weibel *et al.* (2000) reported that the content of phenols (mainly flavanols) was 19 per cent higher in organic apples compared to the conventional counterparts.

2.5.3.10. ***Phosphorus***

Weibel *et al.* (2000) reported that P content was 31 per cent higher in organic apples compared to the conventional fruits.

2.5.4. **Pest attack**

Phelan *et al.* (1995) studied the host preference by European corn borer, *Ostrinia nubilalis* on *Zea mays* cultivated under organic and conventional chemical farming. For which females of *O. nubilalis* were released to soils collected from organic and conventional chemical production systems in Ohio state of USA. It was reported that egg lying was about 18 times higher among plants in the conventional soil than among plants in the organic soil. They concluded that this difference is evidence for a form of biological buffering characteristic of organically managed soils.

A field trial conducted over a period of six years in Rheingau, Germany, investigated the effects of organic and conventional/ integrated cultivation methods on grape varieties. It was reported that, though the pest/ disease incidence was more, losses due to insect pests stayed below the economic threshold in organic system (Hofmann and Harkness, 1997).

Swezey *et al.* (1999) conducted a study on organically and conventionally managed cotton fields. The results showed that the incidence of some common pests was found to be more in the organic cotton growing fields. The populations of the predatory insects like *Geocoris spp.* were also found significantly higher in the organic than in the conventional fields. So it can be concluded that the organic plots have a sort of self-defense against the insect attack.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1. GENERAL DESCRIPTION OF STUDY AREA

The experimental area selected for the study is situated at the Upputhara panchayath of Peermede taluk, in the southwestern border of Idukki district of Kerala (Fig.3). The physiography of the study site comprises moderately steep sloping foothills with thin vegetation and moderate erosion associated with rock out crops.

The climate of the area is humid tropical with an average annual rainfall of 2500 to 4250 mm and temperature ranges from 22.5^0 C (mean min) to 37.5^0 C (mean max). The highland region has cold climate. Occurrence of mist is usual in the region lying over an elevation of 1300 meters above M.S.L. Annual mean monthly rainfall of 2003 in Idukki district was as follows.

Monthly rainfall (mm) of Idukki district during the year 2003												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	00	38.6	142.3	176.2	127.1	470.6	678.8	611.7	142.2	681.4	Not available	

The major rock type observed in the area is granite gneiss. Most of the soils appeared to have developed from the weathered material derived from these rock forms. The very deep well drained clayey soils occurring on moderately sloping foothills are classified as clayey, mixed, Ustic Palehumults associated with clayey mixed ustic Haplohumults as per the soil map of Kerala at 1:250,000 scale. Sadanandan *et al.* (1990) reported that soils of major cardamom growing areas come under the order Alfisols formed under alternate wet and dry conditions and the suborder ustalfs derived from schists granite and gneiss and are lateritic in nature.

Major portions of Upputhara Panchayath consist of tropical rain forest. Tribal population occupies the study area. Major crops grown in the study area are ginger, cardamom, tapioca, tea and coffee.

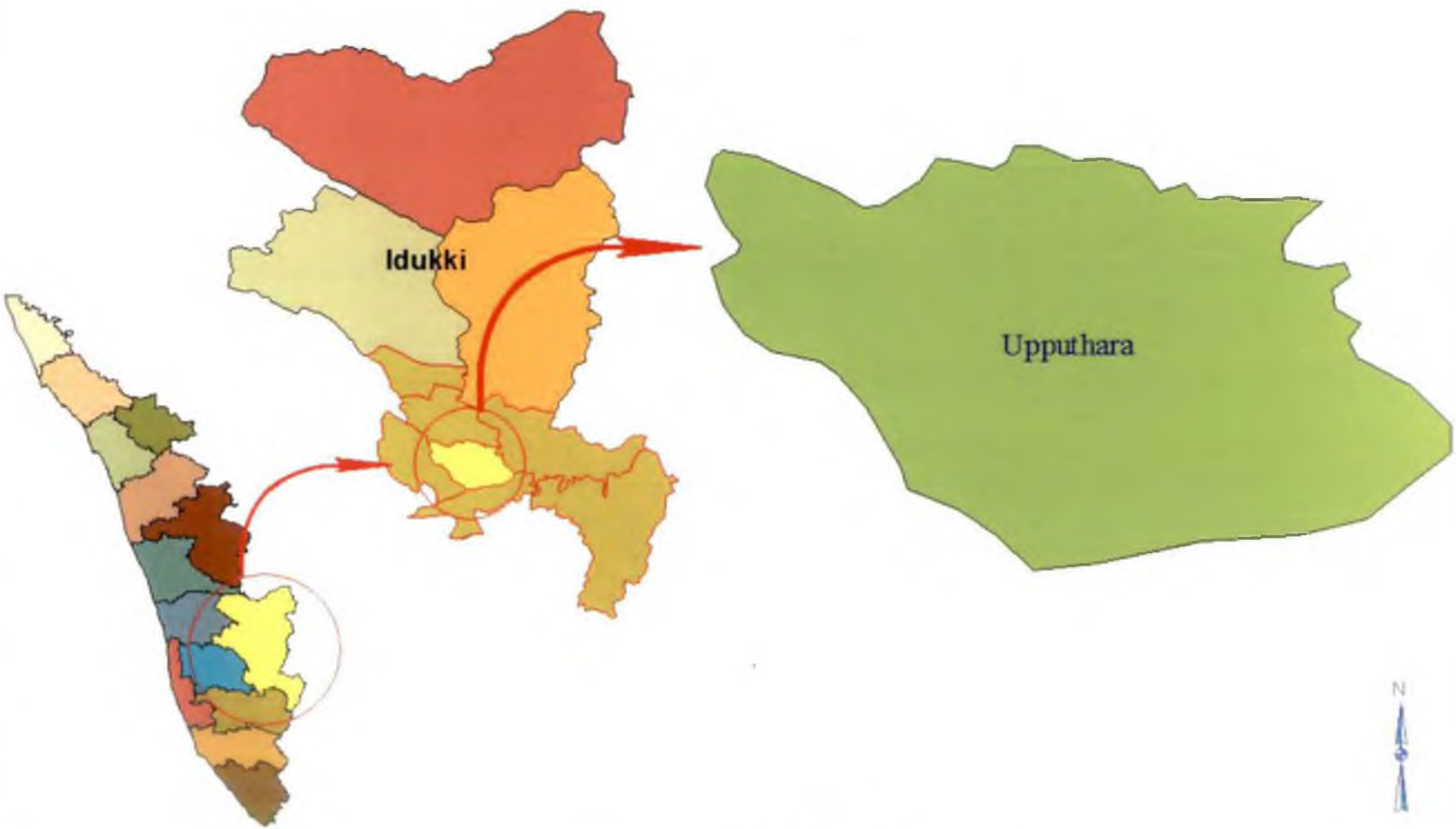

Fig 3 Location map showing the study area

3.2. SELECTION OF SAMPLING SITES

Samples for the study were collected from selected organic and conventional cardamom farms. Nine organic farms were identified for the study. These farms follow IMO and Skal International certification standards and were certified organic farms. Eight adjacent conventional cardamom farms following recommendations of Spices Board were also selected for investigation.

All features of the sites, namely topography, soil type, slope, rainfall and climate were uniform. The parameters namely age of the plant (8-10 years), spacing (3m x 3m), sampling time (second week of November 2003) and depth of soil sampling (25 cm) were kept uniform for the study. Both conventional and organic farms selected for the study were growing locally available varieties like Vazhukka, Mysore and Malabar.

For the purpose of sampling, each organic and conventional farm was further divided into plots of one-acre size. This was done considering the land characteristics and size of the farm. Number of plots selected for sampling depended on size of the farm and topographic features. Altogether, 50 samples each of soil and cardamom leaves were drawn from both organic and conventional farms. Details of the samples collected from different plots are given in table 1.

3.3. DOCUMENTATION OF FARMING PRACTICES

A proforma was developed (Annexure A) in accordance with the standards fixed by IFOAM for documenting farming practices of the study area. More than thirty indicators were used to assess the farming practices. A scoring chart was designed for rating adoption of organic and conventional farming practices by the farmers of the study area.

3.4. BIOMETRIC PARAMETERS OF CARDAMOM PLANTS

Biometric parameters of cardamom plants namely, leaf length (cm), leaf breadth (cm), petiole length (mm), plant height (m), number of tillers per clump and girth of pseudostem (mm) were observed from organic and conventional farms.

Table 1. Details of farms surveyed and samples drawn for the study

Sl. No.	*Type of farm*	*Name and address of the farmer*	*No. of soil and plant samples collected*	*No. of cardamom sample collected*
1	*O	Bhaskkaran, Tharamattam, Kannanpadi	3	1
2	O	VellanRaman, Kandathukara, Kannampadi	8	1
3	O	Thankamma, Adoopottinal, Mathaippara	4	1
4	O	Thankappan, Palathadikkal, Kannanpadi	6	1
5	O	Sekharan, Velluvayal, Kannanpadi	7	1
6	O	Biju Narayanan, Kuruppathu, Kannanpadi	7	1
7	O	James,Thumpasseril, Kannanpadi	7	1
8	O	Chandran K S, Koilvara, Kannanpadi	5	1
9	O	Raghavan, Kovilpurayil, Kannanpadi	3	1
10	*C	Leela Parameswaran, Koilvara,Kannanpadi	6	1
11	C	Sudhakaran, Cheruvalliyil, Kannanpadi	6	1
12	C	Kumaran, Puthen purakkal, Kannanpadi	6	1
13	C	Balan, Ethanal, Kannanpadi	6	1
14	C	Narayanan, Koilvara, Kannanpadi	6	1
15	C	P R Ravi, Puthen purakkal	6	1
16	C	Keshavan K K, Kannamakkal, Kannanpadi	6	1
17	C	Ramakrishnan, Paramattam, Kannanpadi	7	1
18	C	Madhavan, Poykayil, Kannanpadi	7	1

* O = Organic farm, C = Conventional farm

Leaf length was measured from the tip of the leaf to the end of the leaf blade. An average was worked out from the values obtained from three leaves each from ten clumps selected at random. Leaf breadth was also obtained in a similar fashion. The breadth of the leaf at the middle portion of the leaf blade was taken. Petiole length was measured from the pseudo-stem to the beginning of leaf blade. The plant height was measured between the plant base and the leaf tip of the top most leaf of the tallest pseudo-stem, using a measuring tape.

The number of tillers belonging to each clump was counted for ten clumps each, selected randomly from each plot. The girth of pseudo-stem was taken as the average value of the girth of individual ones in the selected clumps. The girth was measured using a Vernier caliper.

3.5. YIELD AND YIELD ATTRIBUTES OF CARDAMOM

Yield data for the organic and conventional cardamom farms selected for the study were collected from farm records during the survey. Yield attributes of cardamom plants namely, panicle length (cm), inter nodal length of panicle (mm), number of panicles per clump, number of racemes per panicle and number of capsules per raceme were recorded. Ten clumps were selected randomly from each plot for recording the observations. Mean values of all the tillers of all the clumps were used as primary data for analysis.

Panicle length was measured from the plant base to the panicle tip. Inter nodal length of panicle was measured between two successive racemes in a panicle. The total number of panicles per clump, and the number of racemes per panicle were also recorded. The total number of capsules in a single raceme was counted. Fifteen such racemes were randomly selected from an individual plant and the values are averaged.

Quality parameters of fresh cardamom capsules from the plant namely, capsule length (mm), capsule girth (mm) and number of seeds per capsule were observed for different tillers of the selected ten clumps and average values were recorded.

3.6. SAMPLE COLLECTION

3.6.1. **Soil Sample Collection**

Five soil samples were taken from each plot of one acre at random spacing. The five samples were mixed into a composite soil sample representing individual plots in the farm. Areas like water channels, plant basin and roads were avoided. Surface samples from 0-25cm depths were collected. About 1.5 kg soil sample each, after uniform mixing, was taken in a polythene bag and labeled for transportation to the laboratory. One core sample of the soil at about 15 cm depth was collected from each plot to study bulk density.

3.6.2. **Plant Sample Collection**

Fully matured healthy leaves were collected at random from cardamom plants representing soil sampling plots. Composite plant samples were prepared from each plot of selected organic and conventional cardamom farms. Diseased, plants growing on the border and isolated plants were avoided. Samples were packed in polythene bags and labeled for transportation to the laboratory.

3.6.3. **Cardamom Sample Collection**

Cured cardamom samples were collected from each farm under study. The collected samples were packed in polythene bags first and then with paper bags in order to preserve quality attributes until analysis.

3.7. SAMPLE PROCESSING

The soil samples were transported to the Centre for Land Resources Research and Management, College of Horticulture. Samples were then air dried and powdered gently. Weighed samples were sieved through a 2 mm sieve. Coarse fractions above 2mm were discarded after careful weighing in an analytical balance. Fine earth fractions were packed in plastic jars and arranged serially in sample racks for laboratory investigations.

Once in the laboratory, the cardamom leaves were spread on a table and were properly cleaned with 0.1 per cent detergent solution and with deionised water. The leaves were then air dried for two days and oven dried for four days at 60 ^{0}C in separate paper bags. The dried leaves were then powdered before chemical analysis.

3.8. LABORATORY INVESTIGATIONS

Laboratory investigations were conducted at the Centre for Land Resources Research and Management and at the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara, Thrissur.

3.8.1. Soil Physical Properties

Bulk density of the surface soil samples was estimated by core method (Culley, 1993).

3.8.2. Soil Chemical Properties

Soil fertility parameters covering various chemical constituents of the soil were analysed as per standard procedures. The pH of the soil was determined by 1:2.5 soil water suspension using combined electrode in a μ pH System 362 of Systronics (Jackson, 1973).

Organic C of the soil was determined by wet digestion method of Walkley and Black (Walkley and Black, 1934). Organic matter of the soil was determined by multiplying with 1.72.

Modified Micro-Kjeldahl procedure was used for the estimation of total soil N (Jackson, 1973). Available P in the soil samples was determined by extracting with Bray No.1 reagent and estimating colorimetrically by Vanadomolybdic-ascorbic acid blue colour method using Spectronic 20 spectrophotometer (Bray and Kurtz, 1945). Available K was extracted with neutral-normal ammonium acetate solution. Content of the element in the extract was determined by flame photometry using ELICO flame photometer (Jackson, 1973). Available Ca and Mg were determined from the above said ammonium acetate extract using versenate method (Jackson, 1973).

Cation exchange capacity of the soils was estimated by the method based on saturating the soil exchange complex with neutral normal ammonium acetate, and estimation of the adsorbed ammonia in the soil by distillation (Jackson, 1973).

3.8.3. Soil Biological Properties

Soil biological properties namely dehydrogenase activity and soil microbial count were taken using standardized procedures as mentioned below.

Dehydrogenase activity in the soil was estimated by the method suggested by Domsch *et al.* (1979). For determination of dehydrogenase activity, the samples were mixed with phosphate buffer containing 1 per cent triphenyl tetrazolium chloride (TTC) and incubated for 15 hours at room temperature. Then it was mixed with 90 per cent carbon tetrachloride and centrifuged at 3000 rpm for 10 minutes. The concentration of triphenyl formasan (TPF) produced by the reduction of TTC was estimated by measuring the intensity of the reddish colour at 530 nm in a spectrophotometer. With reference to the calibration graph prepared from TPF standards the activity of dehydrogenase was expressed as microgram (µg) of TPF formed per gram of soil per hour.

Soil fungi, bacteria and actenomycetes were enumerated through serial dilution plate techniques (Germida, 1993).

3.8.4. Leaf Nutrients

Standard procedures as referred below were employed to estimate nutrient contents in the cardamom leaves.

No.	*Element*	*Method*
1.	N	Modified Kjeldahl's digestion method (Jackson, 1973)
2.	P	Vanadomolybdo phosphoric yellow colour method in nitric acid system (Jackson, 1973)
3.	K	Flame photometry determination (Jackson, 1973)
4.	Ca and Mg	Versanate method (Jackson, 1973)
5.	Fe, Cu, Mn and Zn	Di-acid digestion of leaf sample followed by filteration. The filtrate was collected and analysed for Fe, Mn, Cu and Zn using Perkin Elmer Atomic Absorption Spectrophotometer. (Jackson, 1973)

3.8.5. **Cardamom Produce Quality**

Various physical and chemical quality parameters of cardamom capsules were analysed for comparison of the effect of organic and conventional farming practices.

3.8.5.1. *Physical Quality*

The cured cardamom capsules were filled in a one-litre container, and tapped by hand till the container is completely filled. A Berenger type weighing balance was used to measure the weight of cardamom samples contained in the vessel. The weight obtained was taken as the litre-weight of cardamom sample.

Counting the thrips-affected capsules in the bulk sample under investigation and converting the number into percentage of the total number of capsules resulted in calculation of the percentage thrips attack on the capsules. The capsules were visually compared for the green colour, which is an important quality for marketing cardamom capsules.

3.8.5.2. *Chemical Quality*

The chemical quality attributes of organic and conventional cardamom samples namely volatile oil and ethylene dichloride extractable oleoresin were analysed at the quality evaluation laboratory of Spices Board, Cochin. Oleoresin content was estimated by solvent extraction and cardamom oil was estimated by steam distillation of powdered fruits (ASTA, 1997).

3.9. DATA PROCESSING AND STATISTICAL ANALYSIS

Data generated through physical and chemical analyses of the samples were tabulated and organised for information generation. Statistical analysis namely F test and T test were performed to compare the effect of organic and conventional farming practices on the properties of soil, crop, and cardamom capsules.

RESULTS

4. RESULTS

The present study was aimed at a comparative analysis of the farming practices, soil properties, crop nutrient concentrations and quality of cardamom under organic and conventional farming in the high ranges of Kerala. The salient results of this study are presented below under appropriate headings.

4.1. DOCUMENTATION OF FARMING PRACTICES

Inferences on the farming practices are summarised below.

4.1.1. **Organic System of Cardamom Cultivation**

The organic cardamom growers of Peermede, certified under the IMO (Institute for Marketing Okology) group certification programme, are mainly subsistence farmers belonging to indigenous tribal community. The cultivation is purely based on the indigenous technical knowledge and traditional wisdom. These farmers have not adapted advisory services of the Department of Agriculture, Government of Kerala, or the package of practices for cardamom cultivation developed by the Spices Board of India (Table 2).

As the land is owned by the state Government, the occupants were not allowed to disturb the natural ecosystem of the rain forest. Further, cardamom being a shade loving plant, the farmers maintain a minimum of 50 per cent shade in the farm. Boundaries of the organic farms were protected by means of bio-fencing made out of locally available shrubs and trees that ensured the biodiversity. No heavy tillage practices were done, especially in the sloppy lands. On steep slopes, terracing or raw bunds were constructed.

The varieties mainly cultivated were locally available Vazhukka, Mysore and Malabar types, which are known for their potential to resist pests and diseases. Planting materials were mainly produced within the farm and were free from any potential source of chemical contamination. Any chance of using genetically modified planting materials was very remote. The cardamom plants in this tract were usually

Table 2. Adoption of the organic farming practices in the study area

Sl. No.	Organic farm codes	O-1	O-2	O-3	O-4	O-5	O-6	O-7	O-8	O-9	Total	Adoption in %
1.	Conversion period undergone	1	1	1	1	1	1	1	1	1	9	100
2.	Land and animals altered between O& C	0	0	0	0	0	0	0	0	0	9	0
3.	Forest ecosystem maintained	1	1	1	1	1	1	1	1	1	9	100
4.	Bio-fencing maintained	1	1	1	1	1	1	1	1	1	9	100
5.	Shade trees maintained	1	1	1	1	1	1	1	1	1	9	100
6.	Planting material organic in origin	1	1	1	1	1	1	1	1	1	9	100
7.	GMO used	0	0	0	0	0	0	0	0	0	0	0.0
8.	Plant residues incorporated in soil	1	1	1	1	1	1	1	1	1	9	100
9.	Manures free from human excreta	1	1	1	1	1	1	1	1	1	9	100
10.	Mineral materials used	0	1	0	1	1	1	1	1	0	6	66.67
11.	Minerals applied in natural form	0	1	0	1	1	1	1	1	0	6	66.67
12.	Chemical fertilizers applied	0	0	0	0	0	0	0	0	0	0	0.0
13.	Organic manures used	1	1	1	1	1	1	1	1	1	9	100
14.	Well rotten manures used	0	1	0	1	1	0	1	0	0	4	44.44
15.	Organic manures are farm made	1	1	1	1	1	1	1	1	1	9	100
16.	Organic manures obtained out of farm	1	0	0	1	1	0	1	1	0	5	55.55
17.	Mechanical /cultural pest control	1	1	1	1	1	1	1	1	1	9	100
18.	Biological pest control practiced	1	1	1	1	1	1	1	1	1	9	100
19.	Biological pesticides are farm made	1	1	1	1	1	1	1	1	1	9	100

(Continued……)

Table 2. Adoption of the organic farming practices in the study area (Continued…..)

Sl. No.	Organic farm codes	O-1	O-2	O-3	O-4	O-5	O-6	O-7	O-8	O-9	Total	Adoption in %
20.	Bio-pesticides from out of farm	1	1	1	0	1	1	0	1	1	7	77.77
21.	Chemical pesticides used	0	0	0	0	0	0	0	0	0	0	0.0
22.	Weedicides used	0	0	0	0	0	0	0	0	0	0	0.0
23.	Chemical fungicides used	0	0	0	0	0	0	0	0	0	0	0.0
24.	Chemicals used for washing cardamom capsules	0	0	0	0	0	0	0	0	0	0	0.0
25.	Plastic materials properly removed	1	1	1	1	1	1	1	1	1	9	100
26.	Plastic materials burned	0	0	0	0	0	0	0	0	0	0	0.0
27.	Primary forest protected	1	1	1	1	1	1	1	1	1	9	100
28.	Soil conservation measures taken	1	1	1	1	1	1	1	1	1	9	100
29.	Proper plant spacing maintained	1	1	1	1	1	1	1	1	1	9	100
30.	Farm animals maintained	1	1	1	1	1	1	1	1	1	9	100
31.	Free grazing allowed	0	0	0	0	0	0	0	0	0	0	0.0
32.	Organic cattle feed used	0	0	0	0	0	0	0	0	0	0	0.0
33.	Cattle feed from outside source	1	1	1	1	1	1	1	1	1	9	100
34.	Poultry component maintained	1	1	1	1	1	1	1	1	1	9	100
35.	Honey bees maintained	1	1	1	1	1	1	1	1	1	9	100
36.	Honey bees are naturally occurring	1	1	1	1	1	1	1	1	1	9	100
37.	Proper storage of cured cardamom produce	0	0	0	0	0	0	0	0	0	0	0

1 = Yes, 0 = No, O = Organic, C = Conventional, GMO = Genetically modified organism

propagated vegetatively, using a piece of rhizome with one healthy tiller as the planting material.

The fertilization strategy in the tract was not uniform. However, the main source of plant nutrients was the nutrient reserve in the soil and the recycled plant and crop residues. Plant residues were usually buried in the soil, which serve as good source of organic matter. The crop residues were also used to mulch the soil around the plants, which help to reduce water loss from the soil during summer and protect the soil from erosion during rains. All the farms under study incorporated organic manures in their fertilization programme, but only 44 per cent of them utilized well-decomposed organic manures. Occasionally cow dung was used to supplement the soil fertility but the rate of application was not uniform. No chemical synthetic fertilizers were used. But 67 per cent of the farmers apply mineral materials in the natural form, like powdered rock phosphate, muriate of potash, lime etc. Minerals were used either as fertilizer or as soil amendments. The applied cow dung was usually obtained from own farm or neighboring farms. Manures were observed to be absolutely free from human excreta.

No synthetic chemical pesticides were used in the organic farms of the study area. In the case of severe fungal attack one per cent Bordeaux mixture was often applied. The undisturbed natural ecosystem helped to promote the growth of natural enemies of the pests that helped the plants to survive from severe pest damage. Some farm-made biological pesticides like tobacco, and neem decoctions were used occasionally. Weed control was generally through slash weeding. This practice and mulching with plant residues often helped to reduce soil erosion.

The conversion period of three years for organic certification in the study area started in 1997 and the farms are now legally certified.

4.1.2. Conventional System of Cardamom Cultivation

The major differences in the conventional and organic farming practices of the study area were on fertilization policy, plant protection strategy, weed control and land management. Conventional farmers frequently used synthetic chemical inputs for plant protection, weed control and fertilization (Table 3).

Table 3. Adoption of conventional farming practices in the study area

SL. No.	Conventional Farm Codes	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	Total	Adoption in %
1.	Forest ecosystem maintained	1	1	1	1	1	1	1	1	8	100
2.	Shade trees maintained	1	1	1	1	1	1	1	1	8	100
3.	GMO used	0	0	0	0	0	0	0	0	0	0.0
4.	Plant residues incorporated in soil	1	1	1	1	1	1	1	1	8	100
5.	Manures free from human excreta	1	1	1	1	1	1	1	1	8	100
6.	Mineral materials used	1	1	1	1	1	1	1	1	8	100
7.	Minerals applied in natural form	0	0	0	0	0	0	0	0	0	0.0
8.	Chemical fertilizers applied	1	1	1	1	1	1	1	1	8	100
9.	Organic manures used	1	1	1	1	1	1	1	1	8	100
10.	Well rotten manures used	0	0	1	1	1	0	0	0	3	37.5
11.	Organic manures produced within farm	1	1	1	1	1	1	1	1	8	100
12.	Organic manures obtained out of farm	1	1	1	1	1	1	1	1	8	100
13.	Mechanical /cultural pest control	0	0	0	0	0	0	0	0	0	0.0
14.	Biological pest control practiced	0	0	1	0	0	0	0	0	1	12.5
15.	Biological pesticides farm made	0	0	0	0	0	0	0	0	0	0.0
16.	Bio-pesticides from out of farm	0	0	1	0	0	0	0	0	1	12.5

(Continued……)

Table 3. Adoption of conventional farming practices in the study area (Continued……)

SL. No.	Conventional Farm Codes	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	Total	Adoption in %
17.	Chemical pesticides used	1	1	1	1	1	1	1	1	8	100
18.	Weedicides used	1	1	1	1	1	0	1	1	7	87.5
19.	Chemical fungicides used	1	1	1	1	1	0	1	1	7	87.5
20.	Chemicals used for washing cardamom capsules	0	0	0	0	0	0	0	0	0	0.0
21.	Plastic materials properly removed	0	0	0	0	0	0	0	0	0	0.0
22.	Plastic materials burned	0	0	0	0	0	0	0	0	0	0.0
23.	Primary forest protected	1	1	1	1	1	1	1	1	8	100
24.	Soil conservation measures taken	1	1	1	1	1	1	1	1	8	100
25.	Tillage on slopes	1	1	1	1	1	1	1	1	8	100
26.	Proper plant spacing maintained	1	1	1	1	1	1	1	1	8	100
27.	Farm animals maintained	1	1	1	1	1	1	1	1	8	100
28.	Free grazing allowed	0	0	0	0	0	0	0	0	0	0.0
29.	Cattle feed from outside source	1	1	1	1	1	1	1	1	8	100
30.	Poultry component maintained	0	0	0	0	0	0	0	0	0	0.0
31.	Honey bees maintained	1	1	1	1	1	1	1	1	8	100
32.	Honey bees are naturally occurring	1	1	1	1	1	1	1	1	8	100
33.	Proper storage of cured cardamom produce	1	1	1	1	1	1	1	1	1	100

1 = Yes, 0 = No, O = Organic, C = Conventional, GMO = Genetically modified organism

The fertilization was mainly through synthetic chemical fertilizers, organic fertilizers, minerals and oil cakes obtained from commercial sources. Commonly used chemical fertilizers were Urea, Single Super Phosphate, Muriate of Potash, powdered rock phosphate, 20:20:0 complex fertilizers etc. The organic fertilizers in use included bone meal, neem cake, groundnut cake, cow dung slurry, and some commercially available organic fertilizers. The farmers frequently applied lime in the form of CaO for correcting soil acidity. The N: P: K ratio followed was according to the package of practice recommendations of Spices Board (50: 50:100). The chemical fertilizers were applied in two split dozes during the southwest and northeast monsoons. Oil cakes were applied at the rate of 0.5 to 1 kg per plant. Cow dung slurry was applied at the rate of 5 litres per plant. A minimum gap of 15 days was always observed between the application of lime and fertilizers. The organic manures were applied according to their availability and also depended on the economic status of the farmer. Only 38 percentage of the farmers used well-decomposed farmyard manure or compost. Lime (CaO) was usually applied at the rate of 100 to 250 grams per plant. The fertilization didn't follow a soil test. The fertilizers were generally applied in semi circles around the plants at the elevated position of slopes. Small channels were dug and the fertilizer was applied and the channels were then covered with soil.

Plant protection highly depended on chemical pesticides. Various insecticides like monocrotophos, quinalphos, endosulfan, carbofuran, phorate, prophenophos, triazophos etc., were used at a regular interval of 26 to 30 days. Liquid pesticides were applied as high volume foliar spray and also used for drenching the soil against root grubs. The common fungicides used include Bordeaux-mixture, copper oxy chloride, mercuric chloride etc.

Like the organic farms, the conventional farms also maintained a good forest ecosystem, but used to regulate the shade by pruning the tree branches.

4.2. SOIL PROPERTIES

Physical behavior, chemical properties, and biological characteristics of the soil were subjected to investigation in the present study.

4.2.1. Selected Physical and Electro-Chemical Properties of the Soil

Selected physical and electro-chemical properties of the soil namely pH, cation exchange capacity and bulk density were investigated under the current study. The data (Table 4) shows the values obtained for these parameters from 50 each of soil samples of organic and conventional farms.

4.2.1.1. *Bulk Density*

Bulk density of soils showed significant difference between organic and conventional farming systems. It ranged from 0.69 Mg m^{-3} to 1.62 Mg m^{-3} in the conventional farming system as against 0.57 Mg m^{-3} to 1.10 Mg m^{-3} in the organic farming system. The mean value of organic plots (0.74 Mg m^{-3}) was significantly different from that of the conventional plots (0.99 Mg m^{-3}). The two farming systems also showed difference in their sample variances. Organic farming system recorded a standard deviation (SD) of 0.13 whereas that of the conventional farming system was 0.19.

It is inferred that under the present study the bulk density was low for the soils of the organic farming plots than the soils of the conventional farming plots.

4.2.1.2. *pH*

It was observed that the pH of the soils of conventional plots was significantly lower than that of the organic farming plots, with means of 4.66 and 5.34 respectively of the conventional and organic plots. A pH range of 4.17 to 5.06 was recorded in the conventional farming system as against 4.84 to 5.79 in the organic farming system. The sample variances of the two farming systems for the aforesaid parameter showed no significant variation with standard deviations of 0.30 and 0.23 respectively of organic and conventional plots. It is thus inferred that the acidity of the conventional plots was higher than that of the organic plots.

Table 4. Selected physical and electro-chemical properties of the soils of study area under conventional and organic farming practices

No.	Bulk density (Mg m^{-3})		pH		Cation exchange capacity (cmols (+) kg soil^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	1.22	0.65	5.04	5.23	10.50	19.65
2.	0.93	0.69	4.93	5.25	12.15	19.45
3.	0.81	0.59	4.97	5.30	11.95	19.80
4.	1.12	0.81	5.05	5.56	11.80	20.10
5.	1.00	0.76	5.06	5.61	11.35	20.75
6.	1.20	0.91	4.93	5.58	12.15	20.85
7.	1.00	0.87	4.82	5.75	13.15	20.85
8.	1.27	0.61	4.84	5.55	14.70	21.00
9.	1.24	1.10	4.82	5.64	14.05	19.15
10.	0.95	1.01	4.77	5.74	13.60	20.65
11.	0.82	0.98	4.79	5.73	14.85	19.90
12.	1.10	0.78	4.84	5.51	14.15	19.90
13.	1.11	0.95	4.76	5.48	13.40	20.25
14.	1.17	0.87	4.60	5.42	14.10	20.50
15.	1.62	0.69	4.74	5.48	13.80	19.00
16.	0.91	0.77	4.79	4.99	14.10	18.60
17.	1.05	0.69	4.73	4.84	13.20	17.60
18.	1.27	0.81	4.67	4.96	12.85	18.50
19.	0.87	0.71	4.77	4.85	16.50	18.10
20.	0.95	0.68	4.89	5.07	15.20	17.70
21.	0.79	1.00	4.76	4.93	17.35	18.70
22.	0.85	0.89	4.78	4.89	15.85	17.10
23.	1.10	0.75	4.72	5.09	16.15	18.25
24.	1.00	0.59	4.70	5.06	15.60	17.15
25.	0.91	0.61	4.38	4.94	19.85	17.85
26.	0.79	0.71	4.39	4.99	19.50	17.35
27.	1.10	0.68	4.17	5.00	20.35	18.00
28.	0.87	0.71	4.22	5.06	19.15	18.15
29.	0.86	0.75	4.26	5.40	19.55	20.00
30.	1.09	0.68	4.38	5.46	20.00	20.15

(Continued.....)

Table 4. Selected physical and electro-chemical properties of the soils of study area under conventional and organic farming practices (Continued...)

No.	Bulk density (Mg m^{-3})		pH		Cation exchange capacity (cmols (+) kg $soil^{-1}$)	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
31.	0.81	0.59	4.66	5.49	20.90	20.80
32.	0.69	0.72	4.55	5.51	21.05	20.40
33.	0.79	0.70	4.60	5.46	20.60	20.45
34.	1.00	0.69	4.43	5.47	21.45	20.30
35.	0.81	0.73	4.42	5.54	20.35	20.90
36.	0.87	0.68	4.78	5.73	20.65	20.00
37.	0.76	0.61	4.40	5.73	16.95	20.90
38.	0.84	0.58	4.38	5.71	16.50	20.80
39.	0.98	0.61	4.36	5.66	17.25	20.20
40.	1.10	0.59	4.37	5.79	17.90	20.70
41.	0.85	0.71	4.40	5.68	17.60	20.65
42.	0.69	0.67	4.33	5.74	17.05	20.40
43.	0.73	0.63	4.49	5.08	16.85	14.50
44.	1.12	0.58	4.81	5.00	19.80	15.40
45.	1.25	0.61	4.82	5.09	20.05	14.35
46.	0.99	0.57	4.70	4.92	19.30	15.15
47.	1.11	0.69	4.72	5.05	20.95	14.65
48.	1.02	0.98	4.65	5.39	19.55	17.70
49.	1.08	0.79	4.72	5.40	20.65	17.00
50.	1.21	0.86	4.82	5.31	19.15	18.05
Mean	0.99	0.74	4.66	5.34	16.71	18.97
SD	0.19	0.13	0.23	0.3	3.20	1.86
F	*		NS		*	
T	*		*		*	

* = Significant, NS = Not significant, SD = Standard deviation

4.2.1.3. *Cation Exchange Capacity*

Cation exchange capacity (CEC) under the present study showed a significant difference between the organic and conventional farming systems. The CEC recorded a high value of 21.45 cmols (+) kg $soil^{-1}$ and a low value of 10.50 cmols (+) kg $soil^{-1}$

in the conventional farming system. Whereas in the organic farming plots the values ranged from 21.00 cmols (+) kg soil^{-1} to 14.35 cmols (+) kg soil^{-1}. The mean values of 50 each of organic and conventional farming plots were 18.97 cmols (+) kg soil^{-1} and 16.71) cmols (+) kg soil^{-1} respectively. The variances also showed significant difference, with organic plots recorded a SD of 1.86 and conventional plots registered a SD of 3.20 each. Thus, the cation exchange capacity of the organic system was remarkably higher than that of the conventional farming system.

4.2.2. Selected Soil Organic Parameters

Soil organic parameters namely organic C status, organic matter content and enzymatic activity (activity of soil dehydrogenase enzyme) were investigated under the current study. The table 5 shows the values for the aforesaid parameters for 50 samples each of the organic and conventional farming systems. Among the soil organic parameters, organic C and organic matter were highly interdependent to each other.

4.2.2.1. ***Organic Carbon***

The organic carbon content of the soil is a good indicator of soil quality in different farming systems. In the current investigation the organic carbon content was found non significant between the organic and conventional farming plots. The mean values of 50 organic and conventional plots were 2.65 per cent and 2.77 per cent respectively. The samples didn't exhibit any significant difference in their variances also. The SD values of organic and conventional plots were 0.5 and 0.38 respectively. The organic C content in the soil ranged from 1.81 per cent to 3.53 per cent in the conventional farming system as against 1.63 per cent to 3.53 per cent in the organic farming system.

4.2.2.2. ***Organic Matter***

The organic matter content of the soils varies widely with the management practices and the fertilization strategies. The present study showed that the organic matter content of the organic (mean = 4.56 per cent) and conventional (mean = 4.76 per cent) farming systems were on par. The values of soil organic matter ranged form

Table 5. Selected soil organic parameters in the study area under conventional and organic farming practices

Sl.No.	Organic C (%)		Organic matter (%)		Dehydrogenase (μg of TPF $g^{-1}h^{-1}$)	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	1.81	1.78	3.12	3.07	167.29	199.25
2.	2.05	1.69	3.52	2.91	127.82	167.29
3.	1.84	1.84	3.17	3.17	146.62	191.73
4.	1.96	2.85	3.37	4.90	167.29	225.56
5.	2.08	2.82	3.58	4.85	156.02	148.50
6.	2.08	2.91	3.58	5.01	152.26	193.61
7.	2.73	3.45	4.70	5.93	302.63	176.69
8.	2.76	2.94	4.75	5.06	357.14	167.29
9.	3.00	3.03	5.16	5.21	364.66	156.02
10.	2.82	2.94	4.85	5.06	374.06	152.26
11.	2.85	3.06	4.90	5.26	323.31	187.97
12.	2.82	3.00	4.85	5.16	362.78	216.17
13.	2.58	2.70	4.44	4.65	234.96	165.41
14.	2.41	2.91	4.14	5.01	216.17	180.45
15.	2.67	1.99	4.60	3.42	225.56	172.93
16.	2.73	3.18	4.70	5.47	227.44	308.27
17.	2.79	2.14	4.80	3.68	229.32	159.77
18.	2.64	2.82	4.55	4.85	219.92	263.16
19.	2.64	3.24	4.55	5.57	212.41	193.61
20.	2.47	2.94	4.24	5.06	154.14	266.92
21.	2.55	2.23	4.39	3.83	150.38	274.44
22.	2.38	2.61	4.09	4.50	182.33	338.35
23.	2.47	2.14	4.24	3.68	167.29	293.23
24.	2.67	2.38	4.60	4.09	206.77	304.51
25.	2.94	2.64	5.06	4.55	372.18	293.23
26.	2.94	2.49	5.06	4.29	293.23	274.44
27.	2.94	2.73	5.06	4.70	293.23	317.67
28.	3.15	2.79	5.41	4.80	308.27	287.59

(Continued........)

Table 5. Selected soil organic parameters in the study area under conventional and organic farming practices (Continued……)

Sl.No.	Organic C (%)		Organic matter (%)		Dehydrogenase (µg of TPF $g^{-1}h^{-1}$)	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
29.	3.00	3.03	5.16	5.21	328.95	233.08
30.	2.82	2.44	4.85	4.19	362.78	199.25
31.	3.15	3.03	5.41	5.21	266.92	187.97
32.	3.50	3.06	6.03	5.26	229.32	212.41
33.	3.18	3.09	5.47	5.31	244.36	193.61
34.	3.09	3.12	5.31	5.36	242.48	191.73
35.	3.03	2.94	5.21	5.06	242.48	203.01
36.	2.97	3.09	5.11	5.31	257.52	201.13
37.	2.79	2.85	4.80	4.90	255.64	161.65
38.	2.85	2.79	4.90	4.80	201.13	193.61
39.	3.09	3.53	5.31	6.08	218.05	176.69
40.	3.03	3.18	5.21	5.47	234.96	246.62
41.	2.91	2.97	5.01	5.11	229.32	267.29
42.	2.94	3.21	5.06	5.52	242.48	356.02
43.	3.18	1.93	5.47	3.32	223.68	337.22
44.	2.97	1.69	5.11	2.91	298.87	382.71
45.	2.85	1.63	4.90	2.81	244.36	324.06
46.	2.73	1.99	4.70	3.42	289.47	378.95
47.	2.94	1.87	5.06	3.22	246.24	395.86
48.	2.97	2.44	5.11	4.19	274.44	393.61
49.	3.18	2.38	5.47	4.09	268.80	366.92
50.	3.53	2.14	6.08	3.68	266.92	456.77
Mean	2.77	2.65	4.76	4.56	247.29	246.73
SD	0.38	0.50	0.66	0.86	65.13	79.49
F	NS		NS		NS	
T	NS		NS		NS	

* = Significant, NS = Not significant, SD = Standard deviation

3.12 per cent to 6.08 per cent in the conventional farming system and 2.81 per cent to 6.08 per cent in the organic farming system. Though the variance of the samples of the organic plots (SD = 0.86) was higher than that of the conventional farming plots (SD = 0.66), there was no significant difference found between the two farming systems.

4.2.2.3. *Enzyme Activity*

Soil dehydrogenase is an enzyme, which brings about oxidation reactions in organic and inorganic soil constituents. This enzyme is released by soil microbes and thus regarded as an indicator of soil microbial activity.

In the present investigation, the soil dehydrogenase activity was estimated for the two different farming systems namely organic farming system and conventional farming system. It was found that there was no marked difference in the enzymatic activity of the soils of organic and conventional farming systems. Soil dehydrogenase activity recorded a high value of 374.06 μg of TPF g^{-1} h^{-1} and a low value of 127.82 μg of TPF g^{-1} h^{-1} in the conventional farming system. Whereas in the organic farming plots the values ranged from 456.77 μg of TPF g^{-1} h^{-1} to 148.5 μg of TPF g^{-1} h^{-1}. The mean values of organic and conventional farming systems were 246.73 μg of TPF g^{-1} h^{-1} and 247.29 μg of TPF g^{-1} h^{-1} respectively. Another observation was that the sample variances showed no significant difference between the samples of organic and conventional farming systems, with the organic system recorded a high SD value of 79.49 against 65.13 of the conventional system.

As a whole it is inferred from the results that, there occurred no significant difference between organic and conventional farming systems with respect to the above said three soil organic parameters.

4.2.3. **Soil Microbial Population**

The current study aimed at enumerating the principal fractions of the soil microbial populations namely bacteria, fungi and actinomycetes. The data (Table 6) present the values of microbial count obtained for representative soil samples from nine organic and eight conventional farming plots.

4.2.3.1. *Bacterial Count*

Soil bacterial count as enumerated through serial dilution plate technique was observed to be non-significant between the soils of organic and the conventional farming systems. A data range of 1 700 000 CFU g^{-1} to 4 350 000 CFU g^{-1} was recorded in the conventional farming system as against 1 750 000 CFU g^{-1} to 6 050 000 CFU g^{-1} in the organic farming system. The mean values were 3 655 555.36 CFU g^{-1} and 2 862 500 CFU g^{-1} respectively of the organic and the conventional farming systems. The soil samples of the two different farming systems showed no significant difference in their variances. The SDs of organic and conventional samples were 1 364 836.17 and 763 333.85 respectively.

4.2.3.2. *Fungal Count*

In the same method soil fungal population was also estimated. It was found that the organic and conventional farming systems were on par in this respect also. Even-though the mean value was higher in the organic farming system (51 555.56 CFU g^{-1}) than the conventional farming system (49 062.5 CFU g^{-1}), the difference was found to be non significant in the statistical analysis.

Soil fungal population ranged from 42 000 CFU g^{-1} to 59 500 CFU g^{-1} in the conventional farming system as against 40 500 CFU g^{-1} to 60 000 CFU g^{-1} in the organic farming system. The sample variances also showed no significant difference between the two farming systems. Organic samples have a SD of 7464.27 and the conventional samples have a SD of 5936.80 each.

Table 6. Soil microbial population in the study area under conventional and organic farming practices

Sl. No.	Bacteria (CFU g^{-1})		Fungus (CFU g^{-1})		Actinomycetes (CFU g^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	2 800 000	3 000 000	51 000	58 500	200 000	280 000
2.	1 700 000	1 750 000	59 500	60 000	250 000	170 000
3.	2 900 000	4 800 000	45 000	55 000	210 000	175 000
4.	2 550 000	2 800 000	42 000	40 500	265 000	215 000
5.	4 350 000	6 050 000	43 500	41 000	165 000	255 000
6.	3 200 000	4 550 000	53 000	57 500	235 000	260 000
7.	3 050 000	3 200 000	46 000	46 500	205 000	350 000
8.	2 350 000	2 400 000	52 500	49 500	180 000	160 000
9.	-	4 350 000	-	55 500	-	195 000
Mean	2 862 500	3 655 555	49 062	51 555	213 750	228 888
SD	763 333.85	1 364 836	5936.80	7464.27	34 200.04	62 638.73
F	NS		NS		NS	
T	NS		NS		NS	

* = Significant, NS = Not significant, SD = Standard deviation

4.2.3.3. *Actinomycetes*

The data show that the actinomycetes count in the two farming systems namely organic and conventional farming systems were not significantly different. Albeit, the organic system recorded a high mean value of 228 888.89 CFU g^{-1} as against 213 750 CFU g^{-1} of the conventional system, the statistical analysis showed no significant difference between the two systems. The sample variances were also compared and found that no significant difference existed between the two farming systems. The values of actinomycetes count in the soil ranged form 165 000 CFU g^{-1} to 265 000 CFU g^{-1} in the conventional farming system and 160 000 CFU g^{-1} to 350 000 CFU g^{-1} in the organic farming system.

It is thus inferred that the two farming systems had no difference with respect to the soil microbial populations, at least on a short-term basis.

4.2.4. Major Plant Nutrients in Soil

Major plant nutrient elements in the soil namely total N, available P, exchangeable K, exchangeable Ca and exchangeable Mg were analysed in each of the 50 organic and conventional farming plots, and were subjected to statistical comparison. The results obtained are presented in table 7.

4.2.4.1. *Total Nitrogen*

The total N content of the organic and conventional farming systems in the current investigation showed a significant difference, with the N content high in the conventional farming system (mean of 50 samples = 7916.16 kg ha^{-1}) than the organic farming system (mean of 50 samples = 7338.24 kg ha^{-1}). The values of total N ranged form 5376 kg ha^{-1} to 10 080 kg ha^{-1} in the conventional farming system and 4704 kg ha^{-1} to 10 080 kg ha^{-1} in the organic farming system. The sample variances showed a higher value for the samples of organic plots (SD=1228.2) than that of the conventional farming plots (SD=1054.17). But the difference in variances was not found significant.

So it is inferred that under the present study, total soil N content was superior in the conventional farming system than in its organic counterpart.

4.2.4.2. *Available Phosphorus*

The P fraction determined in the Bray No-1 extract represents the availability of that element to plants for easy uptake and utilization. In the current investigation the available P status of the soils of organic and conventional plots showed a marked variation between the farming systems. The available P content in the soil ranged from 1.58 kg ha^{-1} to 25.55 kg ha^{-1} in the conventional farming system as against 5.60 kg ha^{-1} to 66.50 kg ha^{-1} in the organic farming system.

Table 7. Major plant nutrients in the soils of the study area under conventional and organic farming practices

Sl.No.	Total N (kg ha^{-1})		Available P (kg ha^{-1})		Exchangeable K (kg ha^{-1})		Exchangeable Ca (kg ha^{-1})		Exchangeable Mg (kg ha^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	6720.00	5376.00	6.65	5.60	60.48	69.44	1155.84	1290.24	596.74	32.26
2.	7392.00	5376.00	11.90	9.45	64.96	82.88	1155.84	1612.80	129.02	1757.95
3.	8736.00	5376.00	7.70	7.00	47.04	78.40	860.16	1128.96	483.84	274.18
4.	8064.00	8064.00	10.33	32.38	49.28	98.56	1021.44	4032.00	532.22	193.54
5.	6048.00	10 080.00	5.78	33.43	64.96	100.80	1075.20	4892.16	451.58	193.54
6.	7392.00	8064.00	7.53	30.80	56.00	103.04	1021.44	4112.64	435.46	193.54
7.	6720.00	8064.00	16.63	30.80	80.64	100.80	725.76	4085.76	48.38	177.41
8.	8064.00	4704.00	16.80	32.55	80.64	96.32	860.16	4112.64	112.90	274.18
9.	9408.00	9408.00	14.00	33.60	69.44	94.08	645.12	4166.40	80.64	306.43
10.	8736.00	7392.00	16.98	33.08	71.68	105.28	779.52	4112.64	64.51	177.41
11.	6720.00	8736.00	15.58	32.73	71.68	103.04	806.40	4058.88	48.38	225.79
12.	6048.00	7392.00	15.05	10.33	76.16	78.40	698.88	3037.44	96.77	64.51
13.	6048.00	6720.00	6.30	13.13	47.04	87.36	806.40	2580.48	16.13	290.30
14.	7392.00	6720.00	10.68	11.20	53.76	71.68	725.76	2150.40	145.15	1048.32
15.	6048.00	7392.00	5.25	11.03	29.12	91.84	456.96	2472.96	322.56	370.94
16.	8736.00	8736.00	10.50	31.33	58.24	62.72	752.64	2284.80	96.77	2032.13

(Continued…….)

Table 7. Major plant nutrients in the soils of the study area under conventional and organic farming practices (Continued…….)

Sl.No.	Total N (kg ha^{-1})		Available P (kg ha^{-1})		Exchangeable K (kg ha^{-1})		Exchangeable Ca (kg ha^{-1})		Exchangeable Mg (kg ha^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
17.	5376.00	8064.00	5.08	24.68	47.04	71.68	779.52	1989.12	64.51	290.30
18.	6720.00	7392.00	9.10	28.88	44.80	53.76	806.40	1881.60	80.64	741.89
19.	6720.00	7392.00	1.58	23.63	62.72	51.52	1021.44	1935.36	0.00	435.46
20.	6720.00	8736.00	3.50	30.45	67.20	64.96	1317.12	1962.24	96.77	596.74
21.	10 080.00	7392.00	6.65	28.70	60.48	58.24	1075.20	1989.12	80.64	564.48
22.	8064.00	8064.00	2.63	19.60	64.96	82.88	1155.84	1505.28	80.64	322.56
23.	8736.00	8736.00	1.93	17.33	58.24	78.40	1236.48	2284.80	145.15	306.43
24.	8736.00	9408.00	4.03	20.30	58.24	98.56	1236.48	1128.96	129.02	1177.34
25.	8736.00	7392.00	3.50	22.40	67.20	96.32	806.40	1370.88	16.13	1016.06
26.	7392.00	7392.00	8.05	15.93	71.68	89.60	1263.36	1397.76	80.64	903.17
27.	8736.00	8064.00	5.95	18.38	73.92	103.04	564.48	1317.12	112.90	1048.32
28.	8736.00	7392.00	4.20	25.03	76.16	91.84	887.04	1128.96	16.13	1080.58
29.	8064.00	7392.00	3.85	17.15	69.44	82.88	672.00	1639.68	80.64	322.56
30.	7392.00	6720.00	4.73	14.18	80.64	98.56	618.24	2042.88	96.77	80.64
31.	8064.00	7392.00	2.28	14.18	91.84	105.28	1075.20	2284.80	80.64	387.07
32.	8064.00	7392.00	2.63	14.18	96.32	87.36	1102.08	2069.76	193.54	129.02
33.	8736.00	8736.00	3.50	13.65	94.08	98.56	913.92	2096.64	64.51	80.64
34.	6720.00	8064.00	3.85	15.75	94.08	87.36	1102.08	2150.40	112.90	48.38
35.	8064.00	8736.00	2.10	15.23	87.36	94.08	994.56	2123.52	145.15	48.38

(Continued…….)

Table 7. Major plant nutrients in the soils of the study area under conventional and organic farming practices (Continued…….)

Sl.No.	Total N (kg ha^{-1})		Available P (kg ha^{-1})		Exchangeable K (kg ha^{-1})		Exchangeable Ca (kg ha^{-1})		Exchangeable Mg (kg ha^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
36.	9408.00	8064.00	4.20	23.63	91.84	96.32	1021.44	4542.72	145.15	96.77
37.	8064.00	8064.00	25.38	38.15	91.84	91.84	698.88	4354.56	80.64	225.79
38.	8736.00	8064.00	21.88	32.73	85.12	94.08	618.24	3494.40	161.28	370.94
39.	8736.00	6720.00	24.50	25.38	80.64	89.60	725.76	4300.80	209.66	258.05
40.	7392.00	7392.00	24.85	45.33	80.64	91.84	698.88	4381.44	161.28	209.66
41.	8736.00	7392.00	25.55	37.98	87.36	96.32	698.88	4515.84	145.15	145.15
42.	8064.00	6720.00	22.58	43.05	89.60	87.36	645.12	4408.32	225.79	177.41
43.	8064.00	4704.00	23.80	11.38	82.88	78.40	645.12	1263.36	145.15	145.15
44.	8736.00	6048.00	3.50	13.83	87.36	73.92	376.32	1317.12	80.64	96.77
45.	8736.00	6048.00	3.50	12.43	80.64	71.68	322.56	1935.36	112.90	193.54
46.	8064.00	5376.00	4.38	12.78	60.48	76.16	645.12	1236.48	48.38	177.41
47.	8064.00	5376.00	7.00	13.83	67.20	76.16	376.32	1344.00	129.02	145.15
48.	8736.00	6720.00	18.03	54.43	60.48	85.12	349.44	2338.56	177.41	48.38
49.	8736.00	6720.00	16.45	66.50	69.44	89.60	430.08	3198.72	129.02	145.15
50.	9408.00	6048.00	4.73	53.03	85.12	94.08	403.20	2822.40	161.28	80.64
Mean	7916.16	7338.24	9.74	24.45	70.96	86.24	816.61	2597.68	149.02	394.17
SD	1054.17	1228.20	7.43	13.13	15.41	13.57	263.31	1190.11	132.70	434.38
F	NS		*		NS		*		*	
T	*		*		*		*		*	

* = Significant, NS = Not significant, SD = Standard deviation

The organic farming plots showed a significantly higher content of available P compared to the conventional farming plots with a mean value of 50 samples of the organic farming system as 24.45 kg ha^{-1}, as against 9.74 kg ha^{-1} in the conventional farming system. It was also observed that the variances of the samples of the organic and conventional farming systems showed a significant difference. The organic farming system showed a higher value of SD as 13.13 as against a SD value of 7.43 in the conventional farming system.

It is thus concluded that under the conditions of the present study the organic farming system was superior to that of the conventional farming system with respect to available soil P.

4.2.4.3. *Exchangeable Potassium*

The values of exchangeable K ranged form 29.12 kg ha^{-1} to 96.32 kg ha^{-1} in the conventional farming system and 51.52 kg ha^{-1} to 105.28 kg ha^{-1} in the organic farming system. The t-test showed a significant difference between the farming systems in exchangeable K content of the soil. Organic plots showed a higher mean value of 86.24 kg ha^{-1} than the conventional farming plots (mean = 70.96 kg ha^{-1}) for the 50 soil samples each taken from both organic and conventional farming plots. No significant difference was observed for the sample variances of the two different farming systems even though the numerical value of the same was more for the conventional plots (SD of organic samples was 13.57 and SD of conventional samples was 15.41).

It is thus concluded that the organic farming system was better than the conventional farming system with respect to soil exchangeable K content under the present investigation.

4.2.4.4. *Exchangeable Ca and Mg*

Exchangeable Ca and Mg content in the soil is a parameter which is quite often investigated in comparative analysis of different farming systems. In the current study the following findings were recorded for the above parameters.

Both exchangeable Ca and exchangeable Mg contents were found significantly higher in the organic farming plots compared to their conventional counterparts. A data range of 322.56 kg ha^{-1} to 1317.12 kg ha^{-1} was recorded in the conventional farming system as against 1128.96 kg ha^{-1} to 4892.16 kg ha^{-1} in the organic farming system for exchangeable Ca. Exchangeable Mg recorded a high value of 596.74 kg ha^{-1} and a low value of 0.00 kg ha^{-1} in the conventional farming system. Whereas in the organic farming system, the values ranged from 2032.13 kg ha^{-1} to 32.26 kg ha^{-1}. The mean values of Ca and Mg of 50 organic plots were 2597.68 kg ha^{-1} and 394.17 kg ha^{-1} respectively and that of conventional plots were 816.61 kg ha^{-1} and 149.02 kg ha^{-1} respectively. The sample variances of the two farming systems also showed a significant difference for both exchangeable Ca and exchangeable Mg content. Organic farming plots showed higher values of SD (1190.11 and 434.38 respectively for Ca and Mg) than the conventional system (263.31 and 132.70 respectively for Ca and Mg).

It is inferred that the organic farming system is superior to conventional farming system for exchangeable Ca and Mg under the ambiance of the current study.

4.3. CROP HEALTH PARAMETERS

Various plant health parameters like plant nutrient concentrations, plant morphological observations and crop yield were estimated under the present investigation.

4.3.1. **Plant Nutrient Concentrations**

Plant nutrient concentrations including major elements, minor elements and micronutrients were analysed. The results obtained are as follows.

4.3.1.1. ***Major Nutrient Concentrations in Cardamom Leaves***

Major Plant nutrients like N, P and K were subjected to investigation under the current study. The results obtained are presented in the table 8.

4.3.1.1.1. Nitrogen

It was found that the N content of leaf tissues in organic farming plots differed significantly from that of the conventional farming plots. A data range of 2.25 per cent to 5.7 per cent was recorded in the conventional farming system as against 2.25 per cent to 4.5 per cent in the organic farming system. The mean values of 50 plant samples each from organic and conventional plots were 3.22 per cent and 3.67 per cent respectively. Another observation was that the two farming systems didn't show any significant difference in their variances, with organic farms having a SD of 0.57 and the conventional plots have a SD of 0.75 respectively.

So it is inferred that the leaf N content was low in organic farming plots compared to their conventional counterparts.

4.3.1.1.2. Phosphorus

The leaf P concentration ranged from 225 $\mu g\ g^{-1}$ to 1406.25 $\mu g\ g^{-1}$ in the conventional farming system as against 562.5 $\mu g\ g^{-1}$ to 1500 $\mu g\ g^{-1}$ in the organic farming system. The plant P concentration of the organic farming system was significantly higher than that of the conventional farming system with respective mean values for 50 samples got as 1041.75 $\mu g\ g^{-1}$ and 753.5 $\mu g\ g^{-1}$. The sample variances showed no significant difference for the organic (SD = 231.5) and conventional (SD = 220.05) farming systems.

It is thus concluded that the leaf P concentration was significantly higher in the organic farming system compared to the conventional farming system.

Table 8. Major nutrient concentrations in cardamom leaves under conventional and organic farming practices

Sl. No.	N (%)		P ($\mu g\ g^{-1}$)		K ($\mu g\ g^{-1}$)	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	3.45	3.30	743.75	1162.50	3520.00	3440.00
2.	3.90	3.75	1093.75	956.25	4080.00	3920.00
3.	2.25	2.70	825.00	912.50	3600.00	3840.00
4.	3.60	2.55	781.25	575.00	3520.00	4240.00
5.	3.75	2.40	793.75	1237.50	3600.00	4080.00
6.	3.60	3.45	756.25	762.50	3680.00	3760.00
7.	3.75	2.40	1050.00	581.25	4320.00	4160.00
8.	3.30	2.55	743.75	662.50	4000.00	4240.00
9.	5.70	2.85	1018.75	681.25	4240.00	4080.00
10.	3.75	2.70	1012.50	562.50	4320.00	4160.00
11.	3.60	2.40	918.75	650.00	4240.00	4240.00
12.	3.45	3.75	881.25	1075.00	4240.00	4560.00
13.	3.30	3.30	768.75	868.75	3920.00	4320.00
14.	3.00	4.50	968.75	1268.75	4240.00	4400.00
15.	3.00	3.60	600.00	1018.75	4000.00	4400.00
16.	3.30	2.70	818.75	937.50	4000.00	4400.00
17.	3.15	2.40	962.50	968.75	3920.00	4160.00
18.	3.15	2.40	862.50	862.50	4000.00	4320.00
19.	3.00	2.55	881.25	881.25	4720.00	4400.00
20.	3.00	2.70	518.75	1025.00	4240.00	4320.00
21.	2.85	2.40	825.00	931.25	4160.00	4240.00
22.	3.00	3.00	862.50	1056.25	4320.00	3840.00
23.	3.00	3.15	806.25	725.00	4240.00	4160.00
24.	2.85	3.60	800.00	1206.25	4240.00	4560.00
25.	3.60	3.00	687.50	1106.25	4160.00	3840.00
26.	4.05	3.30	943.75	1068.75	3920.00	4000.00
27.	4.20	3.30	856.25	981.25	4480.00	3840.00
28.	4.05	3.15	818.75	993.75	4000.00	4000.00

(Continued.......)

Table 8. Major nutrient concentrations in cardamom leaves under conventional and organic farming practices (Continued…….)

Sl. No.	N (%)		P (µg g^{-1})		K (µg g^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
29.	3.90	3.60	806.25	1200.00	3920.00	4160.00
30.	4.20	3.00	893.75	1181.25	4080.00	4640.00
31.	3.15	3.45	700.00	868.75	3840.00	4400.00
32.	3.00	3.45	225.00	1087.50	3280.00	4560.00
33.	3.60	3.30	787.50	1118.75	4400.00	4640.00
34.	3.15	3.60	762.50	1156.25	4240.00	4480.00
35.	3.45	3.30	775.00	1150.00	4080.00	4400.00
36.	3.30	3.90	750.00	1325.00	4000.00	3920.00
37.	5.40	3.75	650.00	1150.00	4320.00	4320.00
38.	4.80	4.35	781.25	1168.75	4720.00	4400.00
39.	4.80	3.75	400.00	1193.75	4080.00	4320.00
40.	4.95	4.05	656.25	1250.00	4400.00	4320.00
41.	5.10	4.05	700.00	1162.50	4320.00	4240.00
42.	5.40	3.90	706.25	1281.25	4400.00	4400.00
43.	4.95	3.15	762.50	931.25	4240.00	3840.00
44.	3.60	3.00	1406.25	1243.75	6800.00	4560.00
45.	3.00	2.25	406.25	1500.00	4160.00	4640.00
46.	3.45	3.15	350.00	1437.50	4080.00	4480.00
47.	3.60	3.00	387.50	1462.50	4160.00	4400.00
48.	3.45	3.45	343.75	1325.00	4000.00	4240.00
49.	3.45	4.20	425.00	943.75	4160.00	4400.00
50.	3.45	3.45	400.00	1231.25	4080.00	4400.00
Mean	3.67	3.22	753.50	1041.75	4153.60	4241.60
SD	0.75	0.57	220.05	231.50	475.03	263.35
F	NS		NS		*	
T	*		*		NS	

* = Significant, NS = Not significant, SD = Standard deviation

4.3.1.1.3. Potassium

The concentration of K in the leaf tissues of both organic and conventional farming systems were investigated in the current study. The K content of the leaf tissues recorded a high value of 6800 μg g^{-1} and a low value of 3280 μg g^{-1} in the conventional farming system. Whereas in the organic farming plots, the values ranged from 4640 μg g^{-1} to 3440 μg g^{-1}. It was observed that the leaf K content of the two farming systems didn't differ significantly. The mean values of organic and conventional farming systems were recorded as 4241.6 μg g^{-1} and 4153.6 μg g^{-1} respectively. A significant difference was found between the two farming systems with respect to their sample variances, with organic farms registered a SD of 263.35 and that of the conventional farms recorded a value of 475.03 each.

So it is accounted that under the present investigation the leaf K content didn't show any difference between organic and conventional farming systems.

4.3.1.2. ***Secondary and Micro-Nutrient Concentrations in Cardamom Leaves***

The secondary nutrients investigated under the present study included Ca and Mg. The micronutrients namely Fe, Cu, Mn and Zn were also estimated in the cardamom leaves (Table 9).

4.3.1.2.1. Calcium

It was observed that the Ca content was significantly higher in the samples of the organic plots with a mean value of 0.67 per cent, whereas that of the conventional plots was 0.52 per cent. The variances also showed a significant difference between the samples of the two farming systems with organic farms having a SD of 0.22 and the conventional farms having a SD value of 0.32 each. The Ca content ranged from 0.24 per cent to 2.2 per cent in the conventional farming system as against 0.18 per cent to 1.26 per cent in the organic farming system.

It is inferred from the current research that the organic plots represented higher leaf Ca concentration compared to the conventional plots.

4.3.1.2.2. Magnesium

The Mg content in the leaf tissues of organic farms was significantly higher than that of the conventional farms. It ranged from 0.19 per cent to 0.55 per cent in the conventional farming system as against 0.28 per cent to 0.62 per cent in the organic farming system. The mean values of 50 samples each from organic (0.44 per cent) and conventional (0.37 per cent) were taken for comparison. The variances of the samples of the two farming systems were found to be equal (SD=0.08).

The inference is that the leaf Mg content of the organic farms was higher than that of the conventional farms under the conditions of the present study.

4.3.1.2.3. Micronutrients

Among the four micronutrients analysed (Fe, Mn, Cu and Zn) in the leaf tissues of the two farming systems under the present study, only Fe and Mn were found in appreciable quantity. Cu and Zn concentrations were in negligible ranges and therefore not considered for comparison.

4.3.1.2.3.1. *Iron*

The Fe content of leaf tissues in the two farming systems was significantly different. It was noted that the leaf content of Fe was significantly high in the conventional plots (mean = 77.60 $\mu g\ g^{-1}$) than the organic plots (mean = 68 $\mu g\ g^{-1}$). The variances of the samples of the two systems were also found to be significantly different, with organic system having a SD of 7.82 and conventional farming system having a SD of 17.33 respectively. The Fe content in leaf tissues recorded a high value of 140 $\mu g\ g^{-1}$ and a low value of 50 $\mu g\ g^{-1}$ in the conventional farming system. Whereas in the organic farming plots, the values ranged from 90 $\mu g\ g^{-1}$ to 60 $\mu g\ g^{-1}$.

Table 9. Secondary and micro-nutrient concentrations in cardamom leaves under conventional and organic farming practices

Sl.No.	Ca (%)		Mg (%)		Fe (μg g^{-1})		Mn (μg g^{-1})	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	0.82	0.46	0.35	0.48	130.00	60.00	400.00	90.00
2.	0.48	0.62	0.26	0.28	80.00	60.00	300.00	90.00
3.	0.42	1.04	0.30	0.30	60.00	60.00	650.00	160.00
4.	0.46	1.02	0.29	0.30	70.00	60.00	550.00	240.00
5.	0.44	0.70	0.30	0.44	80.00	70.00	400.00	180.00
6.	0.46	0.92	0.28	0.41	90.00	70.00	500.00	200.00
7.	0.32	0.94	0.49	0.34	100.00	60.00	750.00	230.00
8.	0.30	0.92	0.31	0.36	70.00	70.00	400.00	220.00
9.	0.32	0.94	0.32	0.34	80.00	70.00	650.00	210.00
10.	0.30	0.92	0.32	0.32	90.00	70.00	700.00	250.00
11.	0.30	0.96	0.31	0.34	70.00	60.00	600.00	210.00
12.	0.32	0.60	0.32	0.40	100.00	60.00	550.00	340.00
13.	0.52	0.56	0.40	0.55	90.00	60.00	350.00	230.00
14.	0.36	0.38	0.29	0.52	70.00	70.00	200.00	260.00
15.	0.72	0.56	0.22	0.43	80.00	70.00	650.00	200.00
16.	0.44	0.48	0.38	0.46	80.00	70.00	300.00	340.00
17.	0.48	0.28	0.40	0.41	90.00	70.00	450.00	340.00
18.	0.54	0.58	0.37	0.47	90.00	70.00	500.00	980.00
19.	0.46	0.52	0.41	0.44	140.00	60.00	350.00	390.00
20.	0.82	0.52	0.38	0.47	80.00	70.00	250.00	310.00
21.	0.58	0.48	0.46	0.47	70.00	70.00	150.00	360.00
22.	0.48	1.26	0.54	0.42	100.00	70.00	200.00	460.00
23.	0.52	0.68	0.55	0.41	80.00	70.00	250.00	540.00
24.	0.54	0.40	0.53	0.48	80.00	60.00	400.00	180.00
25.	0.26	0.88	0.28	0.28	60.00	60.00	300.00	480.00
26.	0.36	0.76	0.37	0.37	60.00	70.00	250.00	490.00
27.	0.30	0.80	0.32	0.30	50.00	70.00	200.00	470.00

(Continued……)

Table 9. Secondary and micro-nutrient concentrations in cardamom leaves under conventional and organic farming practices (Continued……)

Sl.No.	Ca (%)		Mg (%)		Fe (μg g^{-1})		Mn (μg g^{-1})	
	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic
28.	0.30	0.76	0.35	0.37	50.00	60.00	350.00	450.00
29.	0.32	0.40	0.32	0.58	60.00	60.00	400.00	60.00
30.	0.28	0.40	0.38	0.47	60.00	60.00	200.00	180.00
31.	0.70	0.70	0.24	0.43	70.00	70.00	2050.00	160.00
32.	1.16	0.42	0.19	0.47	70.00	70.00	300.00	170.00
33.	0.60	0.40	0.43	0.54	80.00	60.00	450.00	190.00
34.	0.74	0.42	0.38	0.48	70.00	70.00	750.00	170.00
35.	0.84	0.42	0.31	0.48	80.00	60.00	350.00	150.00
36.	0.68	0.84	0.40	0.46	70.00	80.00	900.00	300.00
37.	0.28	0.60	0.37	0.55	70.00	80.00	200.00	120.00
38.	0.24	0.86	0.47	0.40	60.00	70.00	800.00	110.00
39.	0.40	0.82	0.41	0.43	110.00	80.00	250.00	150.00
40.	0.28	0.80	0.46	0.46	70.00	80.00	600.00	130.00
41.	0.26	0.82	0.49	0.42	80.00	70.00	950.00	170.00
42.	0.26	0.82	0.48	0.44	70.00	60.00	550.00	150.00
43.	0.28	0.68	0.44	0.52	60.00	80.00	850.00	100.00
44.	2.20	0.18	0.30	0.61	70.00	60.00	100.00	90.00
45.	0.80	0.70	0.40	0.62	70.00	80.00	150.00	160.00
46.	0.58	0.70	0.35	0.53	70.00	60.00	100.00	130.00
47.	0.66	0.68	0.35	0.55	70.00	80.00	200.00	150.00
48.	0.62	0.78	0.46	0.53	70.00	80.00	150.00	160.00
49.	0.80	0.48	0.25	0.42	80.00	60.00	150.00	180.00
50.	0.64	0.78	0.40	0.48	80.00	90.00	200.00	110.00
Mean	0.52	0.67	0.37	0.44	77.60	68.00	445.00	243.80
SD	0.32	0.22	0.08	0.08	17.33	7.82	322.02	160.70
F	*		NS		*		*	
T	*		*		*		*	

* = Significant, NS = Not significant, SD = Standard deviation

4.3.1.2.3.2. *Manganese*

The Mn content of the cardamom leaves was found significant different between the two farming systems. The Mn content of the leaves belonging to the conventional plots (mean=445 μg g^{-1}) registered a significantly higher value than that of the organic plots (mean=243.8 μg g^{-1}). A data range of 100 μg g^{-1} to 2050 μg g^{-1} was recorded in the conventional farming system as against 60 μg g^{-1} to 980 μg g^{-1} in the organic farming system. The variances of the samples from the two farming systems also showed a significant difference (SD of conventional farms = 322.02 and SD of organic farms = 160.70).

It is thus concluded that out of the four microelements analysed in the leaf samples of organic and conventional systems only two of them (Fe and Mn) were found in detectable quantity. And also both Fe and Mn showed higher values in the conventional farms compared to organic farms.

4.3.2. **Plant Morphological Characters**

4.3.2.1. ***Biometric Parameters of Cardamom Plants***

Biometric parameters of cardamom plants like leaf length, leaf breadth, petiole length, plant height, number of tillers per clump and girth of pseudostem were observed in the present study. The results obtained are presented in table 10.

4.3.2.1.1. Leaf Length

Cardamom leaf length in organic and conventional farms was significantly different. The mean value of leaf length from 50 organic plots was 57.73 cm and that of conventional plots was 66.54 cm. The values ranged form 55.0 cm to 77.0 cm in the conventional farming system and 25.33 cm to 74.33 cm in the organic farming system. The variances of the samples from the two farming systems were also found to be significantly different with organic system recorded an SD of 9.32 and conventional system recorded a SD of 5.63 each.

4.3.2.1.2. Leaf Breadth

Leaf breadth was measured from plants belonging to both organic and conventional plots. It was noted that the two systems differ significantly with respect to this aspect. It had recorded a high value of 14.50 cm and a low value of 9.33 cm in the conventional farming system. Whereas in the organic farming plots, the values ranged from 8.23 cm to 12.67 cm. The mean values of 50 samples from organic system were 10.36 cm and that of conventional system was 12.10 cm respectively. The sample variances of the two farming systems showed no significant difference.

It is therefore concluded that the conventional farming system was superior to organic farming system with respect to leaf breadth.

4.3.2.1.3. Petiole Length

The leaf petiole length was measured under the present study and found that organic farming plots recorded higher petiole length with a mean of 26.04 mm. At the same time the mean value of conventional farming plots was got as 23.79 mm. The sample variances of the two farming systems exhibited no significant difference. The values ranged from 15.33 mm to 36 mm in the conventional farming system as against 15.67 mm to 35.33 mm in the organic farming system.

4.3.2.1.4. Plant Height

The height of cardamom plants recorded a high value of 4.48 m and a low value of 2.66 m in the conventional farming system. The organic farming plots showed the same values as ranged from 3.32 m to 2.12 m. The mean values of 50 observations each from individual plots of organic and conventional farms were 2.86 m and 3.59 m respectively.

Table 10.Biometric parameters of cardamom plants in the study area under conventional and organic farming practices

Sl.No.	Leaf length (cm)		Leaf breadth (cm)		Petiole length (mm)		Plant height (m)		No. of tillers per clump		Girth of pseudo stem (mm)	
	Conve-ntional	Organic	Conve-ntional	Organic	Conve-ntional	Organic	Conve-ntional	Organic	Conve-ntional	Organic	Conve-ntional	Organic
1.	69.23	48.67	12.77	9.30	23.67	28.00	3.20	2.37	110	24	26.67	26.00
2.	69.67	46.00	13.40	9.63	27.00	26.67	3.39	2.43	113	32	30.67	27.67
3.	77.00	50.33	13.77	10.17	27.00	26.67	3.38	2.82	124	29	29.67	33.00
4.	71.0	58.70	11.70	10.33	19.33	23.67	4.04	2.85	84	27	28.00	24.00
5.	63.00	52.17	11.90	9.33	16.00	24.67	3.45	2.69	91	21	22.67	21.33
6.	74.50	52.30	11.93	9.67	27.67	26.33	4.07	2.72	85	22	26.67	23.33
7.	72.67	62.33	13.07	9.37	28.67	26.33	3.06	2.81	82	23	26.33	26.00
8.	73.53	58.57	10.67	10.40	18.00	16.67	3.07	2.71	82	22	27.00	23.33
9.	72.67	60.67	14.50	10.27	24.33	21.67	2.97	2.91	69	23	25.67	26.67
10.	69.80	57.33	13.43	8.27	25.67	21.67	4.00	2.61	64	21	27.00	23.00
11.	68.67	52.20	14.10	9.67	26.33	26.67	3.23	2.68	69	27	26.00	23.00
12.	71.67	63.00	12.70	10.40	19.33	27.00	3.33	2.86	73	52	29.33	22.33
13.	68.97	62.33	9.33	10.37	18.33	27.33	4.20	2.58	88	34	28.00	23.33

-(Continued……)

Table 10.Biometric parameters of cardamom plants in the study area under conventional and organic farming practices (Continued.......)

Sl.No.	Leaf length (cm)		Leaf breadth (cm)		Petiole length (mm)		Plant height (m)		No. of tillers per clump		Girth of pseudo stem (mm)	
	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic	Conventi-onal	Organic	Convent-ional	Organic	Convent-ional	Organic
14.	61.33	68.33	12.23	11.23	30.33	21.67	3.88	2.65	61	43	23.33	31.00
15.	57.33	65.67	13.00	12.67	16.67	26.00	4.41	2.82	58	42	31.00	32.33
16.	55.00	47.67	11.50	10.43	27.33	27.00	3.46	3.02	94	36	22.00	23.67
17.	70.33	48.00	12.07	11.47	25.00	32.33	3.13	2.43	71	34	30.33	26.33
18.	59.33	51.67	11.40	12.67	28.33	21.00	3.10	2.85	68	17	24.33	28.00
19.	66.67	45.33	12.00	10.67	27.67	24.00	4.48	3.23	61	41	30.00	21.67
20.	60.00	27.67	11.10	11.67	25.00	22.33	4.03	2.85	48	53	30.33	23.33
21.	55.00	64.00	9.50	9.33	17.00	35.00	3.20	3.01	65	13	28.00	27.00
22.	60.76	59.33	13.67	9.23	17.67	28.00	4.41	2.22	71	21	28.67	23.33
23.	68.67	56.00	11.10	10.33	18.67	30.00	2.66	2.41	68	22	30.00	33.00
24.	58.67	64.67	9.85	8.23	26.67	23.33	3.41	2.53	65	23	23.00	23.67
25.	62.00	52.33	12.13	9.73	36.00	32.67	3.26	2.63	61	34	23.00	32.67
26.	61.67	61.67	11.10	9.40	30.67	23.67	3.41	2.83	68	36	28.67	32.00
27.	69.00	63.00	12.10	8.73	22.33	27.00	3.75	2.83	61	42	27.67	31.67

(Continued........)

Table 10. Biometric parameters of cardamom plants in the study area under conventional and organic farming practices (Continued……)

Sl.No.	Leaf length (cm)		Leaf breadth (cm)		Petiole length (mm)		Plant height (m)		No. of tillers per clump		Girth of pseudo stem (mm)	
	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic	Convent-ional	Organic
28.	74.00	62.00	12.33	9.13	17.33	32.00	3.48	2.72	70	40	24.67	31.33
29.	72.00	64.33	11.30	9.43	15.33	35.33	4.05	3.03	70	12	28.67	26.00
30.	72.67	25.33	13.20	11.33	25.33	22.33	4.11	3.03	72	53	31.33	23.00
31.	64.33	56.67	12.40	12.00	25.00	23.33	4.02	3.21	71	48	26.67	27.33
32.	56.00	53.00	13.67	8.23	25.33	33.33	3.81	3.31	45	42	28.33	26.67
33.	62.67	62.67	11.53	11.27	22.33	23.67	3.89	2.92	86	52	31.33	32.67
34.	67.33	65.33	11.23	9.53	22.67	31.67	4.04	3.13	73	52	31.33	32.33
35.	64.33	59.00	11.53	9.17	22.00	23.67	3.72	2.98	95	54	33.33	31.00
36.	64.33	56.33	12.20	10.27	27.33	16.67	3.87	2.90	74	42	32.33	22.67
37.	71.23	61.67	13.03	10.53	17.67	31.00	3.42	3.21	72	43	25.67	22.67
38.	61.30	56.67	11.93	10.63	23.67	31.33	3.33	3.21	69	43	25.00	23.67
39.	68.53	61.33	10.33	10.10	19.33	26.67	4.05	2.99	81	52	28.67	27.33
40.	69.37	61.67	11.93	10.17	26.00	31.33	3.16	3.01	83	48	21.67	32.00
41.	57.37	57.67	11.23	10.30	17.33	23.33	3.32	3.01	69	41	27.00	24.33

(Continued……)

Table 10.Biometric parameters of cardamom plants in the study area under conventional and organic farming practices (Continued.......)

Sl.No.	Leaf length (cm)		Leaf breadth (cm)		Petiole length (mm)		Plant height (m)		No. of tillers per clump		Girth of pseudo stem (mm)	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
42.	71.33	59.00	12.60	10.60	24.00	32.00	3.16	3.12	70	42	26.33	22.67
43.	65.13	51.00	11.60	11.67	28.67	23.67	2.92	3.32	66	24	21.33	24.00
44.	69.97	69.33	11.53	11.67	21.00	25.00	3.10	3.30	59	39	22.67	28.00
45.	65.83	67.33	11.80	10.00	33.67	25.33	2.93	3.32	62	38	22.67	27.67
46.	67.33	57.67	13.10	11.67	24.00	25.33	3.13	3.21	70	31	27.00	25.33
47.	72.43	67.00	13.73	11.20	23.67	25.33	4.31	3.02	74	42	29.00	27.33
48.	70.97	64.33	13.07	12.50	23.67	15.67	4.05	2.12	91	33	28.00	36.00
49.	63.67	73.00	11.60	11.53	28.00	24.00	3.85	2.67	42	33	28.00	27.67
50.	67.17	74.33	11.90	12.20	25.67	22.67	3.57	2.71	94	46	27.67	22.33
Mean	66.54	57.73	12.10	10.36	23.79	26.04	3.59	2.86	74.25	35.30	27.25	26.73
SD	5.63	9.32	1.14	1.14	4.71	4.48	0.46	0.29	15.86	11.50	2.98	3.88
F	*		NS		NS		*		*		NS	
T	*		*		*		*		*		NS	

* = Significant, NS = Not significant, SD = Standard deviation

Statistical analysis showed that the means were significantly different, thus suggesting that the conventional farming system was superior to organic farming system with respect to plant height. The variances of two farming systems were significantly different with the values of SD of organic and conventional farms as 0.29 and 0.46 respectively.

4.3.2.1.5. Number of Tillers per Clump

Number of tillers per clump is a main biometric attribute controlling the yield and plant's potential to produce yield. The same parameter was studied under the current investigation and found that the two farming systems were significantly different in this aspect. A data range of 42 to 124 was recorded in the conventional farming system as against 12 to 54 in the organic farming system. The number of tillers per clump was found remarkably high in the conventional farming plots with a mean value of 74.25 as against 35.3 in the organic farming plots. The sample variances of the two farming systems were also significantly different. The SD value of organic farming system was 11.50 and that of conventional farming system was 15.86 each.

4.3.2.1.6. Girth of Pseudostem

The pseudostem girth of cardamom plants was measured under the current study. Plants from 50 each of conventional and organic plots were selected and measurements were taken and averaged. The pseudostem girth of cardamom plants ranged from 21.33 mm to 33.33 mm in the conventional farming system as against 21.33 mm to 36.00 mm in the organic farming system. The statistical analysis showed that the plants belong to the two different farming systems had no significant difference with respect to the girth of their pseudostem. The variances of the two farming systems were also on par. The mean values of organic and conventional farming plots were 26.73 mm and 27.25 mm respectively. The SDs of the two farming systems were obtained as 3.88 and 2.98 respectively for the organic and conventional plots. It is inferred therefore that the two farming systems had no difference with respect to the above said parameter.

4.3.2.2. *Yield Attributes of Cardamom Plants*

Yield attributes of cardamom plants namely panicle length, inter-nodal length of panicle, panicles per clump, racemes per panicle and capsules per raceme were observed under the present investigation. The data generated are presented in table 11.

4.3.2.2.1. Panicle Length

The plants of the two farming systems significantly differed with respect to the length of panicles. The conventional plots recorded a mean value of 71.76 cm and the organic plots registered a mean value of 55.98 cm each. The sample variances of the two farming systems were also showed a marked difference, with organic plots having a SD of 21.90 and conventional plots having a SD of 14.74 respectively. A data range of 45.00 cm to 113.33 cm was recorded in the conventional farming system as against 23.67 cm to 113.33 cm in the organic farming system.

4.3.2.2.2. Inter-nodal Length of Panicle

The inter-nodal length of panicle, which is the length between two successive racemes, ranged form 19.67 mm to 32.67 mm in the conventional farming system and 16.33 mm to 44.33 mm in the organic farming system. The result suggested that the two farming system plots differ markedly in this aspect. The organic plot registered a mean value of 28.72 mm and the conventional plots registered a mean value of 26.07 mm each. This indicates that the organic farms bore plants having greater inter-nodal length of panicle. The sample variances also differed significantly between the two farming systems, with organic plots having a SD of 6.15 and conventional plots were having a SD of 3.12 each.

Table 11. Yield attributes of cardamom plants of the study area under conventional and organic farming practices

Sl. No.	Panicle length (cm)		Inter-nodal length of panicle (mm)		No. of panicles per clump		No. of racemes per panicle		No. of capsules per raceme	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	97.33	30.67	23.33	17.00	80	12	31	10	13	9
2.	113.33	36.67	26.67	32.00	20	16	41	15	12	10
3.	96.33	41.67	26.67	18.33	174	12	24	13	20	6
4.	84.67	61.00	22.67	42.33	120	28	23	25	17	17
5.	70.67	67.67	27.00	23.33	145	16	32	16	12	15
6.	90.67	67.33	26.67	25.00	119	17	27	17	13	15
7.	101.00	67.67	27.33	24.00	116	16	24	17	20	17
8.	81.33	71.33	24.00	32.00	124	33	26	21	12	13
9.	78.33	57.67	29.00	32.33	116	33	27	17	15	13
10.	77.67	71.33	25.33	30.33	102	28	22	21	13	14
11.	77.33	58.00	30.00	23.00	93	15	23	17	15	12
12.	68.67	23.67	20.00	32.00	113	17	30	12	12	10
13.	80.33	57.67	30.00	22.67	161	12	23	17	18	9

(Continued.......)

Table 11. Yield attributes of cardamom plants of the study area under conventional and organic farming practices (Continued…….)

Sl. No.	Panicle length (cm)		Inter-nodal length of panicle (mm)		No. of panicles per clump		No. of racemes per panicle		No. of capsules per raceme	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
14.	67.93	34.00	30.00	23.33	75	34	26	22	13	13
15.	75.00	33.33	28.00	22.00	90	30	26	18	12	11
16.	48.00	90.70	26.00	28.00	111	16	35	31	12	13
17.	45.00	53.67	21.00	32.33	100	28	28	18	16	10
18.	61.00	96.00	20.33	31.00	80	22	27	27	11	14
19.	94.00	72.00	26.00	16.33	110	13	28	37	15	12
20.	61.00	86.13	24.67	23.33	50	33	28	32	12	18
21.	67.33	113.33	20.00	44.33	80	41	28	23	13	12
22.	92.00	33.40	27.33	23.00	78	12	28	16	13	11
23.	69.33	40.30	28.00	29.67	90	15	26	17	13	11
24.	61.33	42.33	27.00	32.67	2	22	27	13	13	11
25.	68.47	37.67	28.00	22.33	76	27	25	24	13	12
26.	69.00	42.00	29.33	27.00	90	21	26	22	12	9
27.	70.67	36.33	31.00	22.67	84	35	38	23	20	12

(Continued…….)

Table 11. Yield attributes of cardamom plants of the study area under conventional and organic farming practices (Continued…….)

Sl. No.	Panicle length (cm)		Inter-nodal length of panicle (mm)		No. of panicles per clump		No. of racemes per panicle		No. of capsules per raceme	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
28.	64.00	41.00	27.33	23.33	73	42	34	22	12	12
29.	63.67	113.00	25.00	42.67	71	37	30	25	14	12
30.	62.67	86.40	25.00	36.33	112	12	25	25	13	14
31.	64.33	95.67	24.33	27.00	91	42	27	22	12	14
32.	59.37	34.33	27.33	32.33	72	43	24	12	13	11
33.	62.33	46.67	23.67	23.33	112	52	32	22	13	14
34.	63.00	46.00	27.00	21.67	102	55	29	18	14	10
35.	65.33	48.67	32.67	31.00	123	63	24	14	16	12
36.	67.33	38.00	22.67	30.00	102	68	22	13	16	8
37.	67.37	66.67	19.67	31.33	75	42	28	21	13	12
38.	69.20	68.00	26.67	31.67	71	24	26	13	12	11
39.	76.00	42.33	26.00	31.33	110	42	33	18	13	9
40.	48.67	36.67	30.67	31.00	99	34	32	11	14	12
41.	47.73	37.67	26.33	32.33	90	28	32	21	13	12

(Continued…….)

Table 11. Yield attributes of cardamom plants of the study area under conventional and organic farming practices (Continued…….)

Sl. No.	Panicle length (cm)		Inter-nodal length of panicle (mm)		No. of panicles per clump		No. of racemes per panicle		No. of capsules per raceme	
	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic	Conventional	Organic
42.	71.53	68.00	29.00	31.00	59	23	23	17	12	12
43.	64.67	28.67	28.33	22.33	88	23	27	20	15	13
44.	70.97	61.33	28.33	33.00	96	26	27	27	13	13
45.	64.33	60.00	19.67	35.00	48	26	23	27	16	13
46.	70.30	31.00	27.00	27.00	66	30	26	28	15	12
47.	69.00	57.67	26.67	32.67	103	32	33	27	14	13
48.	53.13	69.33	22.33	33.33	121	23	34	23	14	14
49.	70.10	40.00	25.00	33.00	63	20	28	23	14	13
50.	105.33	59.00	27.67	31.00	110	23	29	21	17	12
Mean	71.76	55.98	26.07	28.72	93.17	28.26	27.89	20.16	13.93	12.11
SD	14.74	21.90	3.12	6.15	30.54	13.24	4.06	5.81	2.16	2.21
F	*		*		*		*		NS	
T	*		*		*		*		*	

* = Significant, NS = Not significant, SD = Standard deviation

4.3.2.2.3. Number of Panicles per Clump

The number of panicles per clump recorded highest value of 174 and lowest value of 2 in the conventional farming system. In the organic farming plots the values ranged from 12 to 68. It was noted that the farming systems were different in this aspect. The conventional farming plot performed outstandingly, producing a mean of 93.17 panicles per clump against 28.26 of the organic farming plots. The variances of samples of the conventional plots (SD = 30.54) and that of the organic plots (SD = 13.24) were statistically significant.

4.3.2.2.4. Number of Racemes per Panicle

Each individual panicle of selected plants from organic and conventional farming plots was observed and the number of racemes per panicle was averaged. It was found that the two different farming systems markedly varied in this aspect. The values ranged form 22 to 41 in the conventional farming system and 10 to 37 in the organic farming system. The mean value of organic plots was 20.16 and that of conventional plots was 27.89 respectively. The sample variances were also recorded to be significantly different between the two farming systems with the SD values of organic and conventional plots were 5.81 and 4.06 respectively. It is inferred that the number of racemes per panicle was greater with conventional farming system than the organic farming systems.

4.3.2.2.5. Number of Capsules per Raceme

The number of fresh capsules per raceme was counted from representative plants of the two farming plots. It was found that the conventional plants possessed higher mean value (13.93) than the organic plots (12.11) and the difference between the means were found significant. The data ranged from 11 to 20 in the conventional farming system as against 6 to 18 in the organic farming system. The sample variances didn't exhibit any marked difference, with SD values of 2.21 and 2.16 of organic and conventional plots respectively.

4.3.2.2.6. Yield

Annual yield as per farm records were collected for comparison. The yield records in the nine organic farms in kg per acre were 45, 40, 50, 76, 65, 70, 55, 68 and 75. Conventional farms yielded better as shown by the values from the eight conventional farms (125, 150, 148, 138, 120, 130, 145and 150).

4.4 QUALITY PARAMETERS OF CARDAMOM CAPSULES

Quality parameters of both fresh and cured cardamom capsules were subjected to investigation.

4.4.1. **Quality of Fresh Cardamom Capsules**

The various quality parameters of the fresh cardamom capsules were also studied and the results are presented in table 12.

4.4.1.1. ***Capsule Length***

Data showed that the values of length of fresh cardamom capsules from organic and conventional plots didn't vary significantly. It ranged from 12.33 mm to 25.67 mm in the conventional farming system as against 13.33 mm to 24.33 mm in the organic farming system. The sample variances of the two farming systems also didn't show any significant difference. It is inferred that the two farming systems were identical with respect to the lengths of fresh cardamom capsules.

4.4.1.2. ***Capsule Girth***

It is observed that the two farming systems were significantly different with respect to the girth of fresh cardamom capsules. Highest value of capsule girth was 13.67 mm and the lowest was 8.00 mm in the conventional farming system. In the organic farming plots the values ranged from 14.33 mm to 7.00 mm. The mean values of 50 samples each were 11.70 mm and 11.04 mm respectively for organic and conventional plots. The variances of the samples of the two systems also varied significantly. The SD values were obtained as 1.49 and 1.07 respectively for organic and conventional farming plots. It is therefore inferred that the organic farming system was superior to conventional farming system with respect to capsule girth or boldness of fresh cardamom.

Table 12. Quality parameters of fresh cardamom capsules in the study area under conventional and organic farming practices

Sl. No.	Capsule length (mm)		Capsule girth (mm)		No. of seeds per capsule	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
1.	14.00	13.33	10.67	10.67	15	12
2.	15.00	13.67	11.33	12.67	15	14
3.	18.00	17.00	11.33	11.33	17	13
4.	18.67	18.33	11.33	14.33	15	16
5.	19.33	20.33	11.00	13.67	12	13
6.	22.33	22.33	11.00	12.67	16	13
7.	15.67	17.33	10.67	14.00	15	14
8.	18.67	18.33	11.00	11.33	13	13
9.	18.67	17.67	10.67	11.33	15	15
10.	18.33	18.67	10.67	12.33	14	16
11.	18.67	21.00	11.33	12.67	16	12
12.	19.00	18.00	10.67	11.00	13	12
13.	20.00	18.33	11.33	13.00	13	14
14.	20.33	17.67	10.00	11.67	18	12
15.	17.33	16.67	9.67	12.67	10	15
16.	16.67	16.00	11.00	11.00	10	10
17.	16.67	15.00	11.33	7.00	18	20
18.	22.33	18.33	11.00	8.00	15	11
19.	18.00	16.33	11.00	7.00	14	10
20.	16.67	16.67	10.00	14.00	17	11
21.	12.33	13.33	8.00	11.67	12	9
22.	22.00	18.67	11.00	10.00	18	11
23.	22.33	19.33	11.00	12.67	18	12
24.	16.67	15.67	11.00	12.00	16	12
25.	22.67	19.33	12.33	12.67	18	12
26.	23.33	20.33	12.00	11.33	14	11
27.	22.67	20.00	11.00	12.00	16	12
28.	19.00	18.00	12.00	11.00	12	13
29.	23.33	21.00	12.67	10.00	18	9
30.	17.33	17.00	13.67	11.00	15	12

(Continued.......)

Table 12. Quality parameters of fresh cardamom capsules in the study area under conventional and organic farming practices (Continued.......)

Sl. No.	Capsule length (mm)		Capsule girth (mm)		No. of seeds per capsule	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
31.	17.67	16.67	12.00	11.33	12	12
32.	19.00	17.00	12.00	12.33	13	9
33.	13.33	13.33	12.33	11.33	13	12
34.	15.00	15.00	8.67	13.00	16	13
35.	13.00	14.00	8.33	12.00	12	14
36.	17.00	15.33	13.00	11.00	15	9
37.	18.33	17.67	12.67	11.67	16	15
38.	18.00	16.33	11.33	10.33	17	9
39.	16.67	16.33	10.00	12.67	16	12
40.	18.67	17.67	11.33	13.33	14	12
41.	17.00	16.00	10.33	11.33	14	15
42.	16.33	16.00	10.33	11.67	16	12
43.	17.00	15.00	11.67	12.33	20	16
44.	20.67	18.67	11.33	13.33	21	8
45.	13.33	14.33	11.33	12.00	15	7
46.	17.00	16.67	10.67	11.67	17	10
47.	19.33	18.67	11.33	11.67	17	9
48.	18.67	17.33	10.67	11.67	15	10
49.	25.67	24.33	9.67	11.33	15	9
50.	16.67	17.67	11.33	12.33	15	11
Mean	18.29	17.35	11.04	11.70	15.07	12.06
SD	2.9	2.31	1.07	1.49	2.31	2.43
F	NS		*		NS	
T	NS		*		*	

* = Significant, NS = Not significant, SD = Standard deviation

4. 4.1.3. *Number of Seeds per Capsule*

The seeds were counted from individual capsule of selected plants from both the farming systems. The number of seeds per capsule of the conventional plots outnumbered the organic plots with a mean value of 15.07 as against 12.06 of the organic farming plots. The sample variances of the two farming systems showed no significant difference. The conventional farming system represented a data range of 10 to 21 and the same for the organic farming systems was 7 to 20.

4.4.2. **Quality Parameters of Cured Cardamom**

In order to study the quality of produce in the organic and conventional cardamom farms, various produce quality variables were studied. Data generated on essential oil, oleoresin, thrips attack on the capsules of cured cardamom and the litre weight of cured cardamom are presented in table 13.

4.4.2.1. *Volatile Oil*

It was found that there was significant difference between organic and conventional system of farming in the content of essential oil in cured cardamom. The organic cardamom samples possessed greater content of essential oil than the conventional cardamom samples. The mean values of eight representative samples of organically and conventionally produced cardamom were 3.20 per cent and 2.96 per cent respectively. The data range of conventional produce was 2.70 per cent to 3.13 per cent and that of organic cardamom was 3.00 per cent to 3.40 per cent. The variances of the two sets of samples showed no significant difference between organic and conventional farming systems. The standard deviations of organic and conventional farming samples were 0.12 and 0.17 respectively. It is therefore concluded that the essential oil content of organic cardamom was higher than that of the conventional cardamom under the conditions of the present study.

4.4.2.2. ***Oleoresin***

In the present study, the oleoresin content of the cured cardamom from eight representative samples was analysed for both the organic and conventional farming systems. It was observed that the oleoresin content of organic cardamom (ranging from 3.28 per cent to 3.63 per cent) was significantly higher than that of the conventional cardamom (ranging from 2.95 per cent to 3.33 per cent). The mean values were obtained as 3.5 per cent and 3.13 per cent for organic and conventional farming systems respectively. It is thus inferred that the oleoresin content of the organic system was higher than that of the conventional system.

4.4.2.3. ***Thrips Attack on Cardamom Capsules***

The incidence of thrips on the cured cardamom capsules was estimated on a percentage basis. There was significantly greater incidence of thrips on the capsules of organic cardamom (ranging from 42.2 per cent to 68.1 per cent) than that of the conventional cardamom capsules (ranging from 14.9 per cent to 21 per cent). The mean values of nine organic cardamom samples were 54.61 per cent and that of eight conventional cardamom samples was 17.92 per cent. The sample variances of the two farming systems were significantly different with organic samples registered a SD 8.26 and the conventional samples recorded a SD of 2.25 each. It is thus inferred that the conventionally produced cardamom capsules were superior to the organic cardamom with respect to the thrips attack on the capsules.

Table 13. Quality parameters of cured cardamom samples under conventional and organic farming practices

Sl. No.	Volatile oil (%)		Oleoresin (%)		Thrips attack on capsules (%)		Litre weight of cured cardamom (g)	
	Convent-ional	Org-anic	Convent-ional	Org-anic	Convent-ional	Org-anic	Convent-ional	Org-anic
1.	2.91	3.00	3.07	3.51	16.8	52.6	360	345
2.	2.73	3.11	2.98	3.63	19.5	59.6	325	330
3.	2.98	3.20	3.11	3.48	18.9	68.1	350	360
4.	3.12	3.20	3.24	3.49	20.1	49.8	340	375
5.	3.13	3.25	3.33	3.46	21.0	62.5	370	350
6.	3.12	3.40	3.27	3.62	14.9	46.8	355	365
7.	2.70	3.16	2.95	3.28	16.7	59.1	335	375
8.	3.00	3.25	3.08	3.53	15.5	50.8	343	325
9.	-	-	-	-	-	42.2	-	360
Mean	2.96	3.20	3.13	3.50	17.92	54.61	347.25	353.89
SD	0.17	0.12	0.14	0.11	2.25	8.26	14.46	17.99
F	NS		NS		*		NS	
T	*		*		*		NS	

* = Significant, NS = Not significant, SD = Standard deviation,

4.4.2.4. ***Litre Weight of Cured Cardamom Capsules***

The weight of one litre of cured cardamom was estimated for both the organic and the conventional cardamom produce and it was noted that in this aspect the organic and conventional farming systems didn't differ significantly. The data ranged from 325 g to 370 g in the conventional farming system as against 325 g to 375 g in the organic farming system.

DISCUSSION

5. DISCUSSION

An organic agriculture movement is now emerging in India at different levels namely producer groups, trainers and advisors, certification bodies, processors and traders. The market of organic products is expected to grow up globally at a rate of 25-30 per cent in the coming years (Yussefi and Willer, 2002). Indian Agriculture comprises a huge number of small farmers who still use traditional methods and do farming with a few agricultural inputs. Even though the green revolution technologies reached the main production areas in the Country, there are still areas and communities that didn't adopt intensive agriculture. Moreover, increasing number of farmers are now consciously abandoning intensive production practices and adopting organic agriculture. Hence there is great scope for production and marketing of certified organic products. Organic agriculture is significant in the Indian context in two distinct ways. First, the organic system helps in reducing production costs and stabilizing yields on marginal soils and second, it helps in increasing product value in areas where farmers have access to organic markets. However, scientific information on the effects of organic farming on soil, crop and produce quality and sustainability is scanty in the Country.

The current report was generated after studying samples from cardamom farms in the area under the jurisdiction of the Peermede Development Society, a leading Non-Governmental Organisation in Kerala, involved in organic product marketing. The organic farms under the study were converted in 1997 and certified organic from the year 2000. Even though the period of conversion is not long enough to arrive at conclusive inferences, the trends are discussed in the light of results obtained from analyzing the soils, cardamom leaves as well as the produce.

1. THE FARMING PRACTICES

Certification of organic farms or produce necessitates a number of strict farming practices that must be followed stringently. The practices encompass a conversion period (time between start of organic management and certification of crops), maintenance of isolation belt, intercropping, crop rotation, mixed farming, planting material, fertilisation, weeding, plant protection, processing, storage, packing, labeling, transportation, etc. However, there will be flexibility in imposing these practices depending on availability of local resources and the level of skill attainment of the farmer. Certified organic farmers are usually richer producers who have market access. Resource-poor farmers practicing organic farming (and selling locally without price premium) have not yet been the focus of attention. The current investigations were on resource poor tribal communities practicing organic cardamom farming under the guidance of the Peermede Development Society, which enabled certification and marketing of the produce.

The organic farms selected for the study do not follow strict package of practices. There were variations among individual farms, within the purview of certification procedures. The major differences in the conventional and organic farming practices of the study area were on fertilization policy, plant protection strategy, weed control and land management. While the organic farms followed indigenous technologies for most of the farming practices, conventional farms followed mostly the package of practices recommendations of the Spices Board of India, with modifications at local level.

2. SOIL QUALITY

According to USDA National Organic Standard Board, the primary role of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people. Several indicators on soil health were observed in the investigations under report.

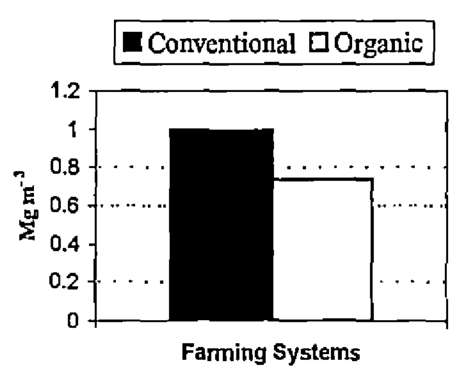

Fig. 4. Bulk density of soils in the farming systems

Soils of the organic cardamom farms were found to have better aeration than conventional farms, which is evident from the significantly lower bulk density of soils of the organic farms (mean value of 0.74) compared to conventional cardamom farms (0.99). This finding was corroborated by the reports of Liebig and Doran (1999) and Blakemore (2000). They reported that, soil under organic farms had lower bulk density, compared to conventional farms.

Another significant effect of organic agriculture in cardamom farms of the study area was the improvement of soil electrochemical properties. Soil acidity was significantly reduced by organic farming practices with mean pH values of 5.34 and 4.66 in organic and conventional farms respectively. A pH range of 4.17 to 5.06 was recorded in the conventional farming as against 4.84 to 5.79 in the organic cardamom farms. Improvement of soil pH due to the contribution of Ca from decomposing organic matter has been reported elsewhere. Mader *et al.* (2002) observed that soil pH was slightly higher in the organic systems than the conventional chemical based farming systems. Zachariah (1975) reported that the soil samples analysed from different cardamom growing areas of Kerala were acidic, the pH being in the range of 5.0 to 5.5. Nair *et al.* (1978) reported that the pH of soils in Idukki is in the range of 4.7 to 6.15.

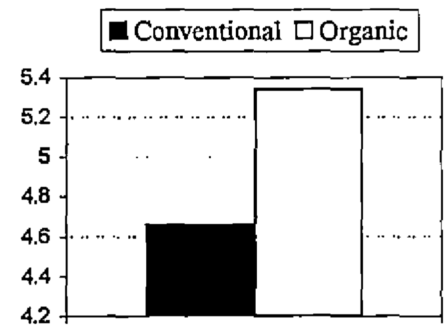

Fig. 5. pH of soils in the farming systems

Cation exchange capacity of the soils was significantly higher in organic farms, possibly due to the contribution of organic colloids towards additional negative charges. The mean values of 50 each of organic and conventional farming plots were (18.97 and 16.71) cmols (+) kg^{-1} respectively. Sadanandan *et al.* (1990) reported that the CEC of cardamom tracts in Kerala varied from 8.6 cmols (p+) kg^{-1} of soil to 58.5 cmols (p+) kg^{-1} of soil. He also observed that the CEC was positively correlated with the organic matter content of the soil.

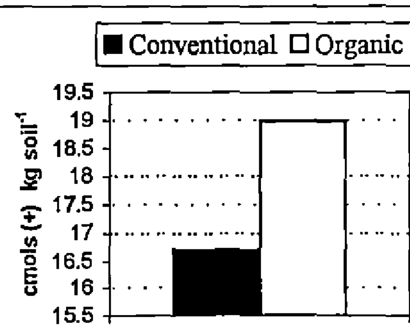

Fig . 6 Cation exchange capacity of soils in the farming systems

Organic matter was found as high as 3.6 per cent in the Idukki cardamom tracts (Nair et al., 1978). The major reason for this was reported to be the much slower rate of decomposition of organic matter in cardamom fields than that of other fields cultivating plantation crops such as tea, coffee etc., at the same elevation because of forest tree association and consequent lower mean annual temperature (Ranganathan and Natesan, 1985). In the present study, the mean values of organic matter were 4.76 per cent and

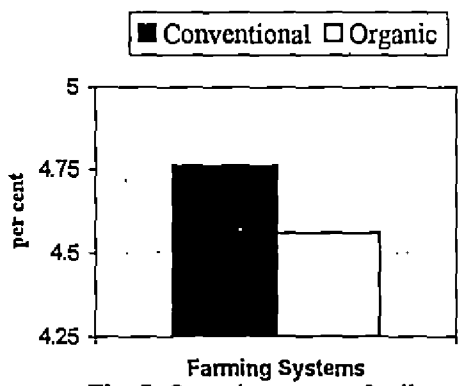

Fig. 7. Organic matter of soils in the farming systems

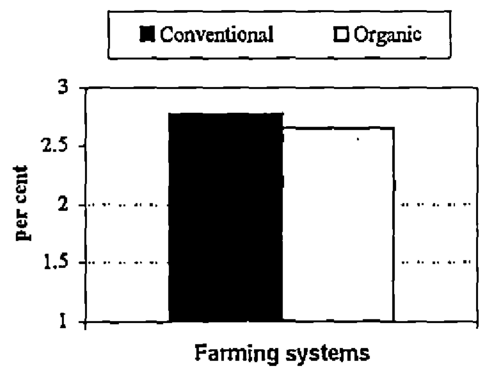

Fig. 8. Organic C of soils in the farming systems

4.56 per cent for conventional and organic farms respectively. Mean values for organic carbon were 2.77 per cent and 2.65 per cent respectively for conventional and organic farms. The contents of both organic matter and organic carbon were high in conventional farms, but the differences from organic farms were not significant. The rich organic soils of the study area may be the reason for insignificant difference in organic carbon and organic matter (derived values) as well as total N in the farms under comparison.

However, it may be noted that microbes were proliferating in the organic farms resulting in better decomposition of organic matter with concomitant solubility of major nutrients in the soil. Mader *et al.* (2002) opined that the microbial biomass and soil enzyme activities were closely related to soil acidity and soil organic matter content. Results of the study revealed that organic cardamom farming facilitated better microbial life in the soil. Population of bacteria, fungi and actinomycetes were higher in organic farms, but the difference was not statistically significant. But Robertson and Morgan (1996) could not find improvement in the soil bacterial numbers and fungal hyphal length after a conversion period of 18 months from conventional to organic farming of vegetable crop.

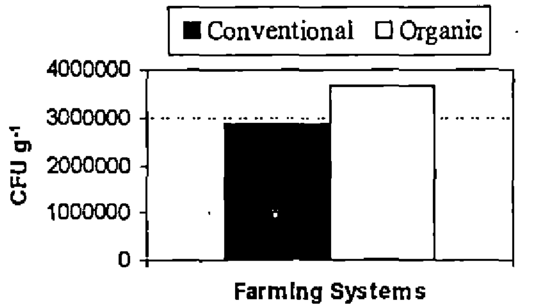

Fig. 9. Soil bacterial population in the farming systems

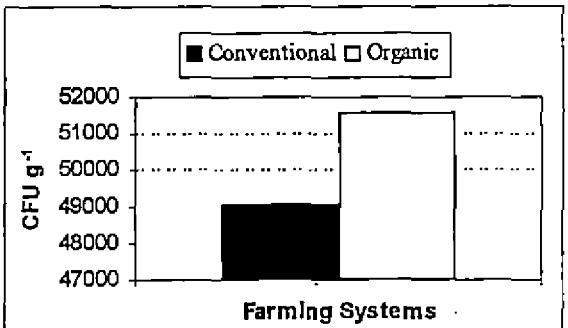

Fig. 10. Soil fungal population in the farming systems

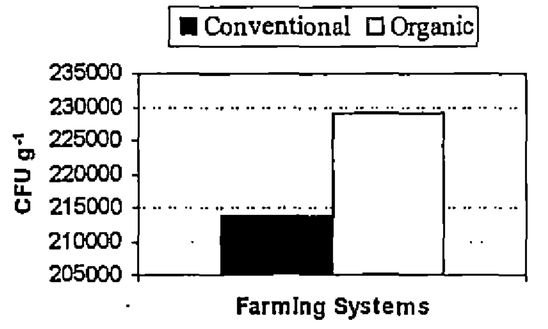

Fig.11.Soil actinomycetes in the farming systems

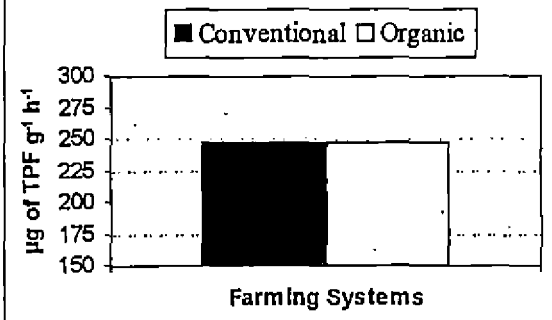

Fig.12. Dehydrogenase activity of soils in the farming systems

The total activity of microorganisms can be estimated by measuring the activity of a living cell associated enzyme such as dehydrogenase. This enzyme plays a major role in the respiratory pathway. The dehydrogenase enzyme activity of the soil, as an indicator of soil biological life, did not differ significantly in the study under report. Mader *et al.* (2002) found that dehydrogenase, protease and phosphatase activities were higher in the organic farming system than in the conventional system. Over the years, the microbial population and enzyme activity are expected to improve in the organic farms that were observed under this study.

Krishnakumar and Potty (2002) suggested that despite the high organic matter content in the traditional cardamom tracts (Western ghats), the heavy rainfall and undulating topography together with intense tilling of sloppy lands enhances soil erosion and nutrient leaching, which ultimately lead to the diminished fertility status of cardamom soils. However, the ranges of major nutrients in the current investigation fall under medium to high levels and hence the difference between organic and conventional cardamom farms with respect to major nutrients was not consistent.

Total N in the soils of organic farms (mean of 50 samples = 7338.24 kg ha^{-1}) was significantly lower than conventional farms (mean of 50 samples = 7916.16 kg ha^{-1}). This was in concurrence with the findings of Murata and Goh (1997). They reported that, the total N content in the soils of biodynamic (organic) mixed cropping farm was decreasing with time, at the same time this was not found in soils from the conventional farm. He explained that this trend was probably due to N fertilizer additions in the conventional farms. Contrary to the above finding, many had reported that the total N content of the organic farms was significantly higher than that of the conventional farms (Albiach *et al.*, 1999; Blakemore, 2000; Liebig and Doran, 1999; Loes and Ogaard, 1997 and Fliessbach *et al*, 1997).

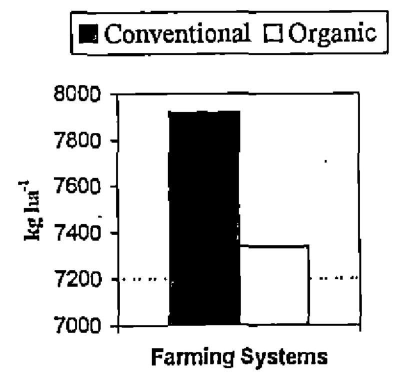

Fig. 13. Total N of soils in the farming systems

In the case of organic C also the trend was same but not statistically significant. The mean values for organic C of 50 organic and conventional plots were 2.65 per cent and 2.77 per cent respectively. This was corroborated with the findings of Breland and Eltun, (1999), which follows that, there were no detectable differences between organic and conventional farming systems in terms of total soil organic C. Mader *et al.* (2000) also, reported that organic C content of the soil showed no significant temporal trends in the organic farms after its conversion from a conventional system of farming. This was against the reports of many others, which suggested that the organic C content significantly increased after converting to an organic system of farming from a previously conventional farming system (Tarhalkar *et al.*, 1996; Clark *et al.*, 1998; Liebig and Doran, 1999 and Blakemore, 2000).

On the contrary, the available P and exchangeable K contents were significantly higher in organic farms. The mean values for available P were 24.45 kg ha^{-1} for organic farms and 9.74 kg ha^{-1} for conventional farms respectively. This was in concurrence with the findings of Hsieh *et al.* (1996) and Blakemore (2000). They reported that the available P content of organic farms was higher than that of comparable conventional farms. Similar results were also reported by Warman and Havard (1998), Pil-Joo *et al.* (2001) and Jessica and Daniel (2002). ICAR (1998) accounted that cardamom tracts in Kerala represented soils that have low to medium availability of P that is, less than 5 kg ha^{-1} to 12.5 kg ha^{-1}.

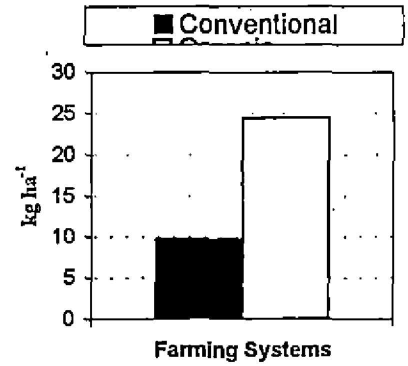

Fig. 14. Available P of soils in the farming systems

There are contradicting reports on the fixation and availability of phosphates in cardamom soils. P fixing capacity of cardmom soil was found to be 16.9 per cent to 32.1 per cent in Kerala (Srinivasan, 1990). While Krishnakumar and Potty (2002) opined that the acidic cardamom soils contain large quantities of Fe and Al oxides and they strongly fix soluble phosphates into insoluble one, Ranganathan and Natasan, (1985) suggested that high organic matter content of the cardamom fields facilitates solubilization of phosphates and thick mulch and grass may help to prevent immediate fixation of soluble phosphates.

The mean values for exchangeable K were 86.24 kg ha^{-1} for organic farms and 70.96 kg ha $^{-1}$ for conventional farms respectively and organic farms were significantly superior in this respect. Clark *et al.* (1998) reported that, exchangeable K content of the soil increased after four years of conversion from conventional farming practices to organic farming practices. The clay fraction of the soils in the cardamom tract of Kerala is reported to be predominantly kaolinitic and hence there is little fixation of K in these soils (Krishnakumar and Potty, 2002). Stephen and Nybe (2003) reported that, the application of 100 per cent K and P through organic source yielded high soil exchangeable K as well as available P. Reduction of soil acidity in organic farms might be another reason for this trend. On the contrary, Fagerberg *et al.* (1996), Loes and Ogaard (1997), Asdal *et al.* (1999) and Bundiniene (2000) observed that P balance was higher in the conventional farms than organic farms.

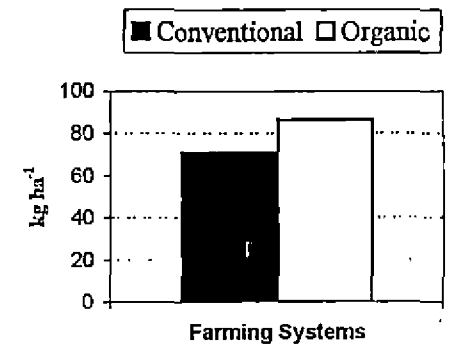

Fig.15 Exchangeable K of soils in the farming systems

As in the case of major nutrients namely available P and exchangeable K, the content of exchangeable fractions of Ca and Mg were significantly high in the organic farms. The findings of Stephen and Nybe (2003) support these results. An experiment conducted by them at Kerala Agricultural University on eight-year-old pepper vines (Panniyur-1 and Panniyur-2) during 2000-2001 revealed that the exchangeable Ca and

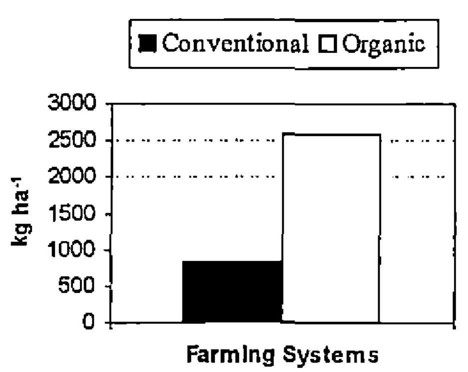

Fig.16 Exchangeable Ca of soils in the farming systems

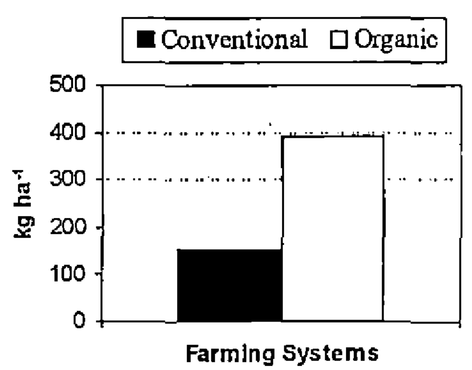

Fig.17 Exchangeable Mg of soils in the farming systems

Mg showed an increment in the organic treatment. Soluble Ca and Mg were found higher in the organic farming systems than in the conventional farming systems by Mader *et al.*, (2002). Warman and Havard, (1998) also reported that Ca and Mg contents were higher in organically fertilized potato plots than conventional plots.

High microbial activity and the resultant degradation of organic matter had contributed more of exchangeable Ca and Mg in the soil. These phenomena in turn caused a liming effect, thereby reducing soil acidity and increasing availability of P in the soil.

3. PLANT MORPHOLOGICAL CHARACTERS

Results of the study reveal that conventional farming with chemical inputs would enhance morphological make up of the cardamom plants. Biometric observations showed significantly lower values of leaf length, leaf breadth, plant height and number of tillers per clump in the case of organic cardamom plants. On the contrary a reverse trend was seen in the case of petiole length. The mean values for organic and conventionally cultivated cardamom plants were 57.73 cm and 66.54 cm for leaf length and 10.36 cm and 12.10 cm for leaf breadth. The leaf petiole length was found to be 26.04 mm and 23.79 mm respectively for organic and conventional farming systems. At the same time the mean values of plant height of organic and conventional cardamom plants were recorded as 2.86 m and 3.59 m respectively. The number tillers per clump was averaged for the conventional farming plots, and mean value of 74.25 was worked out as against 35.5 in the organic farming plots. Girth of pseudostem was also low for organic cardamom, but the difference was not significant. The mean values of pseudostem girth of organic and conventional farming plots were 26.73 mm and 27.25 mm respectively.

The conversion of organic farms under observation was relatively recent. Since chemical fertilizers and insecticides were withdrawn and plantations now depend only on inherent soil fertility, organic inputs and insufficient pest control, the yield levels were generally lower in organic farms. The report of Mader *et al.* (2002) is complimentary to this finding.

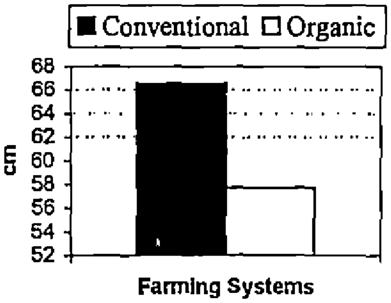

Fig. 18. Leaf length of cardamom in the farming systems

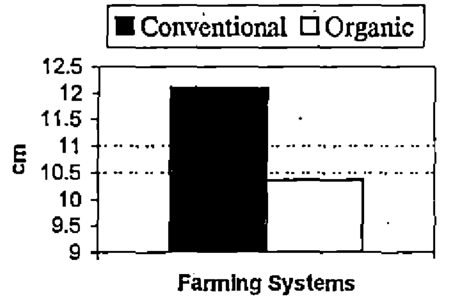

Fig. 19. Leaf breadth of cardamom in the farming systems

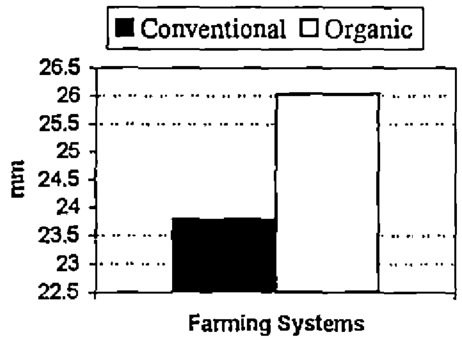

Fig. 20. Petiole length of cardamom in the farming systems

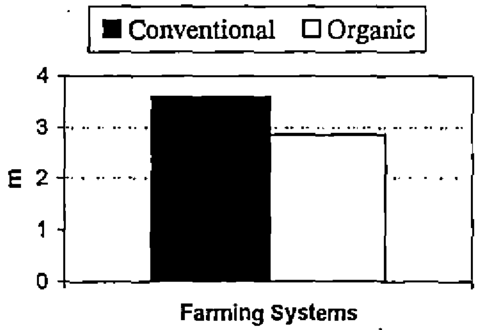

Fig. 21. Plant height of cardamom in the farming systems

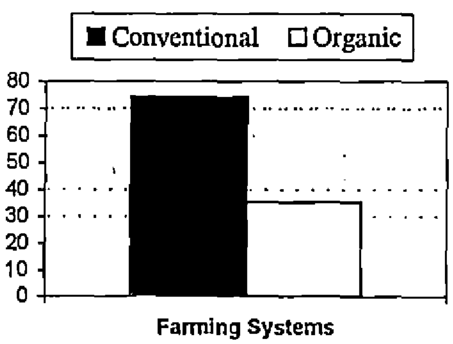

Fig. 22.Number of tillers per clump of cardamom in the farming systems

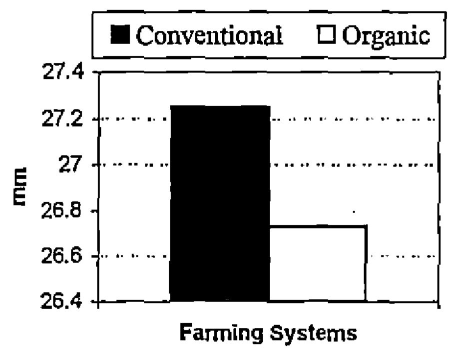

Fig. 23 Girth of pseudostem of cardamom in the farming systems

Yield attributes namely panicle length, number of panicles per clump, number of racemes per panicle and number of capsules per raceme was significantly lower inorganic farms. Mean values for organic and conventional farming systems were 55.98 cm and 71.76 cm in the case of panicle length, 26.07 mm and 28.72 mm for inter-nodal length of panicle, 28.26 and 93.17 for number of panicles per clump and 20.16 and 27.89 for number of racemes per panicle. The mean values for number of fresh capsules per raceme were 12.11 and 13.93 respectively for organic and conventional plants. The inter-nodal length of panicle was high in the organic farms (mean 28.72 mm) than the conventional farms (26.07 mm) resulting in less number of nodes per unit length.

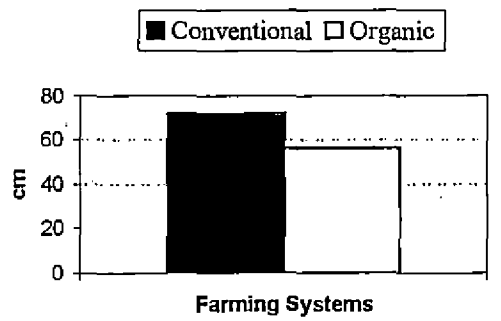

Fig. 24. Panicle length of cardamom in the farming systems

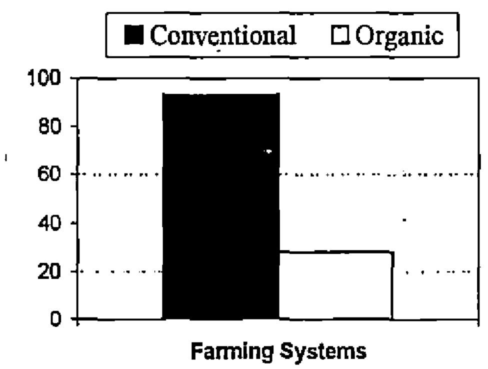

Fig. 25. Number of panicles per clump of cardamom in the farming systems

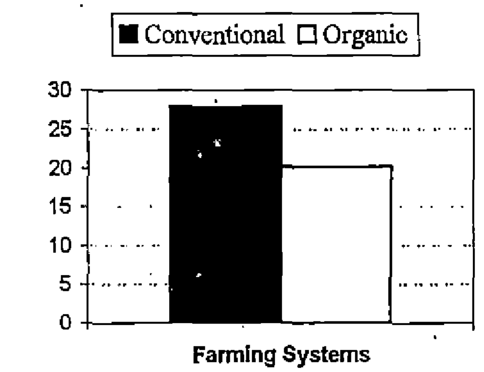

Fig.26. Number of racemes per panicle of cardamom in the farming systems

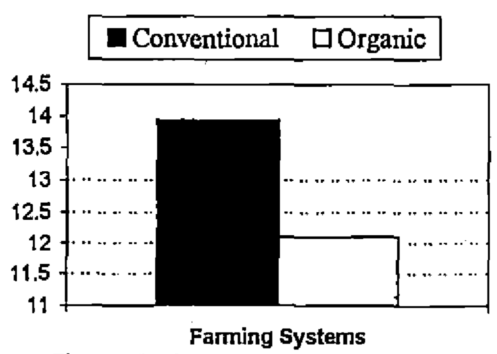

Fig. 27. Number of capsules per raceme in the cardamom panicles of the farming systems

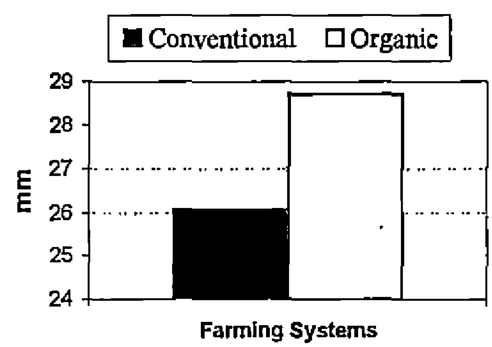

Fig. 28. Internodal length of panicle of cardamom in the farming systems

All these parameters contributed to the observed lower yields, which of course are expected to improve as farming practices stabilize in due course. These results are corroborated with the reports of Schulzova *et al.* (1999) and Reganold *et al.* (2000). They also observed better morphological characters in the conventionally grown plants than the organically grown ones. But the reports of Hsieh *et al.* (1996), Andow and Hidaka (1998) and Blakemore (2000) suggested that the organically grown crops were superior to the conventional ones in the biometric parameters.

4. MINERAL NUTRIENT CONCENTRATIONS IN CARDAMOM PLANTS

As a reflection of the low levels of total N and organic carbon in the soils of organic cardamom farms, the organic cardamom leaves contained significantly lower levels of N compared to that of conventional farms. The mean values were 3.67 per cent and 3.22 per cent for the cardamom leaves from conventional and organic farms respectively. High levels of soil and leaf N are expected in the conventional farms that are fertilized with commercial chemical fertilizers. This observation is bolstered by the reports of Warman and Havard (1998), Stalenga and Alfoldi (2000) and Worthington (2001). They accounted that N content was lower in the organically produced crops compared to conventional crops. On the other hand, Enrique (2001) reported that concentration of N in the leaf dry matter was almost similar for both organically and conventionally grown crops.

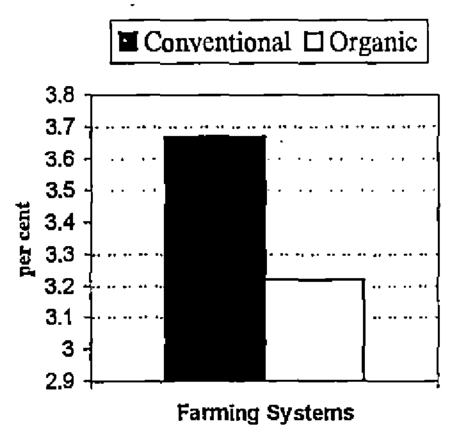

Fig. 29. Leaf N of cardamom in the farming systems

In the case of P, Ca and Mg, cardamom leaves from organic farms contained significantly higher levels. In the case of leaf K, the mean values were higher in organic cardamom leaves but not statistically significant. Stalenga and Alfoldi (2000) and Enrique (2001) reported that the K concentration in the plant tissues of organic crops were lower than that of the conventional crops. The average values of the nutrient elements in the leaf tissues of conventional and organic farms were, 753.50 µg $g^{-1}$and 1041.75 µg g^{-1} for P, 4153.60 µg g^{-1} and 4241.60 µg g^{-1} for K, 0.52 per cent and 0.67 per cent for Ca and for Mg the values were 0.37 per cent and 0.44 per cent respectively.

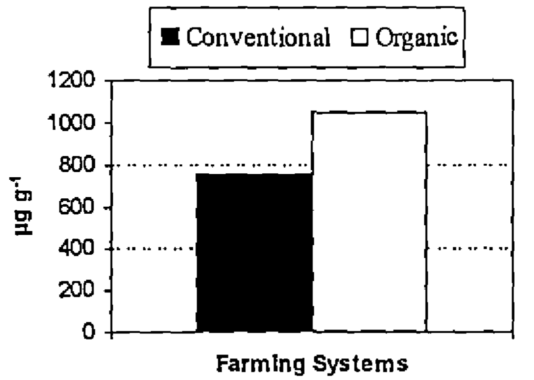

Fig. 30. Leaf P of cardamom in the farming systems

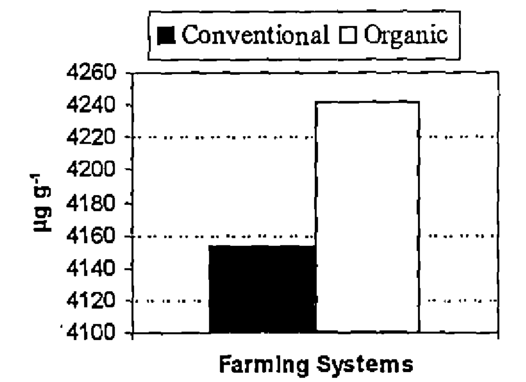

Fig. 31. Leaf K of cardamom in the farming systems

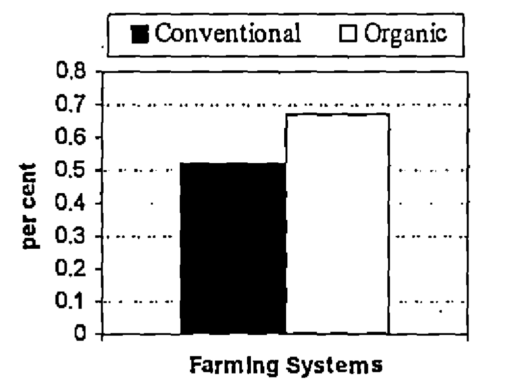

Fig. 32. Leaf Ca of cardamom in the farming systems

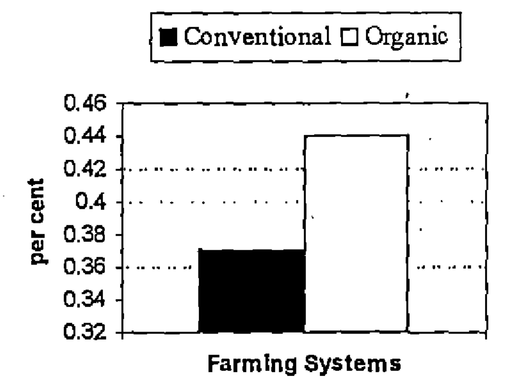

Fig. 33. Leaf Mg of cardamom in the farming systems

Since the morphological make up of the cardamom plants in the organic farms was relatively smaller, the minerals taken up were not diluted resulting in higher concentrations. Another cause for this observation may be the enhanced microbial growth in the organic farming plots. A major part of the soil microbial biomass is composed of fungi. Important representatives of the soil fungi are the mycorrhizae that build up a symbiosis between fungus and plant. Mycorrhizae enlarge the plants rooting zone and mobilize more nutrients to the plant.

Gundersen *et al.* (2000) and Worthington (2001) observed that the P concentration in the organically grown crops was higher than that of the conventional crops, which was in support of the findings of the current investigation. On the contrary, Stalenga and Alfoldi (2000) and Enrique (2001) couldn't observe any significant difference between organic and conventional crops with respect to P content in leaf tissues.

Conventionally managed cardamom plots contained vigorous plants, which yielded better (mean value of eight conventional farms was 138.26 kg per acre and mean value for nine organic farms was 60.44 kg per acre). The reports of Deria *et al.* (1996), Raupp and Lockeretz (1997), Divis and Vodicka (1998), Warman and Havard (1998), Faizabady *et al.* (1998), Schulzova *et al.* (1999), Rembialkowska and Alfoldi (2000), Mader *et al.* (2000), Bartosova *et al.* (2000) and Mader *et al.* (2002), were in concurrence with this result. Opposing the findings of the current study Sadanandan *et al.* (1990), GoI, (2001a) and Stephen and Nybe (2003) reported that the organic farming system exhibited higher yields.

One of the noticeable observations in the current study was the significantly higher concentration of Ca in the plant leaves as well as in the soils of the organic farms. The content of Ca in leaf tissues of organic and conventional cardamom plants of the present study was in concurrence with the report of Enrique (2001). He observed that foliar concentration of Ca was high in the organic plants compared to the conventional ones. In corroboration with the findings of the present study Worthington (2001) observed that the magnesium content of organic crops (fruits, vegetables and grains) was significantly higher than the conventional crops. On the contrary, Warman and Havard (1998) and Enrique (2001) observed that organic crops contained less Mg in leaves compared to conventional ones.

The effect of high levels of Ca in the exchange complex is also reflected in low uptake of Fe and Mn by organic cardamom plants. The mean values of Fe and Mn were 68.00 $\mu g\ g^{-1}$ and 243.80 $\mu g\ g^{-1}$ in the leaves of the organic cardamom compared to 77.60

µg g^{-1} and 445.00 µg g^{-1} respectively in conventional cardamom leaves. This observation was validated by the reports of Warman and Havard (1998). They reported that while comparing organically grown and conventionally grown wheat, the Fe content was low in the organic plants than in conventional ones. But Enrique (2001) couldn't observe any significant difference in the leaf contents of micronutrients such as Cu, Fe, Mn and Zn of the organically grown bananas. However, Worthington (2001) reported that organic crops (fruits, vegetables and grains) contained significantly more Fe than conventional crops.

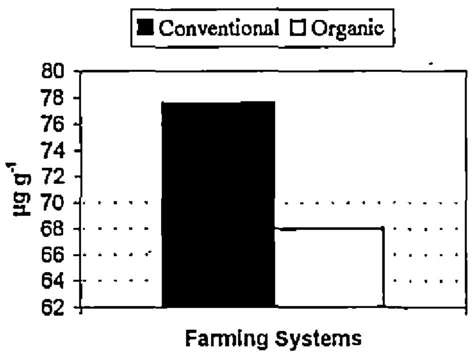

Fig. 34. Leaf Fe of cardamom in the farming systems

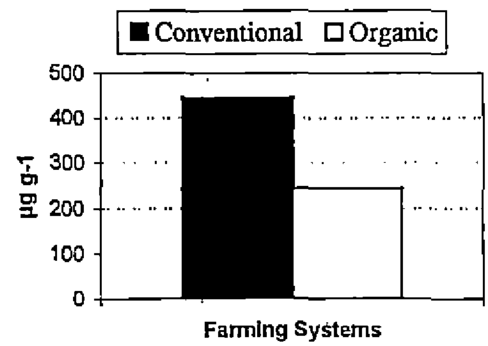

Fig. 35. Leaf Mn of cardamom in the farming systems

5. QUALITY OF CARDAMOM

Size of the fresh cardamom capsules harvested from organic farms was found better. Capsule girth was higher in organic cardamom, whereas the capsule length was non significant. However, the number of seeds per capsule was lower in organic cardamom. The number of seeds per capsule of the organic plots was 12.06 and that of the conventional plots was 15.07 each. The market value of cardamom capsules is largely determined by its colour as well as chemical composition. The colour of organic cardamom was found to excel with the most preferred greenness. But the appearance was distorted by a significantly higher infestation of thrips

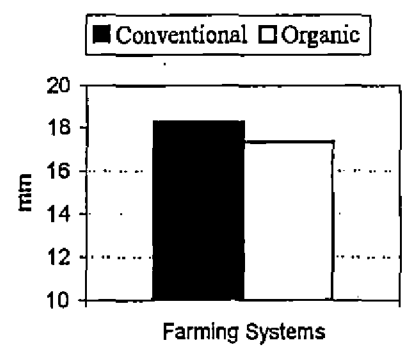

Fig. 36. Capsule length of cardamom in the farming systems

on the capsules (Plate 1). Litre weight of cured cardamom was also found high in the case of organic cardamom but was not statistically significant.

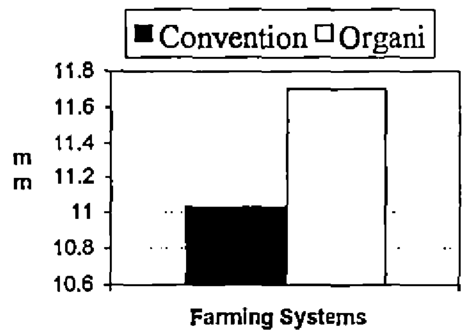

Fig.37. Capsule width (mm) of in the farming

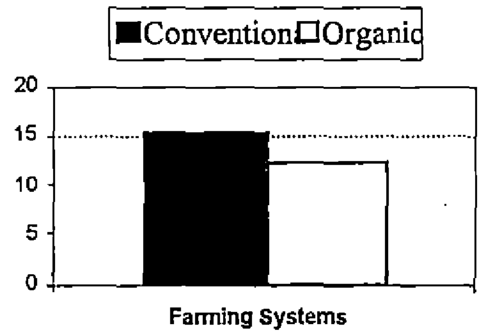

Fig. 38. Number of seeds per capsule in the farming

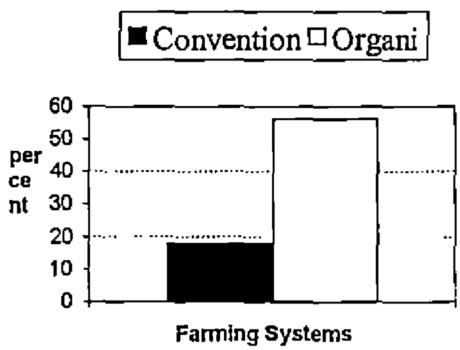

Fig. 39. Thrips attack on cardamom capsules in the farming systems

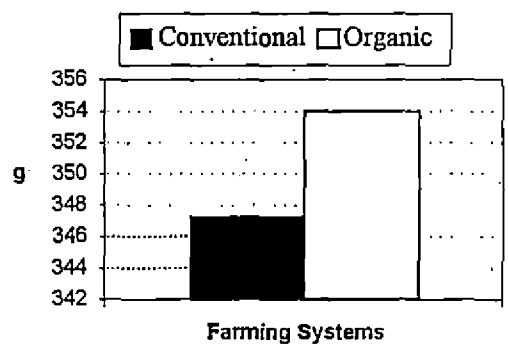

Fig. 40. Litre weight of cardamom in the farming systems

Between the two important chemical constituents analysed for comparison, both oleoresin and volatile oil contents, were found significantly superior in the organic to that of conventional cardamom. The mean values for oleoresin content were obtained as 3.5 per cent and 3.13 per cent for organic and conventional farming systems respectively. The mean values of volatile oil contents in the eight representative samples of organically and conventionally produced cardamom were 3.20 per cent and 2.96 per cent respectively.

The quality of the agricultural produce, particularly horticultural produce improves when the nutrients are supplied through organic manures as in the case of

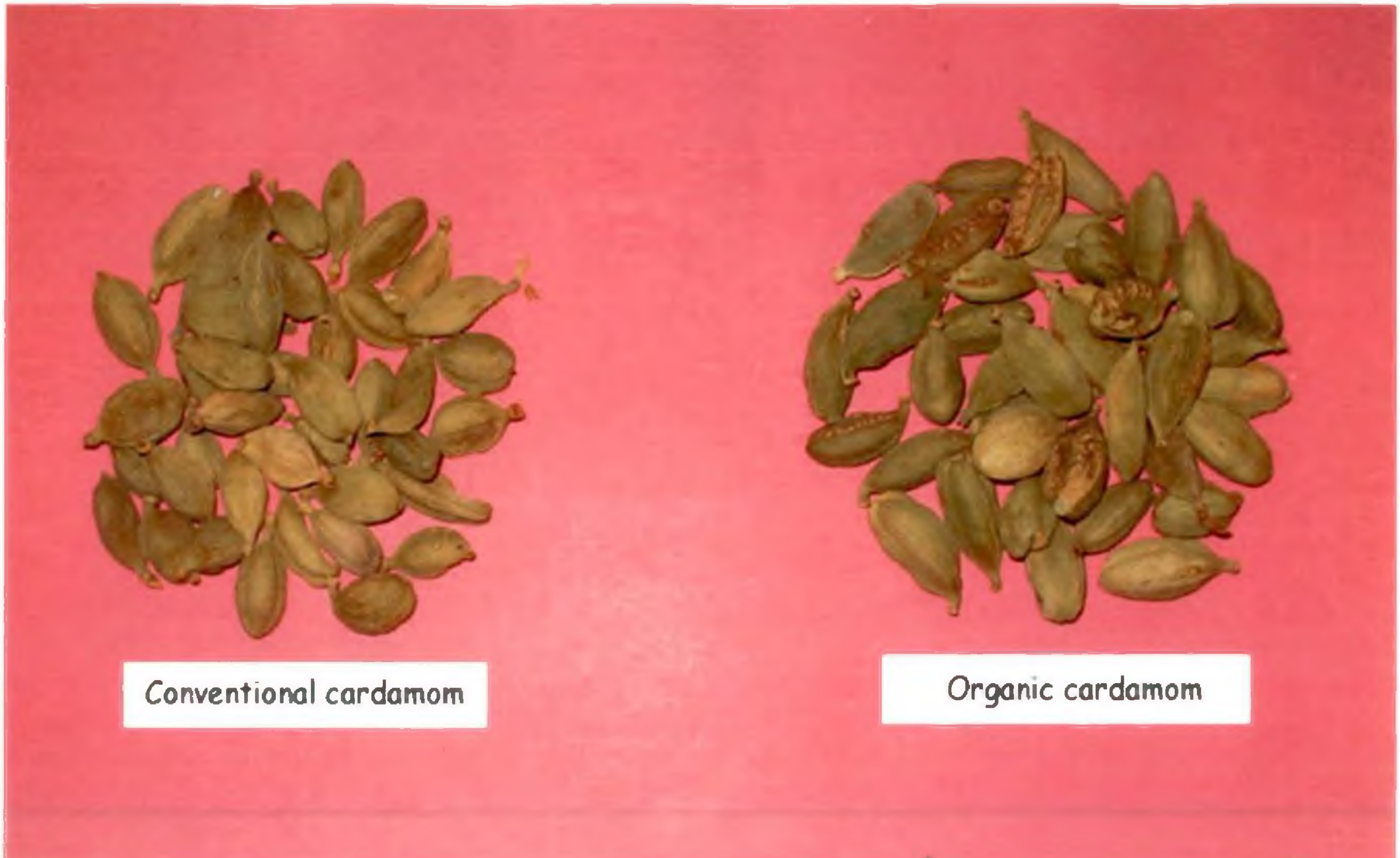

Plate 1. Cured cardamom samples under conventional and organic farming practices

organic farming, than in the form of fertilizers. This is because of the supply of all the growth principles like enzymes, hormones, growth regulators etc., besides all the essential plant nutrients by the manures. As a result, the metabolic functions get regulated more effectively resulting in better synthesis of proximate constituents and consequent improvement in the quality of the produce. Fertilizers, which are the main source of plant nutrients in the conventional farming, would supply one or a few nutrients only, and not the growth principles like enzymes and growth regulators. This may be the reason for better quality of the produce obtained in the organic farming system (Kumaraswamy, 2002). The improvement in the quality parameter of cured cardamom under the current study is consistent with the reports of Yun *et al.* (1998), Divis and Vodicka (1998), Rembialkowska and Fiedorow (1998), Rembialkowska (1999), Schulzova *et al.* (1999), Gutierrez *et al.* (1999), Rembialkowska and Alfoldi (2000) and Weibel *et al.* (2000).

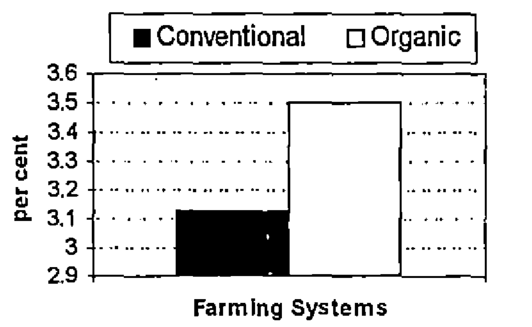

Fig. 41. Oleoresin of cardamom capsules in the farming systems

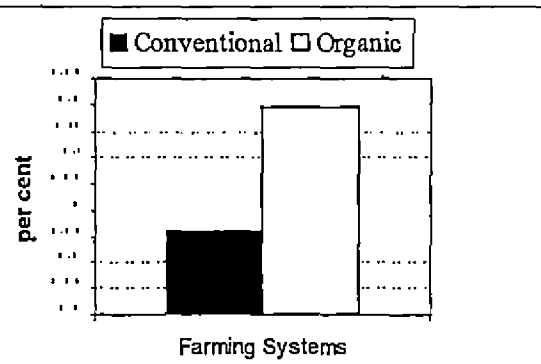

Fig. 42 Volatile oil of cardamom capsules in the farming systems

As a whole the chemical constituents of the cured cardamom produce analysed in the present study showed much lower values compared to normal values [5.2 per cent to 11.3 per cent for volatile oil (Korikanthimath, 2003)]. The reason for this trend may be the improper storage of cured cardamom produce by the farmers, which was noticed at the time of sampling. This finding was corroborated by earlier reports, which suggests that the volatile oil content of the cured cardamom produce will be lost considerably in the absence of proper protective storage (KAU, 2003).

The world continues to "grow organic" with impressive dynamic intensity. In developed countries, organic agriculture is an economically, ecologically and socially sound option to reduce surpluses as well as an alternative to land set-aside. The main aim of several developing countries in promoting organic agriculture is income generation through the promotion of certified organic food in the world market.

Organic agriculture is in many ways an eminently preferable model for the development of agriculture in resource poor areas and marginal soils in India, since it offers multiple benefits. The benefits include economical aspects (e.g. price premiums, high demand), natural resource conservation (e.g. improved soil fertility and water quality, prevention of soil erosion, preservation of natural and agro-biodiversity) and social benefits (e.g. generation of rural employment, improved household nutrition and local food security, reduced dependence on external inputs). However, the development of organic agriculture policies requires widening of market-oriented objectives to include food security objectives, especially in our country, which has to support one fifth of the world population.

Resource-poor farmers practicing organic farming as in the case of present study have not yet been the focus of attention. The yield levels in these farms are not as high as those of big farms in Kerala such as that of the POABS. Introduction of irrigation in the currently rain fed organic cardamom farms of the study area would certainly help to boost productivity. With respect to soil and produce quality, the results of the present study are not conclusive and needs further monitoring on long-term basis. If higher yields and better quality, together with price premium at domestic market are assured through proper incentives, organic agriculture can be the best way of agriculture, especially in the degraded soil areas and hilly tracts in Kerala.

SUMMARY

Studies on the effect of organic farming on the characteristics of soils, crops and produces are scanty in the state. The present study therefore aimed at a comparative analysis of the farming practices, soil properties, crop nutrient concentrations and quality of cardamom under organic and conventional farming in the high ranges of Kerala. In this attempt, an exploratory investigation was conducted in the cardamom farms around Peermade Samples for the study were collected from selected organic and conventional cardamom farms. Nine organic farms were identified for the study. These farms follow IMO and Skal International certification standards and were certified organic farms. Eight adjacent conventional cardamom farms following recommendations of Spices Board were also selected for investigation.

The salient findings of this study are presented below under appropriate headings.

I. SOIL PROPERTIES

1. The bulk density was low in the soils of the organic farming system than the soils of the conventional farming system. Consequently the organic soils possessed good aeration and thereby good biological activity.

2. The acidity of the soils of the conventional farming system was higher than that of the soils of the organic farming system.

3. The cation exchange capacity of the soils of the organic system was remarkably higher than that of the conventional farming system.

4. The total soil N content was superior in the conventional farming system than in its organic counterpart.

5. Under the conditions of the present study the organic farming system was superior to that of the conventional farming system with respect to available soil P.

6. The organic farming system was better than the conventional farming system with respect to soil exchangeable K content under the present investigation.

7. The concentration of soil exchangeable Ca and Mg in the organic farming system was superior to conventional farming systems under the ambiance of the current study.

8. In the current investigation the organic carbon content was not significantly different between the organic and conventional farming systems.

9. The present study showed that the organic matter content of the organic and conventional farming systems were on par.

10. No marked difference was observed in the enzymatic activity of the soils of organic and conventional farming systems.

11. Soil bacterial count was observed to be non-significant between the soils of organic and the conventional farming systems.

12. The organic and conventional farming systems were on par with the count of soil fungal population

13. The actinomycetes count in the two farming systems namely organic and conventional farming systems were not significantly different.

II. CROP HEALTH PARAMETERS

A. Leaf Nutrient Concentrations of the Cardamom Plants

1. The leaf N concentration was low in the organic farming system compared to its conventional counterpart.

2. The leaf P concentration was significantly higher in the organic farming system compared to the conventional farming system.

3. Under the present investigation the leaf K content didn't show any difference between organic and conventional farming systems.

4. The organic farming plots represented higher leaf Ca concentration compared to the conventional farming plots.

5. The leaf Mg content of the organic farms was higher than that of the conventional farms.

6. Among the four micronutrients analysed (Fe,Mn,Cu,Zn) in the leaf tissues of the two farming systems under the present study, only Fe and Mn were found to be in appreciable quantity. Cu and Zn concentrations were in negligible ranges and therefore not considered for comparison.

7. The Fe content of leaf tissues in the two farming systems was significantly different. Leaf Fe content was significantly high in the conventional farming system than the organic farming system.

8. The Mn content of the cardamom leaves belonged to the conventional farming plots registered a significantly higher value than that of the organic farming plots.

B. Biometric Parameters of Cardamom Plants

1. Cardamom leaf length in organic and conventional farms was significantly different. The conventional farming system is superior to the organic farming system in this aspect.

2. The conventional farming system was superior to organic farming system with respect to leaf breadth.

3. The leaf petiole length was higher in the conventional farming plots than the organic farming plots.

4. The conventional farming system was superior to organic farming system with respect to plant height.

5. The number tillers per clump were remarkably high in the conventional farming plots than the organic farming plots.

6. Girth of pseudostem had no difference between the two farming systems.

7. The plants of the two farming systems significantly differed with respect to the length of panicles. The conventional plots recorded superiority against the organic plots in this aspect.

8. The organic farms bore plants having greater inter-nodal length of panicle.

9. Panicles per clump in the conventional farming plots were high against the organic farming plots.

10. The number of racemes per panicle was greater with conventional farming system than the organic farming systems.

11. The conventional plants possessed higher values of 'capsules per raceme' than the organic plots and the difference was significant.

III. QUALITY OF THE PRODUCE

1. The two farming systems were identical with respect to the lengths of fresh cardamom capsules.

2. The organic farming system was superior to conventional farming system with respect to capsule width or boldness of fresh cardamom.

3. The number of seeds per capsule of the conventional plots outnumbered the organic plots.

4. The volatile oil content of organic cardamom was higher than that of the conventional cardamom under the conditions of the present study.

5. The oleoresin content of the organic system was higher than that of the conventional system.

6. There was significantly greater incidence of thrips in the capsules of organic cardamom than that of the conventional cardamom capsules.

7. The weight of one litre of cured cardamom was estimated and found that in this aspect the organic and conventional farming systems did not differ significantly.

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SOIL PROPERTIES AND PRODUCE QUALITY OF CARDAMOM (*Elettaria cardamomum* Maton) UNDER ORGANIC FARMING

By

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ABSTRACT OF THE THESIS

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ABSTRACT

An investigation was conducted at the Upputhara panchayath of Peermede taluk, in Idukki district of Kerala with the objective to compare the soil properties, crop nutrient concentrations and quality of cardamom (*Elettaria cardamomum* Maton) under organic and conventional farming. Nine certified organic farms that follow IMO and Skal International certification standards and eight adjacent conventional cardamom farms following recommendations of Spices Board were selected for investigation.

Fifty samples each of soil and cardamom leaves were drawn from both organic and conventional farms. Cured cardamom samples were collected from each farm under study. A proforma was developed in accordance with the standards fixed by IFOAM for documenting farming practices of the study area. Biometric parameters and yield attributes of cardamom plants were observed directly and yield data for the organic and conventional cardamom farms were collected from farm records during the survey.

The organic farms selected for the study did not follow strict package of practices and there were variations among individual farms, but within the purview of certification procedures. Conventional and organic farming practices of the study area differed mainly on fertilization policy, plant protection strategy, weed control and land management.

Soils of the organic cardamom farms were found to have better aeration than conventional farms, evident from the significantly lower bulk density of soils of the organic farms. Another significant effect of organic agriculture in cardamom was the improvement of soil electrochemical properties.

The rich organic soils of the study area resulted in insignificant difference in organic carbon and organic matter content of the soils of the two farming systems. The ranges of major nutrients in soils were medium to high and hence the difference between organic and conventional cardamom farms with respect to major nutrients was also not consistent. Microbes were proliferating in the organic farms resulting in

better decomposition of organic matter with concomitant solubility of major nutrients in the soil. But dehydrogenase enzyme activity of the soil didn't differ significantly.

Conventional farming with chemical inputs enhanced morphological make up of cardamom plants. Leaf length, leaf breadth, plant height and number of tillers per clump were significantly low in organic cardamom plants. A reverse trend was seen in the case of petiole length.

Panicle length, number of panicles per clump, number of racemes per panicle and number of capsules per raceme were significantly lower in organic farms contributing to lower yields, which of course are expected to improve as farming practices stabilize in due course.

Since the morphological make up of the cardamom plants in the organic farms was relatively smaller, the minerals taken up were not diluted resulting in higher concentrations of major nutrients in organically managed plants. The effect of high levels of Ca in the exchange complex is also reflected in low uptake of Fe and Mn by organic cardamom plants.

Size of fresh cardamom capsules, colour, and litre weight were higher in the organically produced cardamom samples. However, the number of seeds per capsule was lower in organic cardamom. Both oleoresin and volatile oil contents were found significantly superior in the organic to that of conventional cardamom.

ANEXURE

ANNEXURE

Farming practices adopted in the cardamom plantation under study

Sl. No.	Farming practices			
1.	**Conversion requirements**			
1.1.	Conversion period undergone	Yes	No	NA
1.2.	Converted lands and animals are not alternated between	Yes	No	NA
2.	**Ecosystem maintenance**			
2.1.	Forest ecosystem maintained	Yes	No	NA
2.2.	Bio-fencing maintained	Yes	No	NA
2.3.	Shade trees are maintained	Yes	No	NA
2.4.	Percentage of shade available to the cardamom plants	Yes	No	NA
3.	**Choice of crops and varieties**			
3.1.	Organically produced planting materials are used	Yes	No	NA
3.2.	Genetically modified planting materials are used	Yes	No	NA
4.	**Fertilization policy**			
4.1.	Plant residues are generally incorporated in the soil	Yes	No	NA
4.2.	The manures used do not contain human excreta	Yes	No	NA
4.3.	Mineral materials are used	Yes	No	NA

Sl No.	Type of mineral	Per plant (Kg)
A.	Lime	
B.	Dolomite	
C.	Rock phosphate	
D.		

4.4.	Mineral amendments are applied in the natural form only	Yes	No	NA
4.5.	Chemical fertilizers are applied	Yes	No	NA

Sl No.	Chemical fertilizer	N:P:K ratio	No. of application	Month of application
A.				
B.				
C.				
D.				

4.6. Organic manures are applied | Yes | No | NA |

Sl No.	Type of manure	Per plant (Kg)
A.		
B.		
C.		
D.		

4.7. Only well rotten manures are used | Yes | No | NA |

4.8. Organic manures are produced within the farm | Yes | No | NA |

4.9. Organic manures obtained from out side agencies | Yes | No | NA |

Sl.No.	Brand name	Content	Manufacturer	Rate/plant
A.				
B.				
C.				

5. Pest, Diseases, weed management strategies

5.1. Mechanical control and cultural methods are more often adapted | Yes | No | NA |

5.2. Biological pest control products are used, if necessary | Yes | No | NA |

5.3. Biological pesticides are produced with in the farm | Yes | No | NA |

Sl. No.	Products	Rate of application
A.		
B.		
C.		

5.4. Biological pesticides are brought from out side

Yes	No	NA

Sl.No.	Brand name	Content	Manufacturer	Rate/plant
A.				
B.				
C.				
D.				

5.5. Chemical pesticides are used

Yes	No	NA

Sl.No.	Brand name	Content	Manufacturer	Rate/plant
A.				
B.				
C.				
D.				

5.6. Weedicide are used

Yes	No	NA

Sl.No.	Brand name	Content	Manufacturer	Rate/plant
A.				
B.				
C.				
D.				

5.7. Chemical fungicide are used

Yes	No	NA

Sl.No.	Brand name	Content	Manufacturer	Rate/plant
A.				
B.				
C.				
D.				

5.8. Chemicals are used in the washing of capsules before curing

Yes	No	NA

Sl. No.	Products	Rate of application
A.		
B.		
C.		
D.		

6. **Contamination control**

6.1.	Plastic materials are properly removed	Yes	No	NA
6.2.	Plastic materials are not burned in the field	Yes	No	NA
6.3.	Equipments like sprayers, spade, sickle; collection baskets, which are used for conventional cultivation, are not used for organic ones	Yes	No	NA
6.4.	Organic produce is not stored along with the conventional produce	Yes	No	NA

7. **Soil and water conservation**

7.1.	Primary forest is fully protected	Yes	No	NA
7.2.	Soil conservation measures taken	Yes	No	NA
7.3.	Tillage operations done on sloppy land areas	Yes	No	NA
7.4.	Proper spacing maintained	Yes	No	NA

8. **Farm animals**

8.1.	Farm animals are allowed to graze freely	Yes	No	NA

Sl. No.	Type	Adults	Infant	Total	Density
A.					
B.					
C.					

8.2.	Farm animals are fed with organic feed produced in the from	Yes	No	NA

Sl. No.	Cattle feed	Category (Organic/ conventional)
A.		
B.		
C.		

8.3.	Cattle feed bought from extraneous source	Yes	No	NA

Sl.No.	Brand name	Content	Manufacturer
A.			
B.			
C.			
D.			

8.4. Poultry component maintained in the farm

Yes	No	NA

9. **Bee keeping**

9.1. Honey bees are maintained in the farm

Yes	No	NA