

BIODIVERSITY OF MEDICINAL PLANTS IN OIL PALM PLANTATIONS

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2000

DECLARATION

I hereby declare that, this thesis entitled "**Biodiversity of medicinal plants in oil palm plantations**" 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 to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

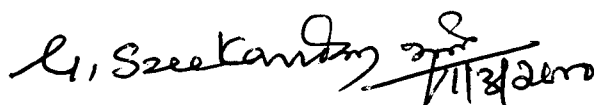
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Certified that this thesis entitled “**Biodiversity of medicinal plants in oil palm plantations**” is a record of research work done independently by **Miss. Sarada. S.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

1. INTRODUCTION

Plants have been a major source of medicine since time immemorial. Ample evidences are there in ancient Vedas on the use of plant derived medicines for curing human ailments. Throughout the world, priority has been given to plant based medicines which are safe, time tested and affordable to common man. Today, more than 75 per cent of the World's population relies mainly on plant based medicines for health care. There are about 2,50,000 higher plant species on the earth out of which more than 80,000 are reported to have medicinal value (Singh and Kumar,1998).

India is endowed with an amazing array of medicinal and aromatic plants and is considered as one of the mega biodiversity centres in the world. Of about 45,000 plant species found in India, about 2000 are being extensively utilised for the treatment of various human and animal ailments. About 400 plants are used in the regular production of Ayurvedic, Unani, Siddha and Tibetan medicines. About 75 per cent among them are from India's tropical forests and 25 per cent are from temperate forests (Hegde, 1999).

The plant wealth of India comprises of several plant species of therapeutic value specified in the pharmacopoeias of various countries. They are seen in abundance in their natural state of growth as weeds in many parts of the country. Throughout the warm humid tropics, growth of natural vegetation is rapid and vigorous. The lush natural flora of shade tolerant weed species growing in the plantations such as oil palm, rubber and forest plantations contain a large number of species which are widely used in the indigenous systems of medicine and folklore medicine.

Organised intercropping is not being practised in oil palm plantations at present. Literature shows that intercropping on an experimental scale has been practised in some plantations in the initial years of their establishment. The plants tried are maize, cowpea, okra, yams and cassava. In some cases cover-cropping with *Calapogonium sp.* is also attempted. As the oil palm plantations are established in forest locations or in their neighbourhood, the agro-climatic conditions prevailing in those areas favour the luxuriant growth of a large number of weeds. The weed growth is controlled by one or two slashing in an year. During slashing, as the root system of the weeds is not disturbed, the weed flora in the oil palm plantations flourishes by the commencement of rain after slashing.

Many of these weeds have medicinal properties and some of them are very valuable as medicinal plants. A study of the medicinal plant flora in the oil palm plantations can be helpful in the present context of scarcity of medicinal plants for officinal use. Further, the study of growth behaviour of selected medicinal plants available in these plantations will provide insight on the possibilities of introducing some of the medicinal plants as intercrops in oil palm plantations. This view can be authenticated by the chemical investigation of active ingredients in these plants. This in turn, will help to increase the unit area income from oil palm plantations.

With these considerations the following were set out as major objectives of the present study:-

- (1) Identification of medicinal plants from among the existing natural flora in the inter spaces of young, medium and mature oil palm plantations and open conditions.
- (2) Study of growth behaviour of selected medicinal plants.
- (3) Investigation on the influence of shade on the pharmacologically active constituents, through biochemical assay.



**REVIEW
OF
LITERATURE**

2. REVIEW OF LITERATURE

The forests in India are principal repositories of large number of medicinal and aromatic plants. They are largely being collected as raw materials for manufacture of drugs and several oriental perfumery products, since ancient times. They also remain to be the exclusive source of plant genetic material in this group of plants. Any information about such genetic resources in these forests and adjoining areas play a vital role in formulating strategies for their conservation as well as their sustainable utilization. The information available on these aspects and on the chemical constituents and medicinal properties of selected plants are reviewed under the following heads:

- 2.1. Biodiversity of medicinal plants
- 2.2. Conservation of biodiversity
- 2.3. Chemical constituents and medicinal properties of selected medicinal plants

2.1. Biodiversity of medicinal plants

Biodiversity can be defined as the sum total of plants, animals and micro-organisms existing as an interacting system in the biosphere. It can be autosustainable and self-regenerating if there are

no natural and/or man-made perturbations. There are two major functions of biodiversity. Firstly, on it depends the stability of the biosphere which leads to stability of climate, water, soil and health of the biosphere. Secondly, the species on which the human race depends for food, fodder, fuel, fibre, medicine *etc.*, by and large exist in Vavilovian centers of diversity and origin, which are located mostly in the tropics and sub-tropics. (Khoshoo, 1991)

Biological diversity is the very basis of human survival and economic well being as it provides food, medicine and industrial raw material and offers a potential for providing many more yet unknown benefits for future generations. (Singh *et al.*, 1994)

Biodiversity refers to the variety and variability of all animals, plants and micro-organisms on earth and is existing at three levels such as genetic diversity, species diversity and ecosystem diversity. (Haeruman, 1995).

2.1.1. Biodiversity in forests

The humid tropical evergreen forests of Kerala are rich in plant wealth with considerable diversity occurring in several economic plants. The Western Ghats harbours different forest types *viz.*, wet evergreen.

semi evergreen, dry deciduous, moist deciduous, scrub jungles, sholas and montane grass lands. Pristine rain forests are found in Silent Valley, Sabarigiri and Agasthyamalai regions.

The pioneer work on the medicinal plants of the Western Ghat region of Kerala state was the 'Hortus malabaricus' written by Rhedean (1678-1693). The twelve volume monumental work gave description of about 742 plants including their medicinal properties, that occurred in the Malabar region at that time.

A descriptive list of the medicinal plants of Kerala forests was prepared by Nambiar *et al.*(1985). Nair and Daniel (1986) published a list of about 46 species of important medicinal plants found in Kerala forests. Twenty five vulnerable medicinal plants of Munnar forest region were described by Bhat and Padmaja (1991).

Sasidharan (1991) observed that, among the medicinal plants of Kerala forests, nearly 150 species are used to manufacture ayurvedic medicines on a commercial scale, while other species are mostly used as single plant remedies by traditional vaidyas and tribals.

In a floristic diversity study of the Agasthyamala area of the Western Ghats, Mohanan *et al.* (1997) located 124 medicinal plant

species which demand active conservation measures to save them from over exploitation.

Miniraj (1997) recorded that medicinal plant populations have large areas of distribution, while there are also endemic species confined to a few pockets. Detailed botanic and ecological studies need to be carried out in these areas to document them and to study their populations and the natural conditions in which they grow.

Raveendran and Pandurangan (1997) revealed that 46 per cent of the flora contained in the Western Ghat region are known medicinal plants.

Gupta and Sethi(1983) reported that the forests in India are particularly rich in medicinal plants. The forest types of India are grouped in 16 categories, based on phytogeography, climate and vegetation. However, most forest ecologists agree with 12 broad biogeographic regions to describe the ecological parameters and distribution of major medicinal plants in these forests. Investigators have conducted several explorations in different regions and reported valuable information on distribution of medicinal and aromatic plant species and their genetic variability.

India as a center of genetic diversity has many wild relatives of crop plants which are potentially useful sources of genes for plant breeding and biotechnology. Medicinal plants, one such genetic resources available, both cultivated and wild offer new pharmaceutical products. (Chandel *et al.*,1992)

Sharma and Hore (1993) observed high diversity of medicinal plants in north eastern India. India, though rich in biodiversity with about 45,000 plant species is now under threat of partial extinction of several species, mainly due to human intervention (Damodaran, 1996)

Nayar (1996) opined that the humid tropical forests of India still present a remarkable diversity of medicinal plants that defy comprehension. The total angiosperm flowering plants of India comprises approximately 18,000 species of which 2500 species possess medicinal or aromatic properties. Ecosystemwise, India has 42 vegetation types, 16 major forest types, 10 biogeographical zones and 25 hot spots of endemic centers. It is the sum total of such remarkable diversity which has made India a gene center for a number of medicinal and aromatic plants.

A macro analysis of the distribution of medicinal plants by Shankar *et al.* (1997) showed that they are distributed across diverse

habitats. About 70 per cent of India's medicinal plants are found in her tropical forests and less than 30 per cent in the temperate forests at higher altitudes. Micro studies showed that a larger per cent of medicinal plants occur in the dry and moist deciduous forest when compared to the evergreen or temperate forests.

Kinghorn and Balandrin (1993) gave an account of tropical forest biodiversity and the potential for new medicinal plants, biological and chemical diversity and the search for new pharmaceuticals and other bioactive natural products.

According to Loreau *et al.*(1995)the diversity of species in a community or region can only be explained if abiotic factors, biological interactions such as competition, predation, parasitism and mutualism, and their various indirect effects, ecosystem processes, temporal and spatial variability of environment, regional processes and historical contingency and evolutionary processes are taken into account.

Younes (1996) discussed about the contributions of tropical biodiversity to the world's medicine cabinets along with lists of plants in use.

2.1.2. Biodiversity in plantations

Coconut plantations (7 lakh ha) and rubber plantations (5 lakh ha) cover the majority of area under plantation crops in Kerala. The growth of the natural vegetation in the interspaces of these crops is rapid and vigorous throughout the warm humid tropics. The vicinity of these plantations to forests also promotes the luxuriant growth of numerous plant species under their canopy.

According to Nair and Chami (1963) bulk of weeds in the coconut garden of CPCRI, Kasargod belong to families viz. Leguminosae, Asteraceae and Rubiaceae. They are represented by *Mimosa pudica*, *Cassia tora*, *Borreria hispida*, *Borreria ocymoides*, *Oldenlandia corymbosa*, *Cleome viscosa*, *Cloeome monophylla*, *Ageratum conyzoides*, *Scoparia dulcis*, *Acrocephalus indicus*, *Hyptis suaveolens*, *Tridax procumbens* etc. Among monocotyledonous plants *Cyperus rotundus* and *Cyperus compressus* formed the major troublesome weeds. Other grass weeds were *Eragrostis plumosa*, *Eragrostis poaeoides*, *Eleusine indica*, *Panicum maximum*, *Pennisetum polystachion*, *Digitaria marginata*, *Cynodon dactylon*, *Ischaemum ciliare*, *Apocopsis wrightii*, etc.

Eupatorium odoratum is a troublesome weed species found in coconut plantations of Ceylon (Salgado, 1972) and India (Mogali and Hosmani, 1981)

Litscher and Whiteman (1982) observed that the most common weeds of coconut plantations in Solomon islands are *Sphaerostephanos unitus* and *Nephrolepis hirsutula*.

Florence *et al.*(1983) observed that the poorly tended coconut plantations of French Polynesia were infested with a number of woody and herbaceous spp., principally *Cassytha filiformis*, *Euphorbia hirta*, *Morinda citrifolia*, *Portulaca lutea* and *Scaevola frutescens*.

Simbolon and Suhardjono (1986) found that the major weed species of coconut plantations in West Java - *Lantana camara*, *Mikania cordata*, *Eupatorium odoratum*, *Imperata cylindrica* and *Lygodium sp.* exhibited a wide ranging tolerance to edaphic and seasonal factors.

Pushparajah and Woo (1971) reported several species of weeds such as *Axonopus compressus*, *Paspalum conjugatum*, *Eleusine indica*, *Cyperus sp.* and *Borreria latifolia* in rubber plantations of Malaysia.

The climatic conditions under which rubber is grown, promote the rapid and luxuriant growth of weeds. As soon as the land is cleared for planting, natural weed species dominate the area. The most common species found in such condition are *Chromolaena odorata*, *Mimosa pudica*, *Imperata cylindrica*, *Pennisetum polystachyon*, *Borreria spp* and *Lantana aculeata* (Potty *et al.*, 1980)

According to Alif (1982) the weeds such as *Imperata cylindrica*, *Eupatorium odoratum* and *Mikania cordata* grow well under the ecological conditions of small scale rubber plantations in Southeast Asia.

Teoh *et al.* (1982) reported that *Asystasia intrusa*, *Clidemia hirta* and *Elettariopsis curtisii* are potentially serious weeds in rubber and oil palm plantations in Malaysia.

Teng *et al.* (1984) observed that grasses such as *Paspalum conjugatum*, *Ottochloa nodosa* and broad leaved weeds such as *Mikania cordata*, *Pueraria phaseoloides* were found in young rubber plantings and ferns such as *Nephrolepis bisserata* in mature rubber plantings.

Arope *et al.* (1985) reported infestation of rubber plantations of Malaysia by *Brachiaria mutica*, *Ottochloa nodosa*, *Paspalum spp*,

Axonopus spp., *Asystasia coromandeliana*, *Mikania micrantha* and *Imperata cylindrica*.

Lima and Pereira (1985) reported that in a mature rubber plantation of South Bahia, the dominant weeds were *Paspalum conjugatum*, *Hydrocotyle bonariensis*, *Veronia scorpioides*, *Scleria pterota* and *Diodia ocimifolia*.

The vegetational structure of a rubber plantation is described in terms of rubber tree density and growth and weed growth including weed composition with a list of most dominant species like *Melastoma malabathricum*, *Chromolaena odorata*, *Scleria sp.*, *Clibadium surinamense*, *Clidemia hirta* and *Imperata cylindrica*. (Tjitrosemito *et al.*, 1986)

Cataloguing of medicinal plants in Vellanikkara rubber estate was done by Raghavan (1992). He catalogued 50 plants growing as undergrowths in rubber plantations.

Quantification of medicinal plants identified in rubber plantations of Vellanikkara was done by Ramabhadran (1993). He described 34 species of medicinal plants and quantified the availability of officinal parts of important medicinal plants.

2.1.3. Biodiversity in Oil palm plantations

Hartley (1911) observed that in Malaya, the 'natural covers' of oil palm consisted of soft weeds followed by grass species like *Paspalum* and *Axonopus* with small shrubs such as *Trema* and *Lantana* and the creepers *Mikania cordata* and *Passiflora* sp. The fern *Nephrolepis biserrata* was also dominant, though mixed with grasses and *Mikania*. In the new oil palm plantings of tropical America, grass species like *Panicum maximum* and *Pennisetum purpureum* were common.

Adansi (1969) reported weeds such as *Cyperus rotundus*, *Ageratum conyzoides*, *Paspalum conjugatum*, *Cynodon* sp., *Euphorbia* sp., *Tridax* sp. and *Commelina nudiflora* in young oil palm plantations of Ghana.

According to Seth and Baba (1970) the dominant weeds in young oil palm plantations were *Paspalum conjugatum*, *Panicum nodosum*, *Digitaria* spp. and *Axonopus compressus*.

Coomans (1971) described the evolution of weed flora in oil palm plantations of Ivory Coast from 5 to 20 years. At about 5 years, a grassy association based on *Axonopus compressus*, *Paspalum conjugatum* and a

few shade tolerant broad leaved plants became common. From 5 to 12 years, grasses and dicotyledons were present in greater variety and in varying proportions, while from 12 to 20 years, the flora around the trunks were chiefly composed of small dicotyledons in an association based on *Diodia rubricosa* and *Desmodium adscendens*. On the edges of roads, *Eleusine indica*, *Sporobolus pyramidalis*, *Centrosema pubescens*, *Setaria megaphylla* and *Setaria chevalieri* were found. Under older palms *Thaumatococcus danielli*, *Talinum* spp., *Phyllanthus amarus*, *Cyathula prostrata*, *Asystasia gangetica* and *Desmodium adscendens* were found.

Gaullier (1986) reported species growing under the palm canopy in Cameroon viz. *Cyperus fertilis*, *Haumania danckelmaniana*, *Aframom* spp., *Stephania* sp., *Mimosa pudica*, *Urera cordifolia*, *Mikania cordata*, *Eupatorium odoratum*, *Lantana camara*, *Asystasia gangetica*, *Cyathula achyranthoides*, *Anthocleista* sp., *Vernonia* sp., *Macaranga* sp. and *Cogniauxia* sp.

Sunitha *et al.* (1995) observed that under humid tropical conditions in India, a large number of plants are found in oil palm plantations. Morphologically these weeds can be differentiated into broad leaved and narrow leaved weeds and their dominance depends

upon the agroclimatological conditions. Grassy weeds dominate the new plantations whereas a mixed flora is found in established plantations.

The following weeds commonly occur in oil palm plantations: *Eupatorium odoratum*, *Borreria sp.*, *Mimosa pudica*, *Imperata cylindrica* and *Paspalum conjugatum* (Panickar, 1997)

2.2. Conservation of biodiversity

Conservation of biodiversity is being defined as a process involving three components *viz.* saving, studying and sustainably using biodiversity (Barbier and Aylward, 1996)

Conservation of biodiversity is considered as something which affects the totality of environment and on which even the very existence of life forms including human species depends. (Khoshoo, 1993)

Conservation of biodiversity is attempted principally through two methods - *in situ* and *ex situ*. *In situ* conservation of species involves conservation under natural conditions. *Ex situ* approach aims at conservation of complete organisms or their relevant parts. These are preserved in living condition in botanical gardens or arboreta (Khoshoo, 1991)

The red data book of India has 427 entries on threatened medicinal and aromatic plant species of which 28 are considered extinct, 124 endangered, 81 vulnerable, 100 rare and 34 insufficiently known. Amongst the above, 35 important endangered medicinal and aromatic plant species of India need detailed studies for *in situ* conservation. (Gupta, 1994)

Ram (1991) reported that Conservation of endangered plant species through *in vitro* micropropagation techniques is a method of recent origin which holds great promise for the conservation of endangered plant species such as *Picrorhiza kurroa*, *Valeriana wallichii*, *Podophyllum hexandrum*, *Saussurea lappa*, *Coptis teeta*, etc.

Within the pharmaceutical industry, there is currently a resurgence of interest in 'pharmaceutical prospecting', or exploring biodiversity as a source of novel chemical compounds for use in the development of new pharmaceuticals. Aylward (1993) examined pharmaceutical prospecting from an economic perspective. His study showed that prospecting for new drugs using biodiversity can be a profitable activity but it is unlikely to make a major contribution to the cost of protecting biodiversity.

Simpson *et al.* (1996) defined biodiversity prospecting as a mechanism for both discovering new pharmaceutical products and saving endangered ecosystems. The relationship between biodiversity and ecosystem function predicts that some taxa will have many ecological analogues and others few. The latter as well as other important functional groups tend to receive priority in conservation. (Donaldson and Scott, 1994)

According to Mehrotra *et al.* (1996) forests are the chief resource for the collection and exploration of biological materials. The past few decades witnessed large scale deforestation in India due to population growth, demand for more land for agriculture, urbanization and industrial activities. This has resulted in the loss of soil cover, habitat destruction, environmental degradation and ecological imbalance. This scenario has created a progressive awareness for the conservation and restoration of habitats and thus the declaration of many forest areas into protected zones, such as national parks and biosphere reserves.

Rajasekharan *et al.* (1996) reported that biodiversity conservation has recently received considerable attention all over the world and its various aspects have been debated at different platforms by scientific communities, policy makers and administrators.

Miniraj (1997) suggested that it is only in nature that plant diversity at genetic, species and ecosystem levels can be conserved on a longterm basis. Unless plant populations are conserved in the wild, that is in their natural habitats, in viable breeding populations, they run the risk of extinction. Though scarce, there are experimental evidences to strengthen the fact that the secondary metabolite production and the properties of the medicinal plants differ with the change of habitat. So, any improvement method or management practice should be designed in such a way that it is not at the expense of its quality. Under domestication outside the normal habitat or ecological range, many of the medicinal plants tend to behave differently. An understanding of the biological and ecological background of the species in their normal habitat is hence essential to understand their conservation biology as well as to predict their behaviour under artificial cultivation.

Considerable number of medicinal species have become rare, endangered or threatened due to various factors. Due to over exploitation several medicinal plants, such as *Rauvolfia serpentina*, *Dioscorea deltoidea*, *Aconitium deinorrhizium*, *Colchicum luteum*, *Atropa acuminata* and *Gentiana kurroo* (Western Himalayas), *Coptis teeta* (Arunachal Pradesh) *Dioscorea praziri* (Eastern Himalayas), *Nardostachys grandiflora* and *Picrorhiza kurroa* (Alpine Himalayas)

have become endangered or are in the verge of extinction (Arora, 1983; Thakur, 1993)

Ved *et al.* (1998) reported that many of the therapeutically useful plants are no longer available from the wild, in quantities required. Non-availability of quality raw material is not only because of the population pressure and increase in demand but also because of the fact that 70 per cent of the plant drugs involve destructive harvesting -roots (29 per cent of the plants), rhizomes (4 per cent), whole plant (16 per cent), bark (14 per cent), wood (3 per cent) and stem (6 per cent).

A red data list of South Indian medicinal plants published recently listed 73 medicinal plants under different categories as rare, vulnerable, endangered, critically endangered, extinct, low risk, data deficient and extinct in wild. (Shankar *et al.*, 1997)

The biodiversity wealth of Kerala was analysed by Manoharan *et al.* (1996). The realisation of conservation efforts achieved through both governmental and peoples' participation is best exemplified in Kerala, where there is a long tradition of religion bound conservation ethics. The biodiversity wealth of Agasthyamala, Thekkady, Eravikulam/Anaimudi highranges and Silent Valley needs special

attention. Establishment of permanent bio-monitoring plots as representatives of states' unique biodiversity wealth is proposed.

2.3. Chemical constituents and medicinal properties of selected medicinal plants

Chopra *et al.*(1958) found that plants generally owe their virtues as medicinal agents to certain characteristic constituents like alkaloids, glycosides, saponins, flavonoids, tannins, volatile oil, steroids or terpenoids, resin and mucilage present in them. Plants synthesise these organic compounds during their metabolic process when they grow. The amount of active substances present in plants is dependent upon several factors, for example, the nature of the soil, the climate, the season, the stage of growth of a plant, the nature and intensity of light, cultivation, *etc.*

The alkaloids give a bitter taste to the plant and a considerable number of medicinal drugs owe their curative properties to these principles. Many naturally derived drugs like morphine from poppy, nicotine from tobacco, cocaine from cocoa, caffeine from coffee *etc.* are alkaloids of plant origin (Chopra *et al.*, 1958)

Mossa *et al.*(1987) observed that glycosides are much wider in occurrence than alkaloids and they are sugar containing compounds. They constitute major classes of drugs like digitalis glycosides, sennosides, rutin, arbutin, etc. Saponins are glycosides generally with sterols or triterpenes and their aglycones. Saponin containing natural ingredients are sarsaparilla, fenugreek, licorice *etc.*

The total effect of a plant when it is administered in its original complex, biochemical package, is rarely produced by the isolated active principle. We can elucidate the reason for this beneficial total effect of the plant extract as a synergistic or modifying action of the accompanying chemicals in the extract on the pharmacological activity of the main constituents. (Mossa *et al.*, 1987)

At least 121 chemical substances of known structure are still extracted from plants that are useful as drugs throughout the world (Farnsworth and Soejarto, 1988). According to an estimate of World Health Organisation (WHO), approximately 80 per cent of the people in developing countries rely chiefly on traditional medicines for their primary health care needs, of which a major portion involves the use of plant extracts or their active principles.

Santhosh and Bharadwaj (1996) reported that plant cells are highly sophisticated chemical factories where a large variety of chemical compounds are manufactured with great precisions and ease from simple raw materials. Plants are thus a very important renewable source of raw materials for the production of a variety of chemicals and drugs. Tropical and subtropical regions of the world exhibit an amazing array of variability, particularly chemical variability for secondary metabolites. India is one of the twelve megadiversity countries in the world for chemical variability of secondary metabolites.

Jaysekhar (1997) observed that the phytochemicals of medicinal importance are secondary metabolites which are biosynthesised in plants from glycerates and pyruvates through acetyl co-enzyme A or malonyl co-enzyme A. Important acetogenins like flavonones, lignans, quinones and lipids exhibited various biological activities. Certain carbohydrates like pectin, gum, dextran, inulin *etc.* have significant role in pharmacy. Isoprenoids like carotenoids, steroids, terpenoids *etc.* become major share in phytochemical so far isolated. The nitrogenous base like alkaloids and certain aminoacids and proteins are found to have marked pharmacological activity.

Miniraj (1997) observed that the active principles in medicinal plants are certain secondary metabolites like alkaloids, glycosides,

coumarins or steroids which are related with the ecology rather than the normal physiology of the plant. The environmental conditions to which the plant is exposed influence the production of these secondary metabolites and ultimately the efficacy of the drug.

Vartak and Mandavgane (1981) reported that out of 46 species surveyed in the tribal area of Karnala forest of Maharashtra, eight species were found to be used for controlling high fever, twelve were used for the control of dysentery, six were used for treating jaundice, eight were used for bronchitis, nine were used for soothing rheumatic pains and the rest eight were used for skin diseases.

Jain and Puri (1984) published a list of 100 species of ethnomedicinal plants with descriptions of their medicinal uses, including 10 species used for diseases of cattle. Methods of preparation of the crude drugs are given and the active ingredients indicated when known.

Antipyretic utility of some Indian plants in traditional medicines were revealed by Anis and Iqbal (1986). Based on a survey of the Gwalior forest region in Central India, fifteen preparations made with seventeen plant species were found to be used by Shareon tribe against pneumonia, malaria, typhoid and other fevers.

2.3.1. *Hemidesmus indicus*

Iyer and Kolammal (1951) recorded that the air dried material of *Hemidesmus* contains about 0.225 per cent essential oil, of which about 80 per cent consist of a crystalline substance, identified as 2-hydroxy - 4- methoxy benzaldehyde. The odour of the drug is due to this aldehyde. The petrol ether extract of the roots contains a ketone, resinols, sterols and fatty acids. The alcohol extract of the defatted roots contains saponins, tannin, a crystalline resin acid, an amorphous resin acid and inositol. The roots also contain small amounts of tetracyclic triterpene alcohols.

Chopra *et al.* (1958) reported that the roots of *Hemidesmus* yield by simple distillation with water a steroterpene which is a volatile acid. The roots also contain an essential oil of which 80 per cent consists of a crystalline material 2-hydroxy-4-methoxy benzaldehyde, sterols (hemidosterol and hemidesmol), resins, tannin, glycoside and saponin.

Subramanian and Nair (1968) listed the flavonol glycosides found in various organs of *Hemidesmus indicus* and the aglycones derived from the hydrolysis of these compounds.

The hexane soluble portion of the ethanol extract of the stem of *Hemidesmus indicus* afforded a new triterpene lactone, characterized as 3-keto-lup-12-ene-21 leads to 28-olide. Further lupanone, delta (12)-dehydrolupanyl-3-beta-acetate, delta(12) - dehydrolupeolacetate, hexadeca-noic acid, 4-hydroxy -3- methoxy benzaldehyde, 3-hydroxy 4-methoxy benzaldehyde were also isolated for the first time from this plant. (Gupta *et al.*, 1992)

Chandra *et al.* (1994) reported that two novel pregnane glycosides, hemidescine and emidine have been isolated from the dried stem of *Hemidesmus indicus*. Chemical and spectroscopic evidence is consistent with the structures 20-O-acetyl calogen in 3-O-beta-D-digitoxo pyranosyl (1 leads to 4)-O- beta- D -Oleandropyranoside and calogenin - 3- O beta - D - digitoxopyranosyl (1 leads to 4)-O- beta - D- digitoxo pyranosyl (1 leads to 4)- O-beta - D - digitoxopyranoside respectively.

The Hindus consider *Hemidesmus indicus* to be demulcent, alterative and tonic and prescribe them in dyspepsia, skin diseases, syphilis, fever and dysentery. The root is used as a remedy for the inflammation of the urinary passage. It is highly diuretic. It also acts as diaphoretic and tonic, and increases appetite. The aroma and taste of the drug is due to the presence of coumarin, which can be obtained in part by boiling the root with water. Crystals of coumarin can be prepared

from the residue after distillation by drying and extracting with alcohol.
(Dymock *et al.* 1891)

Iyer and Kolammal (1951) further reported that *Hemidesmus* is arresting, cures haemorrhage resulting from mutual vitiation of pitta and blood and is cooling. It is also demulcent, productive of semen, cures deficient digestive power, tastelessness, difficult breathing, cough, toxic conditions due to accumulation of unassimilable products of defective digestion, vitiation of the three primary factors - vata, pitta and kapha, uterine haemorrhage, fever and diarrhoea. It is also considered as bitter, as beneficial in thirst, vomiting, skin diseases, bad smell of the body and in poisoning.

Kurup *et al.* (1979) reported that the tuberous root of *Hemidesmus* has cooling and blood purifying action and hence used for making refreshing drinks. The root is also alterative, aphrodisiac, refrigerant, diuretic and tonic. It overcomes vitiated vata, pitta and Kapha and cures dyspepsia, deficient digestive power, dysentery, cough, bronchitis, leucorrhoea, uterine haemorrhage, dysuria and blood diseases. The drug is useful in skin diseases, fever, thirst, vomiting, poisoning, chronic rheumatism, anaemia and debility.

Prasad *et al.* (1983) observed that the oil of *Hemidesmus* showed marked antibacterial activity against both gram negative and gram positive organisms even at 0.2% concentration but it did not show appreciable antifungal effect.

Nambiar *et al.* (1985) reported that the root of *Hemidesmus* is demulcent, alterative, diaphoretic, diuretic and tonic. Root is recommended for fever, skin diseases, leucorrhoea, syphilis and rheumatism.

Rao (1914), Chopra *et al.* (1958) and Narayanaswamy (1987) reported that the roots of *Hemidesmus* are an excellent substitute for sarsaparilla. They are sweet, demulcent, alterative, diaphoretic, diuretic, tonic and blood purifier. The root is prescribed usually in the form of syrup. It is aphrodisiac, antipyretic, alexiteric, antidiarrhoeal, astringent to the bowels, cures leprosy, leucoderma, itching, skin diseases, fevers, foul odour from the body, loss of appetite, asthma, bronchitis, leucorrhoea, thirst, burning sensation, useful in piles, rat bite poisoning, eye troubles, epileptia fits in children, hemicrania, pain in the joints and syphilis. The leaves are good for vomiting, colds, wounds and leucoderma. The stem is diaphoretic, diuretic, laxative, lessen inflammation, good for diseases of brain, liver, kidney, glut, uterine complaints, paralysis, cough, asthma and gargle is good for

tooth-ache. The root in combination with other drugs is prescribed in snake bite.

2.3.2. *Solanum melongena* var. *insanum*

Solasodine content variations in wild collections have been documented. The reported variations are 0.16 to 0.50 per cent by Chaudhuri and Hazarika (1965), 1.55 to 1.89 per cent by Chandra *et al.* (1970), 1.04 to 2.4 per cent by Kaul and Zutshi (1974), 0 to 4 per cent by Khanna and Murthy (1974) and 0.16 to 2.32 per cent by Singh *et al.* (1978).

Saini *et al.* (1965) and Chauhan *et al.* (1975) reported that the study of ontogenic variations in the solasodine content during berry development have shown that the maximum accumulation of solasodine in berries occurred when the berry colour turns from green to yellow.

Large amounts of acid and base are normally required with standard extraction methods for obtaining the glycoderivative of solasodine from *Solanum spp.* for the manufacture of steroidal drugs. The technique described by Marquardt and Blasco (1985) employs 3 per cent aqueous acetic acid for pretreating the plant material which is then leached with water, the glycoderivative being precipitated by

neutralization with ammonia. The amount of reagents required is greatly reduced and the yields are not significantly lower.

Goswami *et al.* (1986) described the method of determining solasodine. Contents in the berries of five species from north eastern India ranged from 0.04 to 1.72 per cent.

There is a worldwide demand for solasonine (a nitrogen derivative of diosgenin) for the manufacture of several steroid drugs whose hormonal derivatives are used as active ingredients of the oral contraceptive pill. A survey of solasonine yielding plants was made and a rapid and easy colorimetric method for estimating solasonine was established (Gupta, 1995).

Evans (1997) reported that *Solanum* genus is responsible for synthesis of steroidal glycosidic alkaloids. These alkaloids have been investigated as potential intermediates in corticosteroid synthesis. It is noted for the production of C₂₇ steroidal alkaloids in many species. Zenk and colleagues have assayed over 250 spp. of *Solanum* for solasodine. Solasodine is the nitrogen analogue of the C₂₇ sapogenin. Steroidal alkaloidal glycosides have haemolytic properties like saponins. The sugar components, one to four in number, are attached in the 3-position and may be glucose, galactose, rhamnose or xylose. Solasodine

and 5-dehydrotomatidine are stereo isomeric spirosolanes and the configuration of the nitrogen atom is apparently always linked to that at C-25. Thus, solasodine, the nitrogen analogue of diosgenin is Δ^5 , 22 β , 25 α -spirosolen-3 β -ol and 5-dehydrotomatidine is Δ^5 , 22 α , 25 β -spirosolen-3- β -ol.

Iyer and Kolammal (1960) reported that Solanum is constipating, digestive, is pungent and bitter, removes bad taste in the mouth. It also cures skin diseases, fever, difficult breathing, pain, cough and dyspepsia. It cures vomiting, heart diseases and internal toxins formed as a result of poor digestion. Its fruit destroys pathogenic organisms and cures skin diseases. The fruits are also useful in treating ulcers. Roots, fruits and leaves form the officinal parts.

3.MATERIALS AND METHODS

The present study was carried out at the oil palm plantations of the Oil palm India Ltd., Kulathupuzha, Kollam District, Kerala. The period of study was from January 1998 to January 1999. Studies were undertaken under the following major heads.

3.1. Identification of flora and collection of plant samples.

3.2. Growth phases of selected medicinal plants

3.3. Chemical analysis of officinal part(s)

3.1. Identification of flora and collection of plant samples

3.1.1. Study site

Table 1. Geographical and weather parameters of the site selected for study

Location	Oil palm India Ltd.,Kulathupuzha
Latitude	9° - 10°N
Longitude	76° - 77°E
Altitude	100 - 300m above mean sea level
Average annual rainfall during the last three years	300 - 400cm
Temperature	25.5°C - 27.5°C

The oil palm estate at Kulathupuzha covers a total area of 390 ha. It comprises of plants belonging to three categories -

- 1) Young - < 5 years (Plate 1)
- 2) Medium - 5-11 years (Plate 2)
- 3) Mature - > 11 years (Plate 3)

The interspaces are densely covered by numerous weed species. No cultural operations are being done in this area. The soil is deep, well drained, clayey loam. Topography is undulating in nature. Palms in the plantation are spaced at 10m in triangular planting system. The variety of oil palm planted is Tenera(Dura x Pisifera)

3.1.2. Flora

3.1.2.1. Sampling technique

Stratified random sampling technique was adopted, the strata being young, medium and mature oil palm plantations and open conditions. The medicinal plants in the interspaces of young, medium and mature oil palm plantations and in the open was identified and quantified by random sampling technique using 1.0 m² frame. The frame was thrown at random and all the plants in each quadrat were collected and sorted. A total of 80 such sampling units were taken randomly giving sufficient representation to the area covered.

PLATES



1. Young oil palm plantation



2. Medium oil palm plantation



3. Mature oil palm plantation

3.1.2.2. Identification

A large number of herbs and shrubs of annual or perennial nature are growing in the interspaces of oil palm plantations. Every plant species contained within a sampling unit was identified. Identified plants were categorized under respective botanical families with vernacular/common name and scientific name and were listed in alphabetic sequence.

3.1.2.3. Observations recorded

Following observations were recorded for each plant species in a quadrat.

3.1.2.3.1. Number of plants

Total number of plants of each species was counted and recorded.

3.1.2.3.2. Fresh weight

Fresh weight of the total number of plants of each species was recorded and expressed in grams. Fresh samples of shoot, flower, fruit and root of the plants, each weighing 100g were collected and dried in hot air oven at 70°C, till a constant weight is obtained. Dry weight of the samples was then recorded. Shoot-root ratios were also calculated.

3.1.2.3.3. Shoot weight

Weight of stem and leaf of all the plants of a species was recorded and expressed in grams.

3.1.2.3.4. Weight of flower and fruit

Weight of flower and fruit of all the plants of a species was recorded and expressed in grams

3.1.2.3.5. Root weight

Weight of root of all the plants of a species was recorded and expressed in grams.

3.1.3. Study of vegetative parameters

3.1.3.1. List or Census quadrat method

Analytical characters are determined by means of list or Census quadrat method. In this method, the plant species are listed and number of individuals of each species is counted. The following vegetative parameters were calculated.

Absolute frequency (F) = (The number of quadrats in which a given species occurs x 100)/ The total number of quadrats used

Relative frequency (Rf)(%) = (Absolute frequency for a species (F) x 100)/Total of the absolute frequencies for all species.

Absolute density(D) = The total number of plants for a given species in all quadrats.

Relative density (Rd)(%) = (Absolute density for a species (D) x 100)/Total number of plants for all species

Importance value (I.V) = Relative frequency(Rf)+
relative density (Rd)

Summed dominance ratio (SDR) = I.V/2

$$\text{Abundance} = \frac{\text{Total number of individuals of a species}}{\text{Number of quadrats of occurrence}}$$

(Kandasamy,1996)

3.1.4. Plant vegetation Analysis

3.1.4.1. Co-efficient of community

When comparing two communities or the vegetation stands of two regions, a mathematical expression of similarity of the lists of species can be used. If community X is compared to Y, the number of species common to both expressed as a per cent of the total number of X plus Y has been termed the co-efficient of community. (Pablico and Moody, 1983)

Using the quantitative data such as I.V or SDR for the various species, pairs of communities may be compared by calculating a co-efficient of similarity (C) using the equation,

$$\text{Similarity co-efficient (C)} = 2 \times (W \times 100)/(a+b)$$

Where, W = sum of the lower IV's or SDR's of species shared by two communities.

a = sum of the IV's or SDR's of all species in the first community.

b = sum of the IV's or SDR's of all species in the second community.

The similarity co-efficient value varies from zero for communities having no species in common to 100 per cent for communities identical both in species composition and quantitative values.

3.1.4.2. Simpson's Index (C)

The Simpson's Index is a measure of the concentration of dominance and can be used to determine the degree of diversity in a community (Whittaker, 1965). This can be determined using the following equation -

$$\text{Simpson's Index (C)} = \sum (Y/N)^2$$

Where $Y = I.V$ or SDR of a given species

$N =$ the sum of I V's or SDR's for all species in the sample

3.1.4.3. Species diversity

Species diversity of each study site was calculated, using a formula given by Magurran (1988)

$$H' = - \sum p_i \ln p_i$$

where, p_i is the proportional abundance of the i^{th} species = (n_i/N)

The distribution of individuals among the species is called species evenness. Evenness Index (J) was calculated by the formula,

$$J = H'/H'_{\text{max}}$$

Where, $H'_{\text{max}} = \log_2 S$

H'_{max} - Species diversity under conditions of maximal equitability.

S - Number of species in the community.

$$\log_2 S = \frac{\log_{10} S}{\log_{10} 2} \quad (\text{Brower and Zar, 1977})$$

3.1.4.4. Site similarity

Similarities of any two given study sites in terms of number of plant species encountered in both sites were quantitatively measured using Sorenson's similarity index. (Bray and Curtis, 1957)

$$C_N = \frac{2N_j}{(N_a + N_b)}$$

Where, C_N = Sorenson's quantitative index

N_j = Number of species common to both sites

N_a = Number of species found in site 1.

N_b = Number of species found in site 2.

(Nambiar *et al.*, 1985)

3.1.4.5. Total biomass production of medicinal plants

From the fresh weight and dry weight of shoot and root of plants in each strata, driage and shoot - root ratios were calculated as follows -

$$\text{Driage (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{Shoot - root ratio} = \frac{\text{Dry weight of shoot}}{\text{Dry weight of root}}$$

3.1.5. Statistical analysis

Vegetation parameters like Absolute density, Relative density, Absolute frequency, Relative frequency, Importance value, Summed dominance ratio and Abundance were determined statistically.

3.2. Growth phases of selected medicinal plants

3.2.1. Materials

Ten important medicinal plant species common in the three categories of oil palm, *viz.* - young, medium and mature plantations and open conditions were selected (Table 13). The light intensity and photosynthetically active radiation (PAR) in the four different strata were measured using Li-cor model LI-185B Quantum/ Radiometer/ Photometer, with respective sensors. The growth behaviour of the selected plants was monitored for one year at three different stages of growth – *i.e.* preflowering, flowering and seed set.

3.2.2. Observations recorded

3.2.2.1 Height of the plant

The height of the plant was measured from the ground level to the growing tip of the plant and expressed in centimeters.

3.2.2.2. Number of branches

The total number of branches in a plant was counted and recorded.

3.2.2.3. Plant spread

The distance occupied by the plant was measured in the north-south and in the east-west direction from its axis. The area occupied was obtained by multiplying the two values and expressed in square centimeters.

3.2.2.4. Height at which first branch is produced

The height at which first branch is produced was measured from the ground level to the position from where the branch is produced and expressed in centimeters.

3.2.2.5. Number of leaves

The total number of leaves produced in a plant was counted and recorded

3.2.2.6. Season of flowering and fruiting

The duration of flowering and fruiting was noted

3.2.2.7. Root length

The length of the longest root was measured and expressed in centimeters.

3.2.2.8. Number of roots

The total number of roots were counted and recorded.

3.2.2.9. Inter nodal length

The distance between successive nodes was measured and the mean value was expressed in centimeters.

3.2.2.10. Stem girth

The average girth of the stem was measured and expressed in millimeters.

3.2.2.11. Fresh and dry weight of officinal part

The fresh weight of the medicinally important part was taken and expressed in grams. The dry weight of the officinal part was calculated after drying 100g of the specimen in a hot air oven at 70°C till a constant weight is obtained.

3.2.2.12. Fresh and dry weight of non-official part

The fresh weight of the non-official part was taken and expressed in grams. The dry weight of the non-official part was calculated after drying 100g of the specimen in hot air oven at 70°C till a constant weight is obtained.

3.2.2.13. Shoot-root ratio

Shoot-root ratio is a ratio between the dry weight of the shoot and the dry weight of the root and is calculated by the formula-

$$\text{Shoot-root ratio} = \frac{\text{Dry weight of shoot}}{\text{Dry weight of root}}$$

3.3. Chemical analysis of officinal part(s)

3.3.1. Experimental materials

The roots of *Hemidesmus indicus* R.Br. collected from the three different categories of oil palm viz. young, medium and mature and open conditions were analysed for essential oil content.

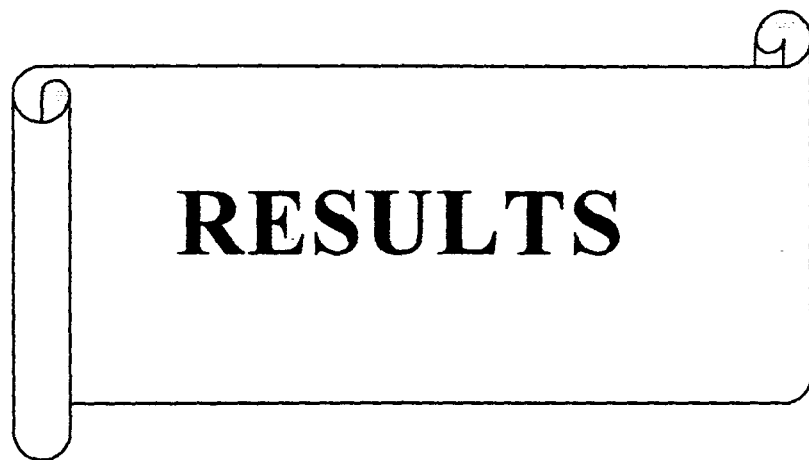
The fruits and roots of (*Solanum melongena* Linn.var. *insanum* (L.)Prain collected from the three different categories of oilplam and open conditions were analysed for solasodine content.

3.3.2. Methods

Essential oil content in *Hemidesmus indicus* R.Br. was estimated by hydro distillation of fresh roots using Cleavenger apparatus. For this, weighed quantity of fresh root sample was first mashed and taken in a 500ml round bottomed distillation flask to which 100ml of distilled water was added. The contents were distilled for 3.5-4 hours until the oil level remained constant and the volume of oil collected was noted and expressed as percentage on volume by weight basis(Augustin,1998)

The assay procedure suggested by Bakshi and Hamied (1972) and Mahato *et al.* (1975) was adopted with some modifications. Oven dried berries were ground to a fine powder. Twenty grams of this powder was defatted in a Soxhlet extractor using 150 ml of petroleum ether (40°-60° C) for about one hour. This defatted material was extracted with 150 ml of ethanol in Soxhlet for about 6 hours. The ethanol extract was concentrated to 30ml, the concentrated material was hydrolysed with 6ml of concentrated HCl and refluxed for 3 hours. This was cooled and basified with 9ml of 10 N Sodium hydroxide and refluxed for one hour. It was then cooled, filtered and washed with distilled water free of alkali and the residue was extracted with chloroform. The extract was heated on waterbath to evaporate chloroform. The solasodine thus extracted was

recrystallised in benzene. This was then evaporated on the waterbath and the solasodine weighed. The quantity of solasodine thus extracted was expressed in percentage on the basis of dry weight of berries.



RESULTS

4. RESULTS

The results of the study on 'Biodiversity of medicinal plants in oil palm plantations' are presented in this chapter.

4. 1. Identification of flora and vegetation analysis

4.1.1. Flora

A total of 85 plant species were identified in the four different strata - young, medium and mature plantations and open conditions belonging to 79 genera and 36 families (Table 2.). None of the plants were endemic. There were 74 indigenous and 10 exotic / naturalised plants. Identified plants were categorised under respective botanical families with vernacular / common name and scientific name and were listed in alphabetic sequence. The strata of occurrence of each plant species is also shown.

Analytical characters like absolute frequency, relative frequency, absolute density, relative density, importance value, summed dominance ratio and abundance were determined by means of List or Census quadrat method.

Table 2 Stratawise distribution of medicinal plants

Sl No	Scientific name	Vernacular name	Family	Strata*				G. O.
				y	Me	Ma	O	
1	<i>Abrus precatorius</i> Linn.	Kunni	Papilionaceae	-	-	✓	-	I
2	<i>Acanthospermum hispidum</i> DC.	Kattunjerinjal	Asteraceae	-	-	-	✓	EN
3	<i>Ageratum conyzoides</i> Linn.	Appa	Asteraceae	-	✓	-	✓	EN
4	<i>Aristida setacea</i> Retz.	Kunthalampullu	Poaceae	✓	-	-	-	I
5	<i>Aristolochia indica</i> Linn.	Garudakodi	Aristolochiaceae	-	-	✓	-	I
6	<i>Asparagus racemosus</i> Willd.	Sathavari	Liliaceae	-	-	✓	-	I
7	<i>Atylosia goensis</i> Dalz.	Kattuzhunnu	Papilionaceae	-	✓	✓	-	I
8	<i>Axonopus compressus</i> P. Beauv	Carpet grass	Poaceae	-	-	✓	-	EN
9	<i>Biophytum sensitivum</i> DC.	Mukkutti	Oxalidaceae	-	-	✓	-	I
10	<i>Buchanania lanzan</i> Spreng.	Moongapezhu	Anacardiaceae	-	-	✓	-	I
11	<i>Bulbostylis barbata</i> Kunth.	Sooryan	Cyperaceae	-	-	-	✓	I
12	<i>Calophyllum polyanthum</i> Wall. ex Choisy	Kattupunna	Clusiaceae	-	-	✓	-	I
13	<i>Calotropis gigantea</i> R. Br.	Erikku	Asclepiadaceae	-	-	-	✓	I
14	<i>Calycopteris floribunda</i> Poir.	Pullani	Combretaceae	-	✓	✓	-	I
15	<i>Canthium angustifolium</i> Roxb.	Kattaramullu	Rubiaceae	-	✓	✓	-	I
16	<i>Careya arborea</i> Roxb.	Pezhu	Lecythidaceae	✓	-	✓	-	I
17	<i>Cassia tora</i> Linn.	Thakara	Caesalpiniaceae	✓	-	-	-	I
18	<i>Catunaregam spinosa</i> Tirvengadam	Kara	Rubiaceae	-	✓	-	-	I
19	<i>Centella asiatica</i> (Linn) Urban	Kudangal	Apiaceae	-	-	✓	-	I
20	<i>Chromolaena odorata</i> King & Robinson	Communist- pacha	Asteraceae	✓	✓	✓	✓	EN
21	<i>Chrysopogon aciculatus</i> Trin.	Lovegrass	Poaceae	✓	✓	✓	✓	I
22	<i>Cissus</i> sp	Vazhavalli	Vitaceae	-	✓	✓	-	-
23	<i>Clerodendrum viscosum</i> Vent.	Peruvelam	Verbenaceae	✓	✓	-	✓	I
24	<i>Costus speciosus</i> Sm	Anakoova	Zingiberaceae	-	-	✓	-	I
25	<i>Crotolaria pallida</i> Dryand.	Kilukki	Papilionaceae	-	-	✓	-	I
26	<i>Curculigo orchioides</i> Gaertn	Nilappana	Hypoxidaceae	-	-	✓	-	I
27	<i>Cyclea peltata</i> Hook. f. & Thoms.	Padathali	Menispermaceae	✓	✓	✓	✓	I
28	<i>Cynodon dactylon</i> Pers.	Karuka	Poaceae	-	-	-	✓	I
29	<i>Cynoglossum furcatum</i> Wall. ex Roxb.	NA**	Boraginaceae	-	-	-	✓	I
30	<i>Cyperus rotundus</i> Linn.	Muthanga	Cyperaceae	✓	-	-	-	I
31	<i>Cyrtococcum trigonum</i> A. Camus	NA**	Poaceae	✓	-	✓	-	I
32	<i>Dalbergia latifolia</i> Roxb.	Veetti	Papilionaceae	-	-	✓	-	I
33	<i>Desmodium gangeticum</i> DC.	Orila	Papilionaceae	-	✓	-	-	I

34	<i>Desmodium triflorum</i> DC.	Nilamparanta	Papilionaceae	✓	✓	✓	✓	I
35	<i>Dioscorea oppositifolia</i> Linn.	Kavalakkizhangu	Dioscoreaceae	-	✓	-	-	I
36	<i>Dioscorea pentaphylla</i> Linn.	Nurankizhangu	Dioscoreaceae	✓	-	-	-	I
37	<i>Elephantopus scaber</i> Linn.	Anachuvadi	Asteraceae	✓	✓	✓	✓	I
38	<i>Emilia sonchifolia</i> DC.	Mryalcheviyan	Asteraceae	✓	✓	✓	✓	I
39	<i>Eragrostis ciliaris</i> Link	NA**	Poaceae	-	✓	-	✓	I
40	<i>Evolvulus alsinoides</i> Linn.	Vishnukranthi	Convolvulaceae	✓	✓	-	-	EN
41	<i>Helicteres isora</i> Linn.	Idampiri - Valampiri	Sterculiaceae	✓	-	-	-	I
42	<i>Hemidesmus indicus</i> R.Br.	Narunanti	Asclepiadaceae	✓	✓	✓	✓	I
43	<i>Hemionettis arafolia</i> Moore	Elicheviyan	Polypodiaceae	-	✓	✓	-	I
44	<i>Holarrhena pubescens</i> Wall. ex Don	Kudakappala	Apocynaceae	✓	✓	-	-	I
45	<i>Holostemma adakodien</i> Schult	Adapathiyam	Asclepiadaceae	-	-	✓	-	I
46	<i>Hybanthus enneaspermus</i>	Orilathamara	Violaceae	-	-	✓	-	I
47	<i>Hyptis suaveolens</i> Poit.	Nattapoochedi	Lamiaceae	✓	✓	✓	✓	EN
48	<i>Ichnocarpus frutescens</i> R.Br. (L.) Muell.	Palvalli	Apocynaceae	-	✓	-	-	I
49	<i>Ipomoea sepiaria</i> Roxb.	Thiruthali	Convolvulaceae	-	-	✓	-	I
50	<i>Knoxia mollis</i> W. & A.	NA**	Rubiaceae	✓	✓	-	✓	I
51	<i>Leucas aspera</i> (Willd.) Spreng.	Thumba	Labiatae	✓	✓	-	✓	I
52	<i>Lantana camara</i> Linn. var. <i>aculeata</i> (L.) Moldenk	Poochedi	Verbenaceae	✓	-	-	✓	EN
53	<i>Mimosa pudica</i> Linn.	Thottavadi	Mimosaceae	✓	✓	✓	✓	EN
54	<i>Naregamia alata</i> Wight & Arn.	Nilanarakam	Meliaceae	-	-	✓	-	I
55	<i>Nephrolepis cordifolia</i> Presl.	Fern	Polypodiaceae	✓	✓	✓	-	I
56	<i>Oldenlandia umbellata</i> Linn	Oldenlandia	Rubiaceae	✓	-	-	✓	I
57	<i>Pergularia daemia</i> (Forssk.) Chiov.	Velipparuthi	Asclepiadaceae	-	-	✓	-	I
58	<i>Perotis indica</i> (L.) Kuntze.	Foxtail grass	Poaceae	-	-	✓	✓	I
59	<i>Phyllanthus amarus</i> Schum. & Thonn.	Kizhanelli	Euphorbiaceae	✓	✓	✓	✓	I
60	<i>Phyllanthus urinaria</i> Linn.	Hazarmani	Euphorbiaceae	✓	-	-	✓	I
61	<i>Pleopeltis lanceolata</i> Kaulf.	Fern	Polypodiaceae	-	-	✓	-	I
62	<i>Pseudarthria viscida</i> (Linn.)	Moovila	Papilionaceae	-	✓	-	-	I
63	<i>Pterocarpus marsupium</i> Roxb.	Venga	Papilionaceae	-	✓	-	-	I

64	<i>Rauvolfia serpentina</i> (Linn.) Benth. ex Kurz.	Sarpagandhi	Apocynaceae	-	✓	-	-	-	I
65	<i>Scoparia dulcis</i> Linn.	Kallurukki	Scrophulariaceae	✓	✓	✓	✓	✓	E/N
66	<i>Sebastiania chamaelea</i> (L.) Muell. Arg.	Cheriyarnanka	Euphorbiaceae	-	✓	-	-	-	I
67	<i>Sida acuta</i> Burm. f.	Cheruparuva	Malvaceae	-	✓	✓	✓	✓	I
68	<i>Sida rhombifolia</i> Linn.	Kurunthotti	Malvaceae	✓	✓	✓	✓	✓	I
69	<i>Solanum melongena</i> Linn. var. <i>insanum</i> (L.) Prain.	Chunta	Solanaceae	✓	✓	✓	✓	✓	I
70	<i>Spermacoce hispida</i> Linn	Tharakkala	Rubiaceae	✓	✓	✓	✓	✓	I
71	<i>Spermacoce latifolia</i> Abul.	Tharakkala	Rubiaceae	✓	-	-	-	-	I
72	<i>Spilanthes calva</i> DC.	Kuppamanjal	Asteraceae	✓	-	-	-	-	I
73	<i>Sporobolus indicus</i> R. Br.	NA**	Poaceae	-	-	-	-	✓	I
74	<i>Stachytarpheta indica</i> Vahl.	Kadapananth	Verbenaceae	-	-	✓	-	-	E/N
75	<i>Terminalia crenulata</i> Heyne ex Roth	Thempavu	Combretaceae	-	✓	-	-	-	I
76	<i>Terminalia paniculata</i> Roth	Maruthu	Combretaceae	✓	✓	✓	-	-	I
77	<i>Torenia asiatica</i> Ktze. ex Schum	Kakkappoovu	Scrophulariaceae	-	-	✓	-	-	I
78	<i>Tragia involucrata</i> Linn.	Kodithuva	Euphorbiaceae	-	✓	✓	-	-	I
79	<i>Tylophora indica</i> (Burm. f.) Merr.	Vallippala	Asclepiadaceae	-	✓	-	-	-	I
80	<i>Urena lobata</i> Linn	Vatturam	Malvaceae	✓	✓	✓	✓	✓	I
81	<i>Vernonia cinerea</i> (Linn.) Less	Poovankurun- thal	Asteraceae	✓	✓	✓	✓	✓	I
82	<i>Vigna trilobata</i> Verdc.	Kattupayar	Papilionaceae	✓	✓	✓	-	-	I
83	<i>Wrightia tinctoria</i> (Roxb.) R. Br.	Koppala	Apocynaceae	-	-	✓	-	-	I
84	<i>Ziziphus oenoplia</i> (L.) Mill	Kottavalli	Rhamnaceae	-	-	✓	-	-	I
85	<i>Zornia gibbosa</i> Spanoghe	Murikoodi	Papilionaceae	-	✓	-	-	-	I

NA** - Not Available

*- Strata consists of oil palm plantation
of different age groups viz.

Y - Young (5 Years)

Me - Medium (5-11 Years)

Ma - Mature (> 11 Years)

O - Open

G.O.- Geographical origin

I - Indigenous

E/N - Exotic/Naturalised

4. 1.2. Study of vegetative parameters of medicinal plants

4.1.2.1. Vegetative parameters in young oil palm plantation

A total of 18 sampling units were taken using 1.0m² frame in young plantation (Table 3.). The dominant species are *Chrysopogon aciculatus* having highest relative density (36.65 per cent) followed by *Cyrtococcum trigonum* (22.92 per cent) and *Aristida setacea* (11.63 per cent). The rare species is *Cassia tora* with a relative density of 0.04 per cent. High relative frequency was observed for *Chrysopogon aciculatus* (9.34 per cent), *Elephantopus scaber* (5.6 per cent) and *Hemidesmus indicus* (5.6 per cent). It was lower for *Spermacoce latifolia* (0.93 per cent) and *Cassia tora* (0.93 per cent) *Chrysopogon aciculatus* is the most abundant species in young oil palm plantation as is evident from its high Importance value index (45.99) and Abundance (91.1).

4. 1.2. 2. Vegetative parameters in medium oil palm plantation

A total of 19 sampling units were taken using 1.0m² frame in medium plantation (Table 4.). The dominant species are



4. *Chrysopogon aciculatus*, the most dominant species in all the four strata



5. *Rauvolfia serpentina* (Sarpagandhi) growing in medium oil palm plantation

Table 3. Vegetative parameters of medicinal plants in young * oilpalm plantations

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
1	<i>Aristida setacea</i>	289	11.63	27.78	4.67	16.3	8.15	57.8
2	<i>Careya arborea</i>	7	0.28	22.22	3.74	4.02	2.01	1.75
3	<i>Cassia tora</i>	1	0.04	5.56	0.93	0.97	0.49	1
4	<i>Chromolaena odorata</i>	8	0.32	22.22	3.74	4.06	2.03	2
5	<i>Chrysopogon aciculatus</i>	911	36.65	55.56	9.34	45.99	23.00	91.1
6	<i>Clerodendrum viscosum</i>	3	0.12	11.11	1.87	1.95	0.98	1.5
7	<i>Cyclea peltata</i>	4	0.16	16.67	2.80	2.96	1.48	1.33
8	<i>Cyperus rotundus</i>	28	1.13	22.22	3.74	4.86	2.43	7
9	<i>Cyrtococcum trigonum</i>	570	22.92	16.67	2.80	25.73	12.87	190
10	<i>Desmodium triflorum</i>	169	6.8	27.78	4.67	11.47	5.74	33.8
11	<i>Elephantopus scaber</i>	128	5.15	33.33	5.6	10.75	5.38	21.33
12	<i>Emilia sonchifolia</i>	17	0.68	16.67	2.8	3.49	1.75	5.67
13	<i>Evolvulus alsinoides</i>	2	0.08	11.11	1.87	1.95	0.98	1
14	<i>Hemidesmus indicus</i>	25	1.01	33.33	5.60	6.61	3.30	4.17
15	<i>Hyptis suaveolens</i>	47	1.89	27.78	4.67	6.56	3.28	9.39
16	<i>Knoxia mollis</i>	87	3.5	27.78	4.67	8.17	4.09	17.4
17	<i>Lantana camara</i> var. <i>aculeata</i>	2	0.08	11.11	1.87	1.95	0.98	1
18	<i>Mimosa pudica</i>	7	0.28	16.67	2.8	3.08	1.54	2.33
19	<i>Oldenlandia umbellata</i>	9	0.36	11.11	1.87	2.23	1.12	4.5
20	<i>Phyllanthus amarus</i>	9	0.36	11.11	1.87	2.23	1.12	4.5
21	<i>Phyllanthus urinaria</i>	44	1.77	22.22	3.74	5.51	2.76	11
22	<i>Scoparia dulcis</i>	9	0.36	22.22	3.74	4.10	2.05	2.25
23	<i>Sida rhombifolia</i>	6	0.24	27.78	4.67	4.91	2.5	1.2

Table 3. Contd.

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
24	<i>Solanum melongena</i> var. <i>insanum</i>	5	0.2	16.67	2.8	3.0	1.5	1.67
25	<i>Spermacoce hispida</i>	24	0.97	27.78	4.67	5.64	2.82	4.8
26	<i>Spermacoce latifolia</i>	3	0.12	5.56	0.93	1.05	0.53	3
27	<i>Spilanthes calva</i>	8	0.32	11.11	1.87	2.19	1.1	4
28	<i>Terminalia paniculata</i>	3	0.12	16.67	2.8	2.92	1.46	1
29	<i>Urena lobata</i>	49	1.97	22.22	3.74	5.71	2.86	12.25
30	<i>Vernonia cinerea</i>	10	0.4	16.67	2.8	3.2	1.6	3.33
31	<i>Vigna trilobata</i>	2	0.08	11.11	1.87	1.95	0.98	1

* Young - < 5 Years

Table 4. Vegetative parameters of medicinal plants in medium* oilpalm plantations

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
1	<i>Ageratum conyzoides</i>	22	1.40	21.05	3.10	4.50	2.25	5.5
2	<i>Atylosia goensis</i>	2	0.13	10.53	1.55	1.68	0.84	1
3	<i>Axonopus compressus</i>	10	0.64	10.53	1.55	2.19	1.10	5
4	<i>Calycopteris floribunda</i>	4	0.25	21.05	3.10	3.35	1.68	1
5	<i>Canthium angustifolium</i>	3	0.19	15.79	2.33	2.52	1.26	1
6	<i>Catunaregam spinosa</i>	2	0.13	10.53	1.55	1.68	0.84	1
7	<i>Chromolaena odorata</i>	40	2.55	42.11	6.20	8.75	4.38	5
8	<i>Chrysopogon aciculatus</i>	903	57.55	63.16	9.30	66.85	33.43	75.25
9	<i>Clerodendrum viscosum</i>	4	0.25	21.05	3.10	3.36	1.68	1
10	<i>Cyclea peltata</i>	5	0.32	26.32	3.88	4.19	2.10	1
11	<i>Desmodium gangeticum</i>	3	0.19	15.79	2.33	2.52	1.26	1
12	<i>Desmodium triflorum</i>	220	14.02	21.05	3.10	17.12	8.56	55
13	<i>Elephantopus scaber</i>	31	1.98	21.05	3.10	5.08	2.54	7.75
14	<i>Emilia sonchifolia</i>	2	0.13	5.26	0.78	0.90	0.45	2
15	<i>Eragrostis ciliaris</i>	14	0.89	10.53	1.55	2.44	1.22	7
16	<i>Evolvulus alsinoides</i>	37	2.36	26.32	3.88	6.23	3.12	7.4
17	<i>Hemidesmus indicus</i>	23	1.47	36.84	5.43	6.89	3.45	3.29
18	<i>Hemionettis arafolia</i>	5	0.32	15.79	2.33	2.64	1.32	1.67
19	<i>Hyptis suaveolens</i>	34	2.17	10.53	1.55	3.72	1.86	17
20	<i>Knoxia mollis</i>	52	3.31	15.79	2.33	5.64	2.82	17.33
21	<i>Mimosa pudica</i>	25	1.59	26.32	3.88	5.47	2.74	5
22	<i>Phyllanthus amarus</i>	8	0.51	5.26	0.78	1.29	0.65	8
23	<i>Pseudarthria viscida</i>	11	0.70	26.32	3.88	4.58	2.29	2.2
24	<i>Pterocarpus marsupium</i>	2	0.13	10.53	1.55	1.68	0.84	1
25	<i>Scoparia dulcis</i>	6	0.38	5.26	0.78	1.16	0.58	6

Table 4. Contd.

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
26	<i>Sebastiania chamaelea</i>	3	0.19	10.53	1.55	1.74	0.87	1.5
27	<i>Sida acuta</i>	3	0.19	5.26	0.78	0.97	0.49	3
28	<i>Sida rhombifolia</i>	10	0.64	26.32	3.88	4.51	2.26	2
29	<i>Solanum melongena</i> <i>var insanum</i>	8	0.51	26.32	3.88	4.38	2.19	1.6
30	<i>Spermacoce hispida</i>	22	1.4	10.53	1.55	2.95	1.48	11
31	<i>Terminalia crenulata</i>	1	0.06	5.26	0.78	0.84	0.42	1
32	<i>Terminalia paniculata</i>	3	0.19	15.79	2.33	2.51	1.26	1
33	<i>Tragia involucrata</i>	1	0.06	5.26	0.78	0.84	0.42	1
34	<i>Tylophora indica</i>	7	0.45	15.79	2.33	2.77	1.39	2.33
35	<i>Urena lobata</i>	22	1.40	26.32	3.88	5.28	2.64	4.4
36	<i>Vernonia cinerea</i>	14	0.89	15.79	2.33	3.22	1.61	4.67
37	<i>Vigna trilobata</i>	2	0.13	10.53	1.55	1.68	0.84	1
38	<i>Zornia gibbosa</i>	5	0.32	10.53	1.55	1.87	0.94	2.5

* Medium - 5 - 11 years

Chrysopogon aciculatus having high relative density (57.55 per cent) followed by *Desmodium triflorum* (14.02 per cent). The rare species are *Terminalia crenulata* (0.06 per cent) and *Tragia involucrata* (0.06 per cent). High relative frequency was observed for *Chrysopogon aciculatus* (9.3 per cent), and *Hemidesmus indicus* (5.43 per cent). It was lower for *Emilia sonchifolia* (0.78 per cent), *Phyllanthus amarus* (0.78 per cent), *Sida acuta* (0.78 per cent), *Scoparia dulcis* (0.78 per cent), *Terminalia crenulata* (0.78 per cent) and *Tragia involucrata* (0.78 per cent). *Chrysopogon aciculatus* is the most abundant species in medium oil palm plantation as is evident from its high importance value index (66.85) and abundance (75.25).

4.1. 2. 3. Vegetative parameters in mature oil palm plantation

A total of 25 sampling units were taken using 1.0m² frame in mature plantation (Table 5.). The dominant species are *Chrysopogon aciculatus* having high relative density (36.02 per cent) followed by *Cyrtococcum trigonum* (32.72 per cent) and *Naregamia ulata* (7.18 per cent). A number of rare species with a relative density of 0.05 per cent were found in mature plantation. They were *Calophyllum polyanthum*, *Calycopteris floribunda*, *Careya arborea*, *Ipomoea septaria*, *Pergularia daemia*.



6. *Holostemma adakodien* (Adapathiyam) growing in mature oil palm plantation

Table 5. Vegetative parameters of medicinal plants in mature * oilpalm plantations

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominannce Ratio	Abundance
1	<i>Abrus precatorius</i>	2	0.11	4	0.65	0.75	0.38	2
2	<i>Aristolochia indica</i>	2	0.11	4	0.65	0.75	0.38	2
3	<i>Asparagus racemosus</i>	3	0.16	12	1.94	2.10	1.05	1
4	<i>Atylosia goensis</i>	3	0.16	12	1.94	2.10	1.05	1
5	<i>Axonopus compressus</i>	20	1.08	12	1.94	3.02	1.51	6.67
6	<i>Biophytum sensitivum</i>	2	0.11	4	0.65	0.75	0.38	2
7	<i>Calophyllum polyanthum</i>	1	0.05	4	0.65	0.70	0.35	1
8	<i>Calycopteris floribunda</i>	1	0.05	4	0.65	0.70	0.35	1
9	<i>Canthium anrgustifoluim</i>	4	0.22	16	2.58	2.79	1.40	1
10	<i>Careya arborea</i>	1	0.05	4	0.65	0.70	0.35	1
11	<i>Centella asiatica</i>	10	0.54	8	1.29	1.83	0.92	5
12	<i>Chromolaena odorata</i>	21	1.13	24	3.87	5.00	2.50	3.5
13	<i>Chrysopogon aciculatus</i>	667	36.02	40	6.45	42.47	21.24	66.7
14	<i>Cissus sp</i>	4	0.22	16	2.58	2.80	1.40	1
15	<i>Curculigo orchuoides</i>	25	1.35	20	3.23	4.58	2.29	5
16	<i>Cyclea peltata</i>	4	0.22	8	1.29	1.50	0.75	2
17	<i>Cyrotococcum trigonum</i>	606	32.72	20	3.23	35.95	17.98	121.2
18	<i>Desmodium triflorum</i>	54	2.92	24	3.87	6.79	3.40	9
19	<i>Elephantopus scaber</i>	38	2.05	20	3.23	5.28	2.64	7.6
20	<i>Emilia sonchifolia</i>	11	0.59	24	3.87	4.46	2.23	1.83
21	<i>Hemidesmus indicus</i>	24	1.30	24	3.87	5.17	2.59	4
22	<i>Hemionettis arafolia</i>	12	0.65	16	2.58	3.23	1.62	3
23	<i>Holostemma adakodien</i>	28	1.51	32	5.16	6.67	3.34	3.5
24	<i>Hyptis suaveolens</i>	26	1.40	16	2.58	3.98	1.99	6.5

Table 5. Contd.

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
25	<i>Ipomoea sepiaria</i>	1	0.05	4	0.65	0.70	0.35	1
26	<i>Mimosa pudica</i>	13	0.70	12	1.94	2.64	1.32	4.33
27	<i>Naregamia alata</i>	133	7.18	40	6.45	13.63	6.82	13.3
28	<i>Pergularia daemia</i>	1	0.05	4	0.65	0.70	0.35	1
29	<i>Phyllanthus amarus</i>	33	1.78	28	4.52	6.30	3.15	4.71
30	<i>Pleopeltis lanceolata</i>	3	0.16	4	0.65	0.81	0.41	3
31	<i>Rauvolfia serpentina</i>	4	0.22	12	1.94	2.15	1.08	1.33
32	<i>Scoparia dulcis</i>	10	0.54	16	2.58	3.12	1.56	2.5
33	<i>Sida acuta</i>	8	0.43	12	1.94	2.37	1.19	2.67
34	<i>Sida rhombifolia</i>	3	0.16	12	1.94	2.09	1.05	1
35	<i>Solanum melongena</i> var <i>insanum</i>	11	0.59	16	2.58	3.17	1.59	2.75
36	<i>Spermacoce hispida</i>	12	0.65	4	0.65	1.29	0.65	12
37	<i>Stachytarpheta indica</i>	3	0.16	12	1.94	2.10	1.05	1
38	<i>Terminalia paniculata</i>	1	0.05	4	0.65	0.70	0.35	1
39	<i>Torenia asiatica</i>	1	0.05	4	0.65	0.70	0.35	1
40	<i>Urena lobata</i>	15	0.81	12	1.94	2.75	1.38	5
41	<i>Vernonia cinerea</i>	20	1.08	24	3.87	4.95	2.48	3.33
42	<i>Vigna trilobata</i>	2	0.11	8	1.29	1.40	0.70	1
43	<i>Wrightia tinctoria</i>	1	0.05	4	0.65	0.70	0.35	1
44	<i>Zornia gibbosa</i>	7	0.38	16	2.58	2.96	1.48	1.75

* Mature - >11 years

Terminalia paniculata, *Torenia asiatica* and *Wrightia tinctoria*. High relative frequency was observed for *Chrysopogon aciculatus* (6.45 per cent), *Holostemma adakodien* (5.16 per cent) and *Naregamia alata* (6.45 per cent). Lowest relative frequency of 0.65 per cent was observed for all the rare plant species. *Chrysopogon aciculatus* is the most abundant species in mature oil palm plantation as is evident from its high importance value index (42.47) and abundance (66.7).

4. 1.2. 4. Vegetative parameters in open conditions

A total of 18 sampling units were taken using 1.0m² frame in open conditions (Table 6.). The dominant species are *Chrysopogon aciculatus* having high relative density (21.56 per cent) followed by *Elephantopus scaber* (12.39 per cent) and *Phyllanthus amarus* (8.8 per cent). The rare species are *Calotropis gigantea* (0.12 per cent) and *Desmodium gangeticum* (0.25 per cent). High relative frequency of 5.77 per cent was observed for *Chromolaena odorata*, *Hemidesmus indicus* and *Phyllanthus amarus*. Lower relative frequency of 0.96 per cent was observed for *Calotropis gigantea*, *Desmodium triflorum*, *Knoxia mollis* and *Urena lobata*. *Chrysopogon aciculatus* is the most abundant

Table 6. Vegetative parameters in Open conditions

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
1	<i>Acanthospermum hispidum</i>	6	0.74	11.11	1.92	2.67	1.34	3
2	<i>Ageratum conyzoides</i>	29	3.59	27.78	4.81	8.40	4.20	5.8
3	<i>Bulbostylis barbata</i>	17	2.11	16.67	2.88	4.99	2.50	5.67
4	<i>Calotropis gigantea</i>	1	0.12	5.56	0.96	1.09	0.55	1
5	<i>Chromolaena odorata</i>	18	2.23	33.33	5.77	8.00	4.00	3
6	<i>Chrysopogon aciculatus</i>	174	21.56	16.67	2.88	24.45	12.23	58
7	<i>Clerodendrum viscosum</i>	4	0.5	16.67	2.88	3.38	1.69	1.33
8	<i>Cyclea Peltata</i>	4	0.5	22.22	3.85	4.34	2.17	1
9	<i>Cynodon dactylon</i>	31	3.84	16.67	2.88	6.73	3.37	10.33
10	<i>Desmodium gangeticum</i>	2	0.25	11.11	1.92	2.17	1.09	1
11	<i>Desmodium triflorum</i>	8	0.99	5.56	0.96	1.95	0.98	8
12	<i>Elephantopus scaber</i>	100	12.39	27.78	4.81	17.19	8.60	20
13	<i>Emilia sonchifolia</i>	26	3.22	27.78	4.81	8.02	4.01	5.2
14	<i>Eragrostis ciliaris</i>	25	3.10	16.67	2.88	5.98	2.99	8.33
15	<i>Hemidesmus indicus</i>	23	2.85	33.33	5.77	8.62	4.31	3.83
16	<i>Hyptis suaveolens</i>	38	4.71	22.22	3.85	8.55	4.28	9.5
17	<i>Knoxia mollis</i>	16	1.98	5.56	0.96	2.94	1.47	16
18	<i>Lantana camara</i> var. <i>aculeata</i>	3	0.37	16.67	2.88	3.26	1.63	1
19	<i>Mimosa pudica</i>	31	3.84	22.22	3.85	7.69	3.85	7.75
20	<i>Oldenlandia umbellata</i>	28	3.47	22.22	3.85	7.32	3.66	7
21	<i>Phyllanthus amarus</i>	71	8.8	33.33	5.77	14.57	7.29	11.83
22	<i>Phyllanthus urinaria</i>	10	1.24	11.11	1.92	3.16	1.58	5
23	<i>Scoparia dulcis</i>	19	2.35	27.78	4.81	7.16	3.58	3.8
24	<i>Sida acuta</i>	13	1.61	16.67	2.88	4.50	2.25	4.33
25	<i>Sida rhombifolia</i>	5	0.62	16.67	2.88	3.5	1.75	1.67

Table 6. Contd.

Sl. No.	Scientific Name	Absolute density	Relative density	Absolute frequency	Relative frequency	Importance value	Summed Dominance Ratio	Abundance
26	<i>Solanum melongena</i> var. <i>insanum</i>	5	0.62	22.22	3.85	4.47	2.24	1.25
27	<i>Spermacoce hispida</i>	41	5.08	22.22	3.85	8.93	4.47	10.25
28	<i>Sporobolus indicus</i>	19	2.35	16.67	2.88	5.24	2.62	6.33
29	<i>Urena lobata</i>	3	0.37	5.56	0.96	1.33	0.67	3
30	<i>Vernonia cinerea</i>	37	4.58	27.78	4.81	9.39	4.70	7.4

species in open conditions as is evident from its high importance value index (24.45) and abundance (58).

4.1. 2. 5. Medicinal plant vegetation pair wise analysis

Parameters used for medicinal plant vegetation pair wise analysis are given in Table 7. When the vegetation stands of pairs of sites were compared, young and open conditions had a high co-efficient of community (34.43). Sorenson's similarity index was also higher for young and open conditions (0.69). The similarity co-efficient value calculated using the importance value was high for young and mature conditions (59.97).

4.1. 2. 6. Plantation site vegetation analysis indices.

Parameters used for plantation site vegetation analysis are given in Table 8. The concentration of dominance as expressed by Simpson's Index (C) is higher in medium oil palm plantation (0.1315). Species diversity (H') was the highest in mature oil palm plantation (2.97) and least in young plantation (2.17). It was slightly lower than in mature for medium plantation (2.92) and open conditions (2.89). The distribution of individuals among the

Table 7. Medicinal Plant vegetation analysis pair wise indices

Strata*	Co-efficient of Community	Similarity Co-efficient(%)	Sorenson's Similarity index (C_N)
Young and Medium	30.43	58.69	0.61
Medium and Mature	30.12	51.46	0.60
Mature and Open	22.67	39.53	0.45
Young and Mature	26.32	59.97	0.52
Young and Open	34.43	48.90	0.69
Medium and Open	32.35	47.43	0.65

Table 8. Plantation site vegetation analysis indices

Strata*	Simpson's index(C)	Shannon's index (H')	Evenness index(J)
Young	0.0882	2.17	0.44
Medium	0.1315	2.92	0.55
Mature	0.0922	2.97	0.54
Open	0.0511	2.89	0.59

*Strata consists of oil palm plantations of different age groups viz.

Young - <5years
 Medium - 5-11 years
 Mature - >11 years
 Open

species is given by Evenness index (J) which is maximum in open conditions (0.59).

4. 1.3. Total biomass production of medicinal plants

From the fresh weight and dry weight of shoot and root of plants in each strata, driage and shoot-root ratio were calculated.

4.1.3.1. Total biomass production in young oil palm plantation

A total of 18 sampling units were taken using 1.0m² frame in young plantation. The fresh weight of each plant species was obtained by taking the mean value from all the quadrats in which it occurs. The data on the biomass production of the plant species in young plantation are given in Table 9.

Plants like *Chromolaena odorata* (23.75g), *Clerodendrum viscosum* (28.75g), *Mimosa pudica* (45.8g), *Solanum melongena* var. *insanum* (39.35g) and *Cyclea peltata* (19.3g) produced higher biomass when compared to other species identified in the strata. Lower biomass production was observed in *Cyperus rotundus* (1.1g), *Phyllanthus amarus* (1.13g), and *Phyllanthus urinaria* (0.79g). The proportion of shoot was much higher than the root in

Table 9. Total biomass production of medicinal plants in young oil palm plantations

Sl No	Scientific Name	Fresh Weight(g)			Dry Weight(g)			Driage(%)			Shoot-Root Ratio
		Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	
1	<i>Aristida setacea</i>	6.2	2.4	8.6	1.2	0.6	1.8	19.35	25	20.93	2:1
2	<i>Careya arborea</i>	1	1.3	2.3	0.5	0.7	1.2	50	53.85	52.17	1:1.4
3	<i>Cassia tora</i>	10	2	12	3.5	0.8	4.3	35	40	35.83	4.4:1
4	<i>Chromolaena odorata</i>	19.5	4.25	23.75	4.88	0.85	5.73	25.03	20	24.13	5.7:1
5	<i>Chrysopogon aciculatus</i>	2.8	2.5	5.3	0.6	0.6	1.2	21.43	24	22.64	1:1
6	<i>Clerodendrum viscosum</i>	20	8.75	28.75	4.2	3.5	7.7	21	40	26.78	1.2:1
7	<i>Cyclea peltata</i>	4	15.3	19.3	1.32	6.12	7.44	33	40	38.55	1:4.6
8	<i>Cyperus rotundus</i>	0.5	0.6	1.1	0.1	0.2	0.3	20	33.33	27.27	1:2
9	<i>Cyrtococcum trigonum</i>	1.5	1.2	2.7	0.3	0.3	0.6	20	25	22.22	1:1
10	<i>Desmodium triflorum</i>	1	0.35	1.35	0.3	0.1	0.4	30	28.57	29.63	3:1
11	<i>Elephantopus scaber</i>	3.06	1.06	4.12	0.49	0.27	0.76	16	25.47	18.45	1.8:1
12	<i>Emilia sonchifolia</i>	2	0.89	2.92	0.4	0.3	0.7	44.5	33.7	23.97	1.3:1
13	<i>Evolvulus alsinoides</i>	14	3.5	17.5	4.2	1.2	5.4	30	34.29	30.86	3.5:1
14	<i>Hemidesmus indicus</i>	1.33	2.95	4.28	0.5	1.2	1.7	38	40.68	39.72	1:2.4
15	<i>Hyptis suaveolens</i>	6.7	1.7	8.4	1.7	0.6	2.3	25.37	35.29	27.38	2.8:1
16	<i>Knoxia mollis.</i>	3	0.8	3.8	0.6	0.1	0.7	20	12.5	18.42	6:1
17	<i>Lantana camara var. aculeata</i>	3	1.5	4.5	0.8	0.6	1.4	26.67	40	31.11	1.3:1

Table 9. Contd.

Sl No	Scientific Name	Fresh Weight(g)			Dry Weight(g)			Driage(%)			Shoot-Root Ratio
		Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	
18	<i>Mimosa pudica</i>	20	25.8	45.8	0.7	10.3	11	3.5	39.92	24.02	1:14.7
19	<i>Oldenlandia umbellata.</i>	1.33	0.55	1.88	0.4	0.2	0.6	30.08	36.36	31.91	2:1
20	<i>Phyllanthus amarus.</i>	0.68	0.45	1.13	0.1	0.07	0.17	14.71	15.56	15	1.4:1
21	<i>Phyllanthus urinaria</i>	0.53	0.26	0.79	0.1	0.04	0.14	18.87	15.38	17.72	2.5:1
22	<i>Scoparia dulcis</i>	1.31	0.65	1.96	0.4	0.3	0.7	30.53	46.15	35.71	1.3:1
23	<i>Sida rhombifolia</i>	7.4	3.2	10.6	2.2	1.4	3.6	29.73	43.75	33.96	1.6:1
24	<i>Solanum melongena var. insanum</i>	30.75	8.6	39.35	15.4	4.7	20.1	50.08	54.65	51.08	3.3:1
25	<i>Spermacoce hispida</i>	1.4	0.9	2.3	0.2	0.09	0.29	14.29	10	12.61	2.2:1
26	<i>Spermacoce latifolia</i>	3	1.3	4.3	0.5	0.1	0.6	16.67	8	13.95	5:1
27	<i>Spilanthes calva</i>	1.85	0.65	2.5	0.4	0.3	0.7	21.62	46.15	28	1.3:1
28	<i>Terminalia paniculata</i>	4	7	11	1.8	3.5	5.3	45	50	48.18	1:1.9
29	<i>Urena lobata</i>	7.3	3.3	10.6	2.2	1.4	3.6	30.14	42.42	33.96	1.6:1
30	<i>Vernonia cinerea</i>	2.8	1.50	4.30	0.6	0.4	1	21.43	26.67	23.26	1.5:1
31	<i>Vigna trilobata</i>	2.5	2	4.5	0.5	0.6	1.1	20	30	24.44	1:1.2

the case of *Chromolaena odorata* and *knoxia mollis* (6:1). This was confirmed by their higher shoot- root ratio. In the case of *Cyclea peltata* (1:4.6), *Hemidesmus indicus* (1:2.4) and *Mimosa pudica* (1:14:7) the proportion of the root was higher than the shoot, which can be observed from the shoot-root ratio.

4.1.3.2.Total biomass production in medium oil palm plantation

A total of 19 sampling units were taken using 1.0m² frame in medium plantation. The fresh weight of each plant species was obtained by taking the mean value from all the quadrats in which it occurs. The data on the biomass production of the plant species in medium plantation are given in Table 10.

Plants like *Calycopteris floribunda* (106g), *Mimosa pudica* (45.8g), *Solanum melongena var. insanum* (209g) *Terminalia crenulata* (150g) and *Terminalia paniculata* (115g) produced higher biomass when compared to other species identified. Lower biomass production was observed in *Axonopus compressus* (1.15g) *Spermacoce hispida* (1.29g), *Emilia sonchifolia* (1.5g), *Phyllanthus amarus* (1.5g) and *Vernonia cinerea* (1.4g). From the shoot-root ratio, it is evident that the proportion of the shoot was much higher than the root in the case of *Chromolaena odorata*

Table 10. Total biomass production of medicinal plants in medium oil palm plantations

Sl. No	Scientific Name	Fresh Weight(g)			Dry Weight(g)			Driage(%)			Shoot-Root Ratio
		Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	
1	<i>Ageratum conyzoides</i>	5.1	2.7	7.8	1	1	2	19.61	37.04	25.64	1:1
2	<i>Atylosia goensis</i>	2.5	1	3.5	0.5	0.3	0.8	20	30	22.86	1.7:1
3	<i>Axonopus compressus</i>	0.65	0.5	1.15	0.1	0.1	0.2	15.38	20	17.39	1:1
4	<i>Calycopteris floribunda</i>	28.75	77.25	106	14.4	42.5	56.9	50.09	50.02	53.68	1:3
5	<i>Canthium angustifolium</i>	13	6	19	4.5	2.4	6.9	34.62	40	36.32	1.8:1
6	<i>Catunaregam spinosa</i>	13	7	20	4.6	2.8	7.4	35.38	40	37	1.6:1
7	<i>Chromolaena odorata</i>	15.2	3.6	18.8	3.8	0.72	4.52	25	20	24.04	5.3:1
8	<i>Chrysopogon aciculatus</i>	1.9	1.8	3.7	0.4	0.5	0.9	21.05	27.78	24.32	1:1.25
9	<i>Clerodendrum viscosum</i>	7.75	2.75	10.5	1.6	1.1	2.7	20.65	40	25.71	1.5:1
10	<i>Cyclea peltata</i>	6.2	6.8	13	2.0	2.7	4.7	32.26	39.71	36.15	1:1.35
11	<i>Desmodium gangeticum</i>	7	2.7	9.7	2.3	1	3.3	32.86	3.7	34.02	2.3:1
12	<i>Desmodium triflorum</i>	1.1	0.8	1.9	0.3	0.3	0.6	27.27	37.5	31.58	1:1

Table 10.Contd.

Sl. No	Scientific Name	Fresh Weight(g)			Dry Weight(g)			Driage(%)			Shoot-Root Ratio
		Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	
13	<i>Elephantopus scaber</i>	3.4	1.3	4.7	0.54	0.33	0.87	15.88	25.38	18.51	1.6:1
14	<i>Emilia sonchifolia</i>	1	0.5	1.5	0.2	0.2	0.4	20	40	26.67	1:1
15	<i>Eragrostis ciliaris.</i>	3.54	3.54	7.08	0.7	0.8	1.5	19.77	22.60	21.19	1:1.1
16	<i>Evolvulus alsinoides</i>	4.1	2.4	6.5	1.2	0.8	2	29.27	33.33	30.77	1.5:1
17	<i>Hemidesmus indicus</i>	1.6	3	4.6	0.6	1.2	1.8	37.5	40	39.13	1:2
18	<i>Hemionettis arafolia</i>	1.5	4.1	5.6	0.4	1.2	1.6	26.67	29.27	28.57	1:3
19	<i>Hyptis suaveolens</i>	2.1	0.45	2.55	0.5	0.2	0.7	23.81	44.44	27.45	2.5:1
20	<i>Knoxia mollis</i>	1.75	0.64	2.39	0.4	0.1	0.5	22.86	15.63	20.92	4:1
21	<i>Mimosa pudica</i>	24.5	21.3	45.8	8.6	8.5	17.1	35.1	39.91	37.34	1:1
22	<i>Phyllanthus amarus</i>	1.13	0.37	1.5	0.2	0.06	0.26	17.7	16.22	17.33	3.3:1
23	<i>Pseudarthria viscida</i>	9.5	5.5	15	3.1	2.2	5.3	32.63	40	35.33	1.4:1
24	<i>Pterocarpus marsupium</i>	15.5	4.5	20	7	2.3	9.3	4.52	51.11	46.5	3:1
25	<i>Scoparia dulcis</i>	2.5	0.83	3.33	0.7	0.3	1	28	36.14	30.03	2.3:1

Table 10.Contd.

Sl. No	Scientific Name	Fresh Weight(g)			Dry Weight(g)			Driage(%)			Shoot-Root Ratio
		Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	Shoot	Root	Shoot +Root	
26	<i>Sebastiania chamaelea</i>	1.5	1	2.5	0.3	0.2	0.5	20	20	20	1.5:1
27	<i>Sida acuta</i>	2	1.3	3.3	0.3	0.1	0.4	15	7.69	12.12	3:1
28	<i>Sida rhombifolia</i>	4.3	2.5	6.8	1.3	1.1	2.4	30.23	44	35.29	1.2:1
29	<i>Solanum melongena</i> var. <i>insanum</i>	182	27	209	91	14.8	105.8	50	54.81	50.62	6.1:1
30	<i>Spermacoce hispida</i>	0.83	0.46	1.29	0.1	0.05	0.15	12.05	10.87	11.63	2:1
31	<i>Terminalia crenulata</i>	30	120	150	13.5	60	73.5	45	50	49	1:4.4
32	<i>Terminalia paniculata</i>	26.7	88.3	115	12	44	56	44.94	49.83	48.7	1:3.7
33	<i>Tragia involucrata</i>	6	2	8	2	0.8	2.8	33.33	40	35	2.5:1
34	<i>Tylophora indica</i>	5.3	7.7	2.7	2.7	5.4	5.09	4	35.06	41.54	1:1
35	<i>Urena lobata</i>	7	2.7	9.7	2.1	1.1	3.2	30	40.74	32.99	1.9:1
36	<i>Vernonia cinerea</i>	0.9	0.5	1.4	0.2	0.2	0.4	22.22	40	28.57	1:1
37	<i>Vigna trilobata</i>	5	3	8	1	0.9	1.9	20	30	23.75	1.1:1
38	<i>Zornia gibbosa</i>	1.4	0.85	2.25	0.4	0.3	0.7	28.6	35.29	31.11	1.3:1

(5.3:1), *Knoxia mollis* (4:1) and *Solanum melongena* var. *insanum* (6.1:1). In the case of *Terminalia crenulata* (1:4.4) and *Terminalia paniculata* (1:3.7), the proportion of root was much higher than the shoot as they were in seedling stage.

4.1.3.3. Total biomass production in mature oil palm plantation

A total of 25 sampling units were taken using 1.0m² frame in mature plantation. The fresh weight of each plant species was obtained by taking the mean value from all the quadrats in which it occurs. The data on biomass production of the plant species in mature plantation are given in Table 11.

Higher biomass production was observed in *Asparagus racemosus* (172g), *Terminalia paniculata* (65g) and *Wrightia tinctoria* (330g). Plants like *Axonopus compressus* (1g), *Biophytum sensitivum* (1g), *Spermacoce hispida* (1.2g) and *Cyrtococcum trigonum* (1.1g) produced lower biomass compared to other plant species. The proportion of shoot was much higher than the root in the case *Spermacoce hispida* (3.3:1), *Cyrtococcum trigonum* (4:1), and *Vernonia cinerea* (3:1) which can be understood from the shoot-root ratio. In the case of *Asparagus racemosus* (1:7.6), *Cyclea peltata* (1:5), *Rauvolfia serpentina*

Table 11 Total biomass production of medicinal plants in mature oilpalm plantation

Sl. No.	Scientific name	Fresh weight(g)			Dry weight(g)			Driage(%)			Shoot -root Ratio
		Shoot	Root	Shoot+Root	Shoot	Root	Shoot+Root	Shoot	Root	Shoot+Root	
1.	<i>Abrus precatorius</i>	5	2	7	1.25	0.6	1.85	25	30	26.43	2:1
2.	<i>Aristolochia indica</i>	1	1.5	2.5	0.4	0.4	0.8	40	26.67	32	1:1
3.	<i>Asparagus racemosus</i>	25	147	172	5	38.2	43.2	20	25.99	25.12	1:7.6
4.	<i>Atylosia goensis</i>	3.7	2.3	6	0.7	0.7	1.4	18.92	30.43	23.33	1:1
5.	<i>Axonopus compressus</i>	0.6	0.4	1	0.1	0.1	0.2	16.67	25	20	1:1
6.	<i>Biophytum sensitivum</i>	0.5	0.5	1	0.1	0.1	0.2	20	20	20	1:1
7.	<i>Calophyllum polyanthum</i>										
		12	28	40	5.4	14	19.4	45	50	48.5	1:2.6
8.	<i>Calycopteris floribunda</i>	10	40	50	5	22	27	50	55	54	1:4.4
9.	<i>Canthium angustifolium</i>	11	6	17	3.8	2.4	6.2	34.55	40	36.47	1.6:1
10.	<i>Careya arborea</i>	15	25	40	6.8	12.5	19.3	45.33	50	48.25	1:1.8
11.	<i>Centella asiatica</i>	3.9	2.5	6.4	0.8	0.8	1.6	20.51	32	25	1:1
12.	<i>Chromolaena odorata</i>										
		10.5	5.5	16	2.6	1.1	3.7	24.76	20	23.13	2.4:1
13.	<i>Chrysopogon aciculatus</i>	2.2	1.9	4.1	0.4	0.5	0.9	18.18	26.32	21.95	1:1.25
14.	<i>Cissus sp.</i>	3.25	6.25	9.5	1.3	2.7	4	40	43.2	42.11	2.1:1
15.	<i>Curculigo orchioides</i>	1.7	2.5	4.2	0.2	0.7	0.9	11.76	28	21.43	1:3.5
16.	<i>Cyclea peltata</i>										
		4.15	17.5	21.65	1.4	7	8.4	33.73	40	38.8	1:5
17.	<i>Cyrtococcum trigonum</i>										
		0.9	0.2	1.1	0.2	0.05	0.25	22.22	25	22.73	4:1
18.	<i>Desmodium triflorum</i>	1.4	0.8	2.2	0.4	0.3	0.7	28.57	37.5	31.82	1.3:1
19.	<i>Elephantopus scaber</i>	2.6	1.1	3.7	0.4	0.3	0.7	15.38	27.27	18.92	1.3:1
20.	<i>Emilia sonchifolia</i>	1.3	0.6	1.9	0.3	0.2	0.5	23.08	33.33	26.32	1.5:1
21.	<i>Hemidesmus indicus</i>	1.5	3	4.5	0.6	1.2	1.8	40	40	40	1:2

Table 11. Contd.

22.	<i>Hemionettis arafolia</i>	1.2	2.2	3.4	0.3	0.7	1	25	31.82	29.41	1:2.3
23.	<i>Holostemma adakodien</i>	1.7	2.7	4.4	0.4	1.2	1.6	23.53	44.44	36.36	1:3
24.	<i>Hyptis suaveolens</i>	4.2	1.3	5.5	1.1	0.5	1.6	26.19	38.46	29.09	2.2:1
25.	<i>Ipomoea sepiaria</i>	8	42	50	4.8	2.3	7.1	60	5.48	14.2	
26.	<i>Mimosa pudica</i>	5.2	4.7	9.9	1.8	1.8	3.6	34.62	38.3	36.36	1:1
27.	<i>Naregamia alata</i>	1	0.7	1.7	0.2	0.3	0.5	20	42.86	29.41	1:1.5
28.	<i>Pergularia daemia</i>	7	18	25	3.2	9	12.2	45.71	50	48.8	1:2.8
29.	<i>Phyllanthus amarus</i>	2	1	3	0.4	0.2	0.6	20	20	20	2:1
30.	<i>Pleopeltis lanceolata</i>	5.3	4.7	10	0.8	1.2	2	15.09	25.53	20	1:1.5
31.	<i>Rauvolfia serpentina</i>	5.3	12.5	17.8	1	5	6	18.87	40	33.71	1:5
32.	<i>Scoparia dulcis</i>	1.7	1	2.7	0.5	0.4	0.9	29.41	40	33.33	1.25:1
33.	<i>Sida acuta</i>	1.25	0.75	2	0.2	0.1	0.3	16	13.33	15	2:1
34.	<i>Sida rhombifolia</i>	5.5	3	8.5	1.7	1.3	3	30.91	43.33	35.29	1.3:1
35.	<i>Solanum melongena</i> var. <i>incanum</i>	13.2	7.4	20.6	6.6	4.1	10.7	50	55.41	51.94	1.6:1
36.	<i>Spermacoce hispida</i>	0.8	0.3	1.2	0.1	0.03	0.13	12.5	10	10.83	3.3:1
37.	<i>Stachytarpheta indica</i>	2	4	6	0.4	1	1.4	20	25	23.33	1:2.5
38.	<i>Terminalia paniculata</i>	20	45	65	9	22.5	31.5	45	50	48.46	1:2.5
39.	<i>Torenia asiatica</i>	5	3	8	1	1	2	20	33.33	25	1:1
40.	<i>Urena lobata</i>	7	3	10	2.1	1.2	3.3	30	40	33	1.75:1
41.	<i>Vernonia cinerea</i>	1.3	0.4	1.7	0.3	0.1	0.4	23.08	25	23.53	3:1
42.	<i>Vigna trilobata</i>	6	3	9	1.2	0.9	2.1	20	30	23.33	1.3:1
43.	<i>Wrightia tinctoria</i>	50	280	330	15	154	169	30	55	51.21	1:10.3
44.	<i>Zornia gibbosa</i>	2	1	3	0.4	0.3	0.7	20	30	23.33	1.3:1

(1:5) and *Wrightia tinctoria* (1:10.3), the proportion of root was much higher than the shoot.

4.1.3.4. Total biomass production in open conditions

A total of 18 sampling units were taken using 1.0m² frame in open conditions. The fresh weight of each plant species was obtained by taking the mean value from all the quadrats of occurrence. The data on the biomass production of the plant species in open conditions are given in Table 12.

Higher biomass production was observed in *Calotropis gigantea* (150g), *Solanum melongena* var. *insanum* (140g) and *Urena lobata* (50g). In the case of *Cynodon dactylon* (0.9g) *Phyllanthus amarus* (1.8g) and *Vernonia cinerea* (2g), the biomass production was lower compared to other species. From the shoot-root ratio it is evident that the proportion of shoot was higher than the root in *Spermacoce hispida* (3.3:1), *Chromolaena odorata* (5.5:1), and *Solanum melongena* var. *insanum* (6.5:1). The proportion of root was higher than the shoot in *Calotropis gigantea* (1:4.3), *Cyrtia peltata* (1:4.5) and *Hemidesmus indicus* (1:1.3)

Table 12. Total biomass production of medicinal plants in open conditions

Sl. No.	Scientific name	Fresh weight(g)			Dry weight(g)			Driage(%)			Shoot -root Ratio
		Shoot	Root	Shoot+Root	Shoot	Root	Shoot+Root	Shoot	Root	Shoot+Root	
1.	<i>Acanthospermum hispidum</i>	4.25	2	6.25	0.9	0.8	1.7	21.18	40	27.2	1.1:1
2.	<i>Ageratum conyzoides</i>	3.6	1.6	5.2	0.8	0.6	1.4	22.22	37.5	26.92	1.3:1
3.	<i>Bulbostylis barbata</i>	1.3	1	2.3	0.2	0.1	0.3	15.38	10	13.04	2:1
4.	<i>Calotropis gigantea</i>	250	500	750	52.5	225	277.5	21	45	37	1:4.3
5.	<i>Chromolaena odorata</i>	8.8	2	10.8	2.2	0.4	2.6	25	20	24.07	5.5:1
6.	<i>Chrysopogon aciculatus</i>	1.9	1.5	3.4	0.4	0.4	0.8	21.05	26.67	23.53	1:1
7.	<i>Clerodendrum viscosum</i>	11.3	5.5	16.8	2.4	2.2	4.6	21.24	40	27.38	1:1
8.	<i>Cyclea peltata</i>	6	21.25	27.25	1.9	8.5	10.4	31.67	40	38.17	1:4.5
9.	<i>Cynodon dactylom</i>	0.6	0.3	0.9	0.12	0.07	0.19	20	23.33	21.11	1.7:1
10.	<i>Desmodium gangeticum</i>	7	3	10	2.3	1.2	3.5	32.86	40	35	1.9:1
11.	<i>Desmodium triflorum</i>	1.5	1	2.5	0.5	0.3	0.8	33.33	30	32	1.7:1
12.	<i>Elephantopus scaber</i>	1.7	0.8	2.5	0.3	0.2	0.5	17.65	25	20	1.5:1
13.	<i>Emilia sonchifolia</i>	2.3	1.3	2.6	0.5	0.4	0.9	21.75	30.77	34.62	1.25:1
14.	<i>Fragrostis ciliaris</i>	1.9	1.3	3.2	0.4	0.3	0.7	21.05	23.08	21.88	1.3:1
15.	<i>Hemidesmus indicus</i>	1.6	1.9	3.5	0.6	0.8	1.4	37.4	42.11	40	1:1.3
16.	<i>Hyptis suaveolens</i>	1.8	1.2	3	0.5	0.4	0.9	27.78	33.33	30	1.25:1
17.	<i>Knoxia mollis</i>	2.4	1.1	3.5	0.5	0.2	0.7	20.83	18.18	20	2.5:1
18.	<i>Lantana camara var. aculeata</i>	16	4.7	20.7	4.3	2	6.3	26.88	42.55	30.33	2.15:1
19.	<i>Mimosa pudica</i>	4.2	2.6	6.8	1.5	1	2.5	35.71	38.46	36.76	1.5:1
20.	<i>Oldenlandia umbellata</i>	2	0.6	2.6	0.6	0.2	0.8	30	33.33	30.77	3:1

Table 12. Contd.

21.	<i>Phyllanthus amarus</i>	1	0.8	1.8	0.2	0.1	0.3	20	12.5	16.67	2:1
22.	<i>Phyllanthus urinaria</i>	1.5	0.7	2.2	0.3	0.1	0.4	20	14.29	18.18	3:1
23.	<i>Scoparia dulcis</i>	2.5	1.2	3.7	0.7	0.5	1.2	28	41.67	32.43	1.4:1
24.	<i>Sida acuta</i>	2	0.8	2.8	0.3	0.1	0.4	15	12.5	14.29	3:1
25.	<i>Sida rhombifolia</i>	4.2	2.8	7	1.3	1.2	2.5	30.95	42.86	35.71	1.1:1
26.	<i>Solanum melongena</i> var. <i>insanum</i>	123	17	140	61.5	9.4	70.9	50	55.29	50.64	6.5:1
27.	<i>Spermacoce hispida</i>	1.6	0.6	2.2	0.2	0.06	0.26	12.5	10	11.82	3.3:1
28.	<i>Sporobolus indicus</i>	4.5	3	7.5	0.9	0.8	1.7	20	26.67	22.67	1.1:1
29.	<i>Urena lobata</i>	33.3	16.7	50	10	6.8	16.8	30	40.72	33.6	1.5:1
30.	<i>Vernonia cinerea</i>	1.3	0.7	2	0.3	0.2	0.5	23.08	28.57	25	1.5:1

4. 2. Growth phases of selected medicinal plants.

Ten important medicinal plant species were selected as candidate species, which were common to the four strata - young, medium and mature oil palm plantations and open conditions (Table 13.). The light intensity and photosynthetically active radiation (PAR) in the four different strata are presented in Table 14. The growth behaviour of the selected plants was monitored for one year at three different stages of growth - i.e. pre-flowering, flowering and seed set.

4.2.1. Plant Height

The data on plant height of the candidate species are given in Table 15. It is evident that the height of the plant increases from the pre-flowering to the seed set stage for all the ten plants.

Among the four different strata, the plants growing under medium and mature oil palm plantations were found taller compared to those under young and open conditions. The height difference was greater for *Hemidesmus indicus* and *Cyclea peltata* than others. Lesser plant height was recorded in mature than in open for two species viz. *Solanum melongena* var. *insanum* with

Table 13. List of medicinal plants selected for studying growth phases

Sl. No.	Scientific Name	Vernacular Name	Family
1	<i>Chromolaena odorata</i> King & Robinson	Communist pacha	Asteraceae
2	<i>Cyclea peltata</i> Hook. F. & Thoms	Padathali	Menispermaceae
3	<i>Elephantopus scaber</i> Linn.	Anachuvadi	Asteraceae
4	<i>Emilia sonchifolia</i> DC.	Muyalcheviyan	Asteraceae
5	<i>Hemidesmus indicus</i> R.Br.	Narunanti	Asclepiadaceae
6	<i>Hyptis suaveolens</i> Poit.	Nattapoochedi	Lamiaceae
7	<i>Phyllanthus amarus</i> Schum. & Thonn.	Kizhanelli	Euphorbiaceae
8	<i>Sida rhombifolia</i> Linn.	Kurunthotti	Malvaceae
9	<i>Solanum melongena</i> Linn. var. <i>insanum</i> (L.) Prain	Chunta	Solanaceae
10	<i>Vernonia cinerea</i> Less.	Poovankurunthal	Asteraceae

Table 14. Light intensity and photosynthetically active radiation (PAR) in the four different strata

Strata	Light intensity (lux)	Photosynthetically active radiation (PAR) ($\mu\text{Es}^{-1}\text{m}^{-2}$)
Young	2964 - 25596	100.34 - 2101.66
Medium	1713.5 - 3386.5	156 - 348
Mature	72 - 1522	35 - 61
Open	46488 - 53712	2676 - 4044



7. *Hemidesmus indicus* (Narunanti), a candidate species growing in all the four strata



8. *Elephantopus scaber* (Anachuvadi), a candidate species growing in all the four strata



9. *Cyclea peltata* (Padathali), a candidate species growing in all the four strata



10. *Chromolaena odorata* (Communist pacha), a candidate species growing in all the four strata

Table 15. Plant height of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	Plant height(cm)* / Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	45	43	35	12
		2	66	63	82	48
		3	80	90	97	75
2	<i>Cyclea peltata</i>	1	22	39	30	25
		2	44	62	101	32
		3	78	95	120	65
3	<i>Elephantopus scaber***</i>	1	4	3	7	3.5
		2	7.5	5.5	18	8
		3	16	22	25	12
4	<i>Emilia sonchifolia</i>	1	8	8.5	36	5
		2	14	32	45	7.3
		3	21	33	48	10
5	<i>Hemidesmus indicus</i>	1	9.5	12	8.5	10
		2	17	41	36	17
		3	51	60	75	34
6	<i>Hyptis suaveolens</i>	1	25	28	25	22
		2	42	37	38	57
		3	55	54	56	75
7	<i>Phyllanthus amarus</i>	1	8.5	7.8	7	15
		2	13	14	14.5	21
		3	16	17	25	24
8	<i>Sida rhombifolia</i>	1	9.5	18	21	15
		2	18	27	28	17
		3	32	31	38	19
9	<i>Solanum melongena var. insanum</i>	1	18	14	15	15
		2	39	29	20	46
		3	44	65	37	52
10	<i>Vernonia cinerea</i>	1	18.5	25	35	23
		2	26	30	41	32
		3	36	42	45	38

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz

Y - Young (<5 years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

*** Long inflorescence axis contributes to increase in height in stage 2 (flowering) and stage 3 (seed set stage)

mature (37cm) and open (52cm) and *Hyptis suaveolens* with mature (56cm) and open (75cm) during seed set stage.

4. 2.2. Number of branches

The data on number of branches of candidate species are given in Table 16. For all the ten plant species number of branches was found to increase from the pre-flowering to the seed set stage.

More number of branches were produced under open conditions in *Chromolaena odorata*, *Elephantopus scaber*, *Sida rhombifolia*, *Solanum melongena* var. *insanum* and *Hyptis suaveolens* than under the completely shaded conditions. In *Hemidesmus indicus*, *Cyclea peltata*, *Phyllanthus amarus*, *Emilia sonchifolia* and *Vernonia cinerea*, number of branches was greater under medium and mature conditions.

4.2.3. Plant spread

The data on plant spread of candidate species are given in Table 17. It was observed that the plant spread increased from the pre-flowering to the seed set stage for all the ten plant species.

Table 16. Number of branches of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	No of branches*/ Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	7	8	2	9
		2	10	10	4	11
		3	12	10	6	13
2	<i>Cyclea peltata</i>	1	2	3	6	2
		2	3	3	6	3
		3	3	4	7	3
3	<i>Elephantopus scaber</i>	1	3	1	1	0
		2	7	3	2	1
		3	8	3	2	7
4	<i>Emilia sonchifolia</i>	1	0	1	5	0
		2	1	1	6	1
		3	2	5	9	1
5	<i>Hemidesmus indicus</i>	1	2	2	2	2
		2	2	8	4	4
		3	7	13	9	4
6	<i>Hyptis suaveolens</i>	1	3	21	20	27
		2	14	27	29	32
		3	19	31	32	39
7	<i>Phyllanthus amarus</i>	1	0	0	0	0
		2	0	0	3	0
		3	0	1	4	0
8	<i>Sida rhombifolia</i>	1	18	8	0	10
		2	24	10	10	33
		3	31	24	13	48
9	<i>Solanum melongena</i> <i>var. insanum</i>	1	5	2	4	0
		2	6	15	5	15
		3	10	43	15	17
10	<i>Vernonia cinerea</i>	1	0	2	1	0
		2	0	3	4	0
		3	3	6	7	1

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

- Y - Young (<5years)
- Me - Medium (5-11 years)
- Ma - Mature (>11 years)
- O - Open

Table 17. Plant spread of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	Plant spread(cm ²)* / Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	384	360	221	20
		2	700	391	336	99
		3	840	504	460	044
2	<i>Cyclea peltata</i>	1	99	72	70	294
		2	150	77	88	512
		3	176	108	96	525
3	<i>Elephantopus scaber</i>	1	224	180	154	120
		2	315	288	342	238
		3	442	380	504	340
4	<i>Emilia sonchifolia</i>	1	13	12	10	1125
		2	54	63	20	1352
		3	143	66	23	1410
5	<i>Hemidesmus indicus</i>	1	54	22	30	56
		2	55	63	126	56
		3	135	1472	168	99
6	<i>Hyptis suaveolens</i>	1	270	208	154	23
		2	504	440	378	750
		3	750	725	575	1350
7	<i>Phyllanthus amarus</i>	1	9	9	24	15
		2	16	54	36	30
		3	20	60	70	165
8	<i>Sida rhombifolia</i>	1	84	150	20	432
		2	375	340	102	546
		3	560	440	375	837
9	<i>Solanum melongena</i> <i>var. insanum</i>	1	300	84	46	84
		2	336	180	399	1350
		3	368	10925	2530	3828
10	<i>Vernonia cinerea</i>	1	30	14	28	70
		2	84	23	30	90
		3	90	88	54	104

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5years)
 Me - Medium (5-11 years)
 Ma - Mature (>11 years)
 O - Open

The plants growing under open conditions were found to have greater plant spread compared to the young, medium and mature conditions for eight out of the ten selected species. Lesser plant spread was recorded in open than in mature for two species viz. *Elephantopus scaber* with mature (504cm²) and open (340cm²), *Hemidesmus indicus* with mature (168cm²) and open (99cm²) during seed set stage.

4. 2. 4. Height at which first branch is produced

The data on the height at which first branch is produced for the candidate species are given in Table 18. A slight increase in the height of the first branch was observed for all the ten plant species from the pre-flowering to the seed set stage.

The height of the first branch was found to be lower under open conditions and progressively higher under young, medium and mature plantations in all the ten plant species.

4.2.5. Number of leaves

The data on the number of leaves of the candidate species are given in Table 19. Number of leaves produced was found to

Table 18. Plant height at which fist branch is produced for selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	Height of first / Strata** branch (cm)*			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	6	6	7	0.1
		2	8	6	11	0.3
		3	8.5	20	18	1
2	<i>Cyclea peltata</i>	1	0.5	0.8	1.5	0.6
		2	0.6	1	2.3	0.7
		3	0.9	1	4.5	0.8
3	<i>Elephantopus scaber</i>	1	0.3	0.5	0.5	0
		2	0.6	0.7	1.2	0.5
		3	1	1.3	3	0.6
4	<i>Emilia sonchifolia</i>	1	0	0.5	1	0
		2	0.8	2	1.7	1
		3	1	2.2	4.5	1.5
5	<i>Hemidesmus indicus</i>	1	0.5	0.5	0.3	1
		2	1	3	2	1.5
		3	3.5	4	8	4
6	<i>Hyptis suaveolens</i>	1	3	3.5	3.5	3.5
		2	4	4	4	3.8
		3	4.5	5	10	4
7	<i>Phyllanthus amarus</i>	1	0	0	0	0
		2	0	0	1.5	0
		3	0	1	2	0
8	<i>Sida rhombifolia</i>	1	2.5	3	0	1
		2	2.8	4	3	2
		3	3.5	4.5	7.5	2.5
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	0.4	0.8	2.5	0
		2	1.5	1	5	1.5
		3	2	3	12	2
10	<i>Vernonia cinerea</i>	1	0	1	2	0
		2	0	2.5	3	0
		3	4	6.5	8	3

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

Table 19. Number of leaves of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	No of leaves*/ Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	38	34	29	12
		2	54	50	58	42
		3	43	41	42	22
2	<i>Cyclea peltata</i>	1	6	8	5	6
		2	9	10	26	9
		3	8	9	16	8
3	<i>Elephantopus scaber</i>	1	12	11	12	10
		2	30	21	27	16
		3	23	16	15	13
4	<i>Emilia sonchifolia</i>	1	7	8	27	4
		2	9	12	33	6
		3	15	22	35	8
5	<i>Hemidesmus indicus</i>	1	8	13	8	7
		2	23	35	51	15
		3	22	14	10	14
6	<i>Hyptis suaveolens</i>	1	105	98	123	23
		2	211	242	305	85
		3	136	140	150	54
7	<i>Phyllanthus amarus</i>	1	8	9	10	18
		2	10	15	21	19
		3	14	17	30	20
8	<i>Sida rhombifolia</i>	1	75	62	63	28
		2	80	70	71	65
		3	88	75	86	72
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	18	10	13	32
		2	20	48	20	35
		3	44	95	156	36
10	<i>Vernonia cinerea</i>	1	14	18	23	15
		2	16	32	25	21
		3	28	38	44	24

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5 years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

increase from the pre-flowering to the flowering stage and then to decrease in the seed set stage for eight out of the ten plant species.

More number of leaves were produced under young plantation in *Chromolaena odorata*, *Elephantopus scaber*, *Sida rhombifolia* and *Hemidesmus indicus*. Greater number of leaves under mature conditions was recorded in the other species.

4.2.6. Season of flowering and fruiting

The data on season of flowering and fruiting of the candidate species are presented in Table 20. *Elephantopus scaber* and *Hyptis suaveolens* was found to flower twice in a year. *Phyllanthus amarus* flowers during July to November. All the other species flowers throughout the year.

4.2.7. Root Length

The data on root length of the candidate species are given in Table 21. For all the ten plant species root length was found to increase from the pre-flowering to the seed set stage.

Table 20. Season of flowering and fruiting of ten important medicinal plant species.

Sl. No.	Scientific Name	Flowering & Fruiting season
1	<i>Chromolaena odorata</i> King&Robinson	Throughout the year
2	<i>Cyclea peltata</i> Hook.F & Thoms	Throughout the year
3	<i>Elephantopus scaber</i> Linn.	January - May, October - December
4	<i>Emilia sonchifolia</i> DC.	Throughout the year
5	<i>Hemidesmus indicus</i> R.Br.	Throughout the year
6	<i>Hyptis suaveolens</i> Poit.	March - May, October - December
7	<i>Phyllanthus amarus</i> Schum.&Thonn.	July - November
8	<i>Sida rhombifolia</i> Linn.	Throughout the year
9	<i>Solanum melongena</i> Linn. var. <i>insanum</i> (L.)Prain	Throughout the year
10	<i>Vernonia cinerea</i> Less.	Throughout the year

Table 21. Root length of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	Root length(cm)*/ Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	15	14	12	14
		2	18	17	19	20
		3	22	23	23	21
2	<i>Cyclea peltata</i>	1	16	8.6	18	14
		2	20	9.8	25	16
		3	32	10	40	28
3	<i>Elephantopus scaber</i>	1	7	5	5.5	4.5
		2	13	9	7	8
		3	16	11	17	15
4	<i>Emilia sonchifolia</i>	1	3.5	3	9	3
		2	5	8	13	3.8
		3	8	11	16	6
5	<i>Hemidesmus indicus</i>	1	14	15	12	20
		2	17	16	14	21
		3	28	17	35	26
6	<i>Hyptis suaveolens</i>	1	23	20	17	4
		2	29	27	26	41
		3	32	30	38	106
7	<i>Phyllanthus amarus</i>	1	4	3	3.2	6
		2	5	5	7	6
		3	5.2	5.8	7.5	11
8	<i>Sida rhombifolia</i>	1	12	14	11	4.5
		2	15	18	16	8
		3	19	20	17	24
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	13	22	16	10
		2	18	24	16	30
		3	26	62	18	34
10	<i>Vernonia cinerea</i>	1	5.5	5	8	9
		2	7.5	6	11.4	7
		3	8	10.5	12	11

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

Root length was greater under open conditions for *Sida rhombifolia*, *Hyptis suaveolens*, and *Phyllanthus amarus*. For all the other species, plants growing in mature or medium plantation recorded higher root length.

4.2.8. Number of roots

The data on number of roots of candidate species are given in Table 22. An increase in number of roots was recorded for all the ten plant species from the pre-flowering to the seed set stage.

Sida rhombifolia, *Hyptis suaveolens* and *Phyllanthus amarus* produced more number of roots in open conditions. For most of the other species, plants growing under mature plantation recorded greater number of roots.

4.2.9. Inter nodal Length

The data on inter nodal length of the candidate species are given in Table 23. It is evident that the inter nodal length of the plant increases from the pre-flowering to the seed set stage for most of the selected plants.

Table 22. Number of roots of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	No. of roots*/ Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	18	17	16	23
		2	23	21	22	25
		3	32	31	28	26
2	<i>Cyclea peltata</i>	1	9	10	6	4
		2	10	11	8	13
		3	12	13	21	10
3	<i>Elephantopus scaber</i>	1	18	13	16	12
		2	21	19	17	15
		3	24	26	27	21
4	<i>Emilia sonchifolia</i>	1	12	18	20	28
		2	21	23	30	30
		3	24	25	34	32
5	<i>Hemidesmus indicus</i>	1	1	2	2	2
		2	2	3	3	2
		3	9	3	9	6
6	<i>Hyptis suaveolens</i>	1	43	36	20	39
		2	57	48	41	51
		3	70	60	70	106
7	<i>Phyllanthus amarus</i>	1	24	22	15	23
		2	26	28	28	32
		3	28	29	35	38
8	<i>Sida rhombifolia</i>	1	20	18	16	26
		2	25	20	26	34
		3	58	28	38	78
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	3	13	5	36
		2	10	14	18	24
		3	40	88	23	42
10	<i>Vernonia cinerea</i>	1	12	8	15	15
		2	30	12	21	18
		3	32	14	35	28

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

- Y - Young (<5 years)
 Me - Medium (5-11 years)
 Ma - Mature (>11 years)
 O - Open

Table 23. Inter nodal length of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	Inter nodal length(cm)* / Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	3.5	4	5	2.5
		2	5.5	6	10.5	5
		3	6	12	8	7
2	<i>Cyclea peltata</i>	1	1.2	2.5	4	1
		2	1.3	3	5	1.2
		3	1.5	3	6	1.5
3	<i>Elephantopus scaber</i>	1	0.4	0.5	0.2	0.4
		2	1.5	1.5	2.5	1.3
		3	2.8	2.5	3.8	1.8
4	<i>Emilia sonchifolia</i>	1	1	1	1	0.5
		2	1	1.2	2.2	0.9
		3	1.2	1.3	4.2	1
5	<i>Hemidesmus indicus</i>	1	0.7	0.5	1.5	1
		2	4	1.8	9	3
		3	4.5	4.8	10	4
6	<i>Hyptis suaveolens</i>	1	1.5	1.5	1	1.5
		2	1.8	2	2	1.8
		3	2	2.2	2.5	2
7	<i>Phyllanthus amarus</i>	1	0.5	0.8	0.7	1
		2	1	1	1.2	2.5
		3	1	1.2	2.5	3
8	<i>Sida rhombifolia</i>	1	0.3	0.8	0.6	0.6
		2	0.4	1	0.7	0.8
		3	0.7	1.3	1.2	1.2
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	2	0.7	0.5	1
		2	2.5	1	1.5	2.5
		3	3.5	2	4	2.5
10	<i>Vernonia cinerea</i>	1	1.4	1.8	1.5	1.5
		2	2	2	1.6	1.6
		3	3	2.2	3	2.3

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

Among the four different strata, the plants growing under mature conditions were found to have greater inter nodal length compared to the other three conditions. This was observed prominently in *Cyclea peltata*, *Phyllanthus amarus*, *Emilia sonchifolia* and *Hemidesmus indicus*

4. 2. 10. Stem girth

The data on stem girth of the candidate species are given in Table 24. A slight increase in stem girth was observed for all the plants from the pre-flowering to the seed set stage.

Stem girth was more in the plants growing in open conditions and young plantation compared to those under medium and mature conditions. It was highest for *Chromolaena odorata* (2.5cm) under open conditions in seed set stage and least for *Cyclea peltata* (0.2) in the pre-flowering stage.

4. 2. 11. Fresh and dry weight of officinal Part

The data on the fresh and dry weight of the medicinally important part of the candidate species are given in Table 25. It is

Table 24. Stem girth of selected medicinal plants at three different stages of growth in different strata of oil palm plantations

Sl. No.	Scientific name of plant	Growth Stage	Stem girth*(cm)/ Strata**			
			Y	Me	Ma	O
1	<i>Chromolaena odorata</i>	1	1	0.5	0.5	1.4
		2	1.2	1	0.8	2
		3	1.5	1.2	1	2.5
2	<i>Cyclea peltata</i>	1	0.4	0.3	0.2	0.6
		2	0.5	0.4	0.3	0.6
		3	0.7	0.5	0.3	0.8
3	<i>Elephantopus scaber</i>	1	1	0.7	0.5	1
		2	1	1	0.6	1.2
		3	1.4	1.2	0.8	1.5
4	<i>Emilia sonchifolia</i>	1	0.6	0.5	0.5	0.8
		2	0.6	0.6	0.5	0.9
		3	0.8	0.6	0.5	0.9
5	<i>Hemidesmus indicus</i>	1	0.5	0.4	0.3	0.8
		2	0.6	0.5	0.4	1
		3	0.8	0.6	0.4	1
6	<i>Hyptis suaveolens</i>	1	1	0.5	0.4	1
		2	1.2	0.8	0.4	1.2
		3	1.3	1	0.8	1.5
7	<i>Phyllanthus amarus</i>	1	0.8	0.6	0.5	1
		2	0.8	0.7	0.6	1.2
		3	0.9	0.8	0.6	1.3
8	<i>Sida rhombifolia</i>	1	1	0.8	0.7	1
		2	1	1	0.8	1.2
		3	1.3	1.2	1.2	2
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	0.8	1.2	0.6	1.4
		2	1	1.3	0.7	1.5
		3	1.2	1.4	0.8	2
10	<i>Vernonia cinerea</i>	1	0.6	0.4	0.4	0.7
		2	0.6	0.5	0.5	0.8
		3	0.7	0.6	0.5	0.8

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

Table 25. Fresh and dry weight of officinal part of selected medicinal plants at three different stages of growth in different strata of oil palm plantations.

Sl. No.	Scientific name of plant	Growth Stage	Fresh and dry weight of officinal part(g)*/Strata**				Remarks
			Y	Me	Ma	O	
1	<i>Chromolaena odorata</i>	1	14(3.5)	15(4.0)	1(0.25)	15(4)	Shoot is the officinal part
		2	20(5)	19(4)	11(3)	20(5)	
		3	23(6)	20(5)	23(6)	24(6)	
2	<i>Cyclea peltata</i>	1	15(6)	10(4)	10(4)	8(3.2)	Root is the officinal part
		2	10(4)	12(4.8)	8(3.2)	15(6)	
		3	20(8)	15(6)	12(4.8)	22(8.8)	
3	<i>Elephantopus scaber</i>	1	11(2.1)	8(1.5)	9(1.7)	8(1.5)	Whole plant is the officinal part
		2	20(3.6)	12(2.2)	11(2.1)	11(2.1)	
		3	30(5.5)	16(2.9)	18(3.3)	19(3.5)	
4	<i>Emilia sonchifolia</i>	1	0.42(0.08)	0.43(0.08)	0.26(0.05)	2.26(0.42)	Shoot is the officinal part
		2	1(0.2)	2.1(0.41)	0.37(0.07)	3.2(0.6)	
		3	1.4(0.28)	1.28(0.23)	0.54(0.1)	3.45(0.64)	
5	<i>Hemidesmus indicus</i>	1	3(1.05)	5(1.75)	3(1.05)	2(0.7)	Root is the officinal part
		2	2(0.7)	5(1.75)	5(1.75)	3(1.05)	
		3	8(2.8)	5(1.75)	2(0.7)	8(2.8)	
6	<i>Hyptis suaveolens</i>	1	20(5)	20(5)	17(4)	2(0.5)	Shoot is the officinal part
		2	32(8)	33(8)	30(7.5)	5.7(1.4)	
		3	40(10)	39(9)	41(10)	46(11.5)	
7	<i>Phyllanthus amarus</i>	1	0.26(0.05)	0.23(0.05)	0.18(0.04)	0.94(0.19)	Shoot is the officinal part
		2	0.25(0.05)	0.94(0.19)	0.93(0.19)	1.71(0.34)	
		3	0.92(0.18)	1.92(0.24)	1.3 (0.26)	1.9(0.38)	
8	<i>Sida rhombifolia</i>	1	3(1.2)	1(0.4)	0.2(0.08)	2(0.8)	Shoot is the officinal part
		2	2(0.8)	4(1.6)	0.5(0.2)	3(1.2)	
		3	4(1.6)	3(1.2)	1 (0.4)	4(1.6)	
9	<i>Solanum melongena</i> var. <i>insanum</i>	1	3(1.65)	5(2.75)	3(1.65)	8(4.4)	Root is the officinal part
		2	15(8.25)	10(5.5)	10(5.5)	15(8.25)	
		3	35(19.25)	10(5.5)	15(8.25)	110(60.5)	
10	<i>Vernonia cinerea</i>	1	0.59(0.13)	0.9(0.17)	1.3(0.25)	1(0.18)	Shoot is the officinal part
		2	0.7(0.15)	1.06(0.19)	1.7(0.32)	1.36(0.29)	
		3	1.36(0.29)	2.2(0.41)	2.1(0.4)	2.4(0.4)	

*Representative single plant observation.

**Strata consists of oil palm plantations of different age groups viz.

Y - Young (<5years)

Me - Medium (5-11 years)

Ma - Mature (>11 years)

O - Open

Data in Parantheses indicate dry weight of officinal part.

evident that the fresh and dry weight of officinal part increases from the pre-flowering to the seed set stage for most of the ten selected plants.

Among the four different strata, the plants growing under young and open conditions were found to produce higher quantity of officinal part compared to medium and mature plantations. Fresh and dry weight of officinal part was more in the case of *Cyclea peltata*, *Hyptis suaveolens* and *Solanum melongena* var. *inasanum* compared to the other species.

4. 2. 12. Fresh and dry weight of non-officinal Part

The data on the fresh and dry weight of the non-officinal part of the candidate species are given in Table 26. For most of the ten selected species, the fresh and dry weight of non-officinal part increases from the pre-flowering to the seed set stage.

Fresh and dry weight of non-officinal part was more in the case of plants growing under young and open conditions compared to medium and mature. *Solanum melongena* var. *inasanum* produced the highest quantity of non-officinal part under open conditions in seedset stage.

Table 26. Fresh and dry weight of non-official part of selected medicinal plants at three different stages of growth in different strata of oilpalm plantation

Sl. No.	Scientific name of plant	Growth Stage	Fresh and dry weight* / Strata**				Remarks
			Y	Me	Ma	O	
1.	<i>Chromolaena odorata</i>	1	5(2.06)	5(2.06)	0.3(0.12)	5(2.06)	Root is the non-official part
		2	8(3.29)	7(2.88)	4(1.65)	8(3.29)	
		3	9(3.71)	8(3.29)	6(2.5)	6(2.5)	
2.	<i>Cyclea peltata</i>	1	2(0.9)	1(0.45)	1(0.45)	1(0.45)	Shoot is the non-official part
		2	3(1.35)	2(0.9)	2(0.9)	10(4.5)	
		3	5(2.25)	3(1.2)	3(1.2)	10(4.5)	
3.	<i>Emilia sonchifolia</i>	1	0.08(0.03)	0.05(0.02)	0.04(0.01)	0.14(0.05)	Root is the non-official part
		2	0.2(0.07)	0.25(0.08)	0.05(0.02)	0.28(0.09)	
		3	0.2(0.07)	0.18(0.06)	0.06(0.02)	0.35(0.12)	
4.	<i>Hemidesmus indicus</i>	1	1(0.3)	3(0.9)	3(0.9)	1(0.3)	Shoot is the non-official part
		2	1(0.3)	2(0.6)	2(0.6)	2(0.6)	
		3	2(0.6)	3(0.9)	1(0.3)	2(0.6)	
5.	<i>Hyptis suaveolens</i>	1	3(1.2)	4(1.65)	4(1.65)	0.5(0.21)	Root is the non-official part
		2	5(2.06)	6(2.47)	4(1.65)	1.6(0.66)	
		3	10(4.12)	8(3.29)	7(2.88)	11(4.53)	
6.	<i>Phyllanthus amarus</i>	1	0.03(0.01)	0.03(0.01)	0.02(0.003)	0.06(0.01)	Root is the non-official part
		2	0.04(0.01)	0.06(0.01)	0.09(0.02)	0.09(0.02)	
		3	0.08(0.01)	0.2(0.03)	0.7(0.12)	0.2(0.03)	
7.	<i>Sida rhombifolia</i>	1	4(2.2)	0.6(0.3)	5(2.75)	5(2.75)	Root is the non-official part
		2	5(2.75)	1.9(1.1)	6(3.3)	5(2.75)	
		3	7(3.85)	4.3(2.3)	8(4.4)	8(4.4)	
8.	<i>Solanum melongena</i> var. <i>insanum</i>	1	5(2.5)	15(7.5)	2(1)	3(1.5)	Shoot is the non-official part
		2	150(75)	25(12.5)	15(7.5)	10(5)	
		3	275(137.5)	40(20)	35(17.5)	1200(600)	
9.	<i>Vernonia cinerea</i>	1	0.11(0.04)	0.1(0.03)	0.2(0.06)	0.2(0.06)	Root is the non-official part
		2	0.12(0.04)	0.14(0.05)	0.3(0.1)	0.14(0.05)	
		3	0.14(0.05)	0.3(0.1)	0.3(0.1)	0.2(0.06)	

* Representative single plant observation

** Strata consists of oilpalm plantation of different age groups viz

Y- young (<5 years)

Me- Medium (5-11 years)

Ma- Mature (> 11 years)

O - Open.

Data in parantheses indicate dry weight of non-official part.

4. 2. 13. Shoot - Root Ratio

The data on the short-root ratio of the candidate species are given in Table 27. Out of the ten species, eight species had higher contribution of shoot. They were *Chromolaena odorata*, *Elephantopus scaber*, *Sida rhombifolia*, *Solomonum melongena* var. *insanum*, *Hyptis suaveolens*, *Phyllanthus amarus*, *Emilia sonchifolia* and *Vernonia cinerea*. The proportion of root was higher than the shoot in the case of *Cyclea peltata* and *Hemidesmus indicus*.

4.3. Chemical analysis of officinal part (s)

The mean values of the data on the amount of active principles present in selected medicinal plants under different strata of oil palm plantations were statistically analysed and presented in Table 28.

It is evident that the amount of essential oil in the roots of *Hemidesmus indicus* was highest under open conditions (0.25 per cent) and lowest in mature oil palm plantation (0.12 per cent). There was no significant difference between the amount of

Table 27. Shoot-root ratio of selected medicinal plants at three different stages of growth in different strata of oil palm plantation

Sl. No.	Scientific name of plant	Growth Stage	Shoot-root ratio * / Strata**				Remarks
			Y	Me	Ma	O	
1.	<i>Chromolaena odorata</i>	1	1.7:1	1.7:1	2.08:1	1.94:1	Shoot>Root
		2	1.5:1	1.4:1	1.8:1	1.5:1	
		3	1.6:1	1.8:1	2.4:1	2.4:1	
2.	<i>Cyclea peltata</i>	1	1:6.7	1:10	1:8.9	1:7.1	Shoot<Root
		2	1:2.9	1:6	1:3.6	1:1.3	
		3	1:3.5	1:5	1:3.6	1:2	
3.	<i>Elephantopus scaber</i>	1	1.6:1	1.8:1	2.1:1	1.8:1	Shoot>Root
		2	1.1:1	1.8:1	1.6:1	2.7:1	
		3	1.2:1	1.3:1	1.2:1	1.7:1	
4.	<i>Emilia sonchifolia</i>	1	2.7:1	4:1	3.9:1	8.4:1	Shoot>Root
		2	2.9:1	5.1:1	3.5:1	6.5:1	
		3	4:1	3.8:1	5:1	5.3:1	
5.	<i>Hemidemus indicus</i>	1	1:3.5	1:1.9	1:1.2	1:2.3	Shoot<Root
		2	1:2.3	1:2.9	1:2.9	1:1.8	
		3	1:4.7	1:1.9	1:2.3	1:4.7	
6.	<i>Hyptis suaveolens</i>	1	4.2:1	3:1	2.4:1	2.4:1	Shoot>Root
		2	3.9:1	3.2:1	4.6:1	2.1:1	
		3	2.4:1	2.7:1	3.5:1	2.5:1	
7.	<i>Phyllanthus amarus</i>	1	5:1	10:1	13.3:1	19:1	Shoot>Root
		2	5:1	19:1	9.5:1	17:1	
		3	18:1	8:1	2.2:1	12.7:1	
8.	<i>Sida rhombifolia</i>	1	2.8:1	4.1:1	6.9:1	2.3:1	Shoot>Root
		2	2.3:1	5.3:1	2.1:1	3.4:1	
		3	2.4:1	5.9:1	3.7:1	2.8:1	
9.	<i>Solanum melongena</i> var. <i>insanum</i>	1	1.5:1	2.7:1	1:1.6	1:5.5	Shoot>Root
		2	9:1	1.4:1	1.4:1	1.1:1	
		3	7.1:1	3.6:1	2.1:1	9.9:1	
10.	<i>Vernonia cinerea</i>	1	3.3:1	5.7:1	3.6:1	3:1	Shoot>Root
		2	3.8:1	3.8:1	3.2:1	8:1	
		3	5.8:1	4.1:1	4:1	7.5:1	

* Representative single plant observation

** Strata consists of oilpalm plantation of different age groups viz

Y- young (<5 years)

Me- Medium (5-11 years)

Ma- Mature (> 11 years)

O - Open.

Table 28. Amount of active principles in selected medicinal plants growing under different strata of oilpalm plantation.

Treatments	<i>Hemidesmus indicus</i> (% essential oil)	<i>Solanum melongena</i> var. <i>incanum</i> (% solasodine)	
	Root	Fruit	Root
Young	0.21	0.29	0.32
Medium	0.20	0.08	0.25
Mature	0.12	0.15	0.23
Open	0.25	0.31	0.34
$F_{3,8}$	25.58**	11.39**	8.26**
CD	0.036	0.103	0.06

** - Significant at 1% level.

essential oil in the roots under young (0.21 per cent) and medium oil palm plantations (0.20 per cent). The per cent of solasodine in the fruits of *Solanum melongena* var. *insanum* was highest under open conditions (0.31 per cent) and lowest in medium oil palm plantation (0.08 per cent). There was no significant difference between the per cent of solasodine in the fruits in young oil palm plantation (0.29 per cent) and open conditions (0.31 per cent) and in medium oil palm plantation (0.08 per cent) and mature oil palm plantation (0.15 per cent). The per cent of solasodine in the roots of *Solanum melongena* var. *insanum* was highest under open conditions (0.34 per cent) and lowest in mature oil palm plantation (0.23 per cent). There was no significant difference between the per cent of solasodine in the roots in young oil palm plantation (0.32 per cent) and open conditions (0.34 per cent) and in medium oil palm plantation (0.25 per cent) and mature oil palm plantation (0.23 per cent)



DISCUSSION

5. DISCUSSION

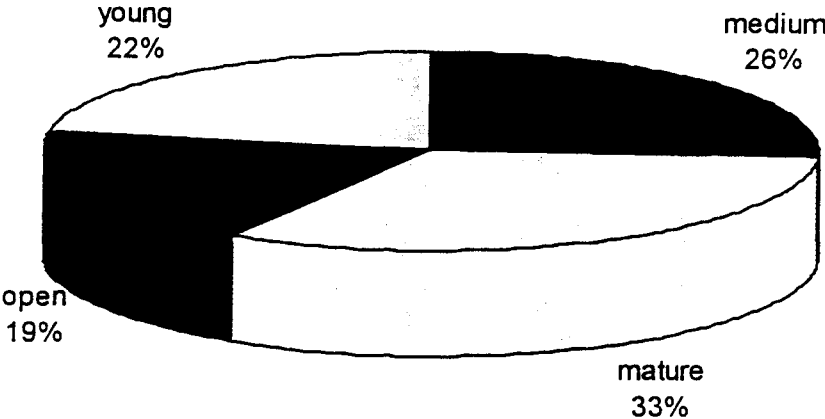
The present study on "Biodiversity of medicinal plants in oil palm plantations" was carried out at the oil palm plantations, Kulathupuzha, of the oil palm India Ltd; in the Kollam district. The objectives of the study were to identify the medicinal plants in oil palm plantations, to study the growth behaviour of selected medicinal plants and to assess the influence of shade on pharmacologically active constituents. The results of the study are discussed in this chapter.

5.1 Identification of flora and vegetation analysis

5.1.1. Flora

A total of 85 plant species were identified in the four different strata - young, medium and mature plantations and open conditions, belonging to 79 genera and 36 families (Table 2). The occurrence of a few out of the 85 species recorded from all the four strata during the present study was verified with previous reports and studies carried out by other workers in oil palm plantations elsewhere. The growth of *Axonopus sp.*, *Lantana sp.* and *Nephrolepis sp.* in the oil palm plantations of Malaya was reported by Hartley (1911). *Cyperus rotundus*, *Ageratum conyzoides* and *Cynodon sp.* in the oil palm

Fig 1. Stratawise distribution of medicinal plants



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plantations of Ghana was reported by Adansi (1969). Seth and Baba (1970) and Coomans (1971) reported the presence of *Axonopus compressus* in oil palm plantations. *Mimosa pudica*, *Eupatorium odoratum* (*Chromolaena odorata*), *Lantana camara* and *Vernonia sp.* were reported growing in oil palm plantations of Cameroon by Gaullier (1986). *Eupatorium odoratum* (*Chromolaena odorata*), *Boerraria sp.* and *Mimosa pudica* were reported in Indian oil palm plantations by Panikar (1997).

5.1.2. Study of vegetative parameters of medicinal plants

Chrysopogon aciculatus dominated all the four strata with high relative density, frequency and Importance value. *Cyrtococum trigonum* was another dominating species with high relative density occurring in young and mature oil palm plantations. *Naregamia alata* was a dominant and abundant species occurring in mature plantation. *Hemidesmus indicus* was found frequently in all the four strata. *Phyllanthus amarus* was more frequent in mature plantation and open conditions. *Holostenma adakodien* and *Naregamia alata* also occurred frequently in mature plantation. *Elephantopus scaber* was frequent in young plantation and *Chromolaena odorata* in medium plantation.

5.1.2.1. Vegetative parameters in young oil palm plantation

Chrysopogon aciculatus, *Elephantopus scaber* and *Hemidesmus indicus* were species found most frequent in the young plantation (Table 3.). The dominance by the three top ranking species, i.e. *Chrysopogon aciculatus*, *Cyrtococcum trigonum* and *Aristida setacea* with their contribution to 71.2 per cent of stand density and high I.V., indicates that these species utilize majority of space and resources (Parthasarathy and Sethi, 1997). A very few grass species thus dominate the community numerically. This is in conformity with the findings of Sunitha *et al.* (1995) that grassy weeds dominate the new oil palm plantations. Majority of the species showed absolute density below ten, and were represented by less number of individuals. *Cassia tora*, represented by a single individual in all the four strata, was considered as a rare species. Similar conclusion was made by Parathasarathy and Karthikeyan (1997) who considered species represented by one or two individuals as rare.

5.1.2.2. Vegetative parameters in medium oil palm plantation

The more frequently observed species in medium oil palm plantation were *Chrysopogon aciculatus* and *Hemidesmus indicus*

(Table 4.). The relative densities of the two dominant species come to 71.57 per cent. A very few species thus dominate the plant community in medium plantation numerically, consisting of both grasses and dicotyledons (Coomans, 1971, Sunitha et al, 1995). *Terminalia crenulata* and *Tragia involucrata* were considered as rare species, since both were represented by a single individual each (Parthasarathy and Karthikeyan, 1997).

5.1.2.3. Vegetative parameters in mature oil palm plantation

The more frequently observed species in mature oil palm plantation were *Chrysopogon aciculatus*, *Holostemma adakodien* and *Naregamia alata* (Table 5.). The relative densities of the dominant species - *Chrysopogon aciculatus*, *Cyrtococcum trigonum* and *Naregamia alata* come to 75.92 per cent. Thus a very few species e.g. grasses and dicotyledons dominate in mature oil palm plantation (Coomans, 1971, Sunitha et al., 1995). A number of rare species represented by a single individual were recorded in mature oil palm plantation. They were *Calophyllum polyanthum*, *Calycopteris floribunda*, *Careya arborea*, *Ipomoea sepiaria*, *Pergularia daemia*, *Terminalia paniculata*, *Torenia asiatica* and *Wrightia tinctoria*.

5.1.2.4. Vegetative parameters in open conditions

Chrysopogon aciculatus was the most dominant species in open conditions also, though the relative density was not as high as in the interspaces of oil palm plantations (Table 6.). *Chromolaena odorata*, *Hemidesmus indicus* and *Phyllanthus amarus* were most frequently encountered in open conditions. The relative densities of the dominant species - *Chrysopogon aciculatus*, *Elephantopus scaber* and *Phyllanthus amarus* together were 33.15. Hence other species like *Spermacoce hispida*, *Hyptis suaveolens* and *Vernonia cinerea* also dominated open conditions. *Calotropis gigantea* and *Desmodium gangeticum* were the rare species represented by one and two individuals respectively.

5.1.2.5. Medicinal plant vegetation pairwise analysis

From the co-efficient of community and Sorensons similarity index (C_N), young oilplam plantations and open conditions were found to be the most similar strata with more number of species in common (Table 7.). According to the similarity co-efficient value calculated using the Importance value, young and mature oil palm plantations were found similar in vegetation while mature plantation and open

conditions were found to be the most dissimilar strata in vegetation pairwise analysis.

5.1.2.6. Plantation site vegetation analysis indices

Medium oil palm plantation was found to have higher concentration of dominance as expressed by Simpson's Index (Table 8.). Here the floristic diversity as expressed by Simpson's Index was 0.13, which indicated that 13 pairs out of 100 taken at random were composed of different species (Seetharam *et al.*, 1999). Shannon's Index represents abundant species and Simpson's Index represents very abundant species. Simpson's Index gives more weightage to the common species but relatively little weightage to the rare species. It ranges in value from 0 to a maximum of $(1-1/s)$, where s is the number of species (Raizada *et al.*, 1998). Hence it was found that abundant species occurred more in mature oil palm plantations and very abundant species occurred more in medium oil palm plantations. Evenness index was maximum in open conditions. The distribution of individuals among the species is called species evenness. Evenness is maximum when all species have the same number of individuals (Hurlbert, 1971). Hence it can be said that under open conditions almost all species had equal number of individuals.

5.1.3. Total biomass production of medicinal plants in all the four strata

Total biomass production refers to the total weight of shoot and root. Higher biomass production in *Clerodendrum viscosum*, *Chromolaena odorata*, and *Solanum melongena* var. *insanum* resulted from the luxuriant growth of the shoot of these plants under the bright sunlight received in the interspaces of young oil palm plantation (Table 9.). Extensive root growth in *Mimosa pudica* and tuberous nature of roots in *Cyclea peltata* resulted in higher biomass production.

Higher biomass production in *Calycopteris floribunda*, *Terminalia crenulata* and *Terminalia paniculata* in medium oil palm plantation can be attributed to the thick growth of the root system (Table 10.). In *Solanum melongena* var. *insanum*, the shoot together with the berries contributed to the higher biomass production whereas both shoot and root contributed to higher biomass production in *Mimosa pudica*. Plants such as *Axonopus compressus*, *Spermacoce hispida*, *Emilia sonchifolia*, *Phyllanthus amarus* and *Vernonia cinerea* produced lower biomass.

Highly thickened, fibrous root system in *Asparagus racemosus* and large roots in *Terminalia paniculata* and *Wrightia tinctoria* contributed to the higher biomass production in mature oil palm plantation (Table 11.). Herbaceous nature of *Axonopus compressus*, *Biophytum sensitivum*, *Spermacoce hispida* and *Cyrtococcum trigonum* resulted in the lower biomass production in these plant species.

Higher biomass production in *Calotropis gigantea* in open conditions can be attributed to the thick growth of its root system (Table 12.). In *Solanum melongena* var. *insanum*, the shoot together with the berries contributed to the higher biomass production. The shoot contributes to higher biomass production in *Urena lobata*. Herbaceous nature of growth of *Cynodon dactylon*, *Phyllanthus amarus* and *Vernonia cinerea* resulted in the lower biomass production of these plant species.

Inference on biomass yield in different species in different strata was well augmented by the shoot-root ratio in these plants.

5.2. Growth phases of selected medical plants

There has been a phenomenal increase in many characters indicating growth behaviour such as plant height, number of branches,

plant spread, height at which first branch is produced, number of leaves, inter nodal length and stem girth from pre-flowering to seed set stage. It is observed that the increase in these features from pre-flowering to seed set stage has a positive co-relationship with the physiological growth and age of the plants.

5.2.1. Plant height

Among the four different strata, the plants growing under medium and mature oil palm plantations were found to be taller compared to those under open conditions and young plantation for eight out of the ten selected species (Table 15; Fig.2). The inter spaces of medium and mature oil palm plantations are much shaded compared to young and open condition. This is due to the luxuriant umbrella like growth of the palm canopy. The young oil palm plantation is almost similar to open conditions since the palm canopy is limited. Increase in height in plants growing under medium and mature oil palm plantations may be due to the lanky growth of plants in shade compared to open conditions and the inherent ability of the plants to tolerate shade. However, *Solanum melongena* var *insanum* and *Hyptis suaveolens* in mature plantation were shorter in height than those found in open conditions. Competition for eco-physiological requirements like water, nutrients and light might have

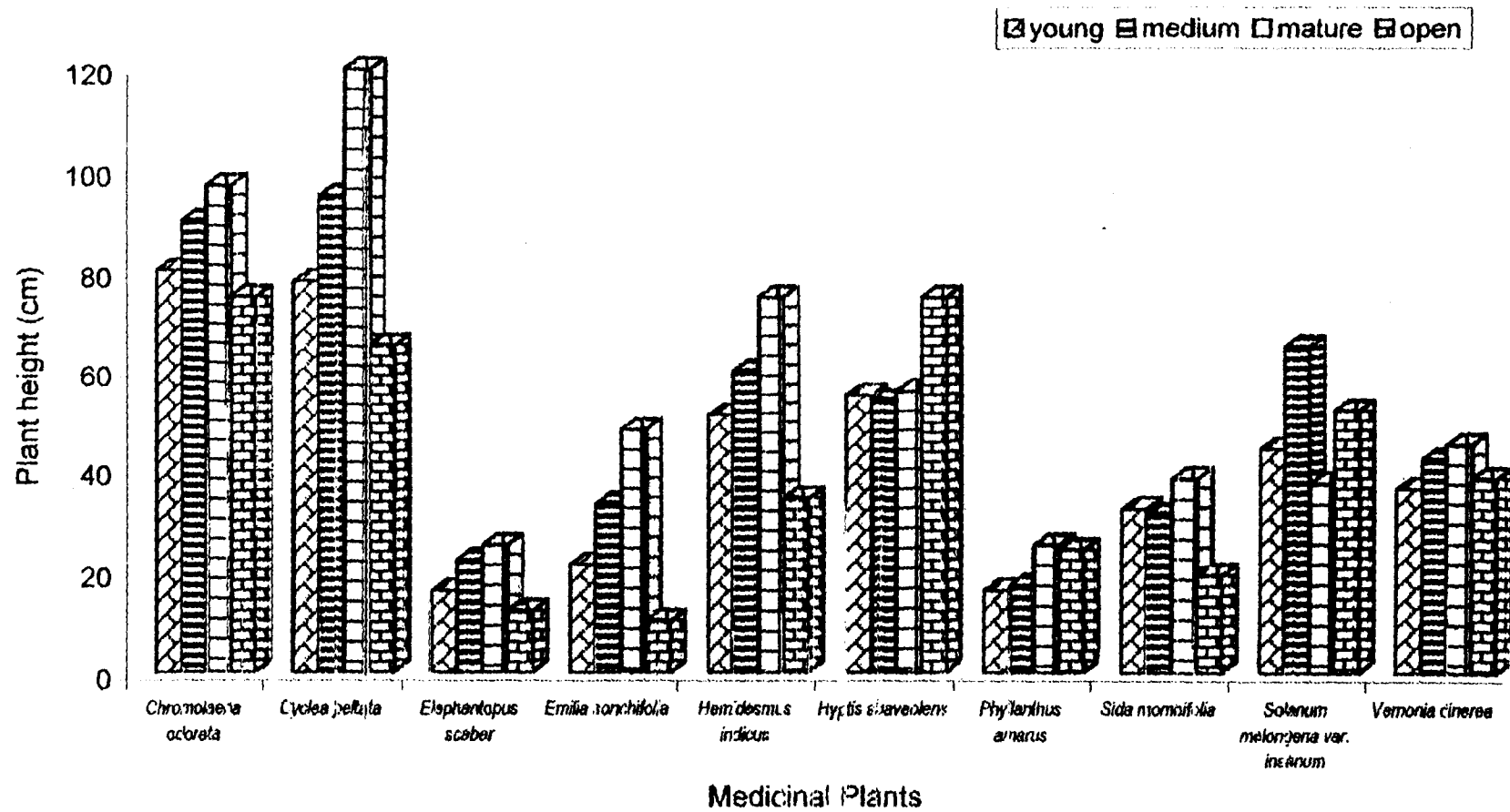


Fig. 2. Plant height (cm) of selected medicinal plants at seed set stage in different strata

resulted in an unfavourable situation for rapid vegetative growth, thereby causing a reduction in plant height (Anilkumar, 1984)

5.2.2. Number of branches

Plant height and the branching pattern were co-related. Lanky growth of plants growing under shaded situations of medium and mature oil palm plantations resulted generally in the production of less number of branches (Table 16; Fig.3). However in *Hemidesmus indicus*, *Cyclea peltata*, *Phyllanthus amarus*, *Emilia sonchifolia* and *Vernonia cinerea*, number of branches were greater under medium and mature plantations. This can be due to the inherent ability of plants to tolerate the partial shade under the palm canopy. Branching in plants growing under young plantation and open conditions will be more since the height of plants is less compared to medium and mature conditions. More branches were thus observed in *Chromolaena odorata*, *Elephantopus scaber*, *Sida rhombifolia*, *Solanum melongena* var. *insanum* and *Hyptis suaveolens* under open situations.

5.2.3. Plant spread

Greater plant spread under open conditions compared to the young, medium and mature plantations may be due to the shortening

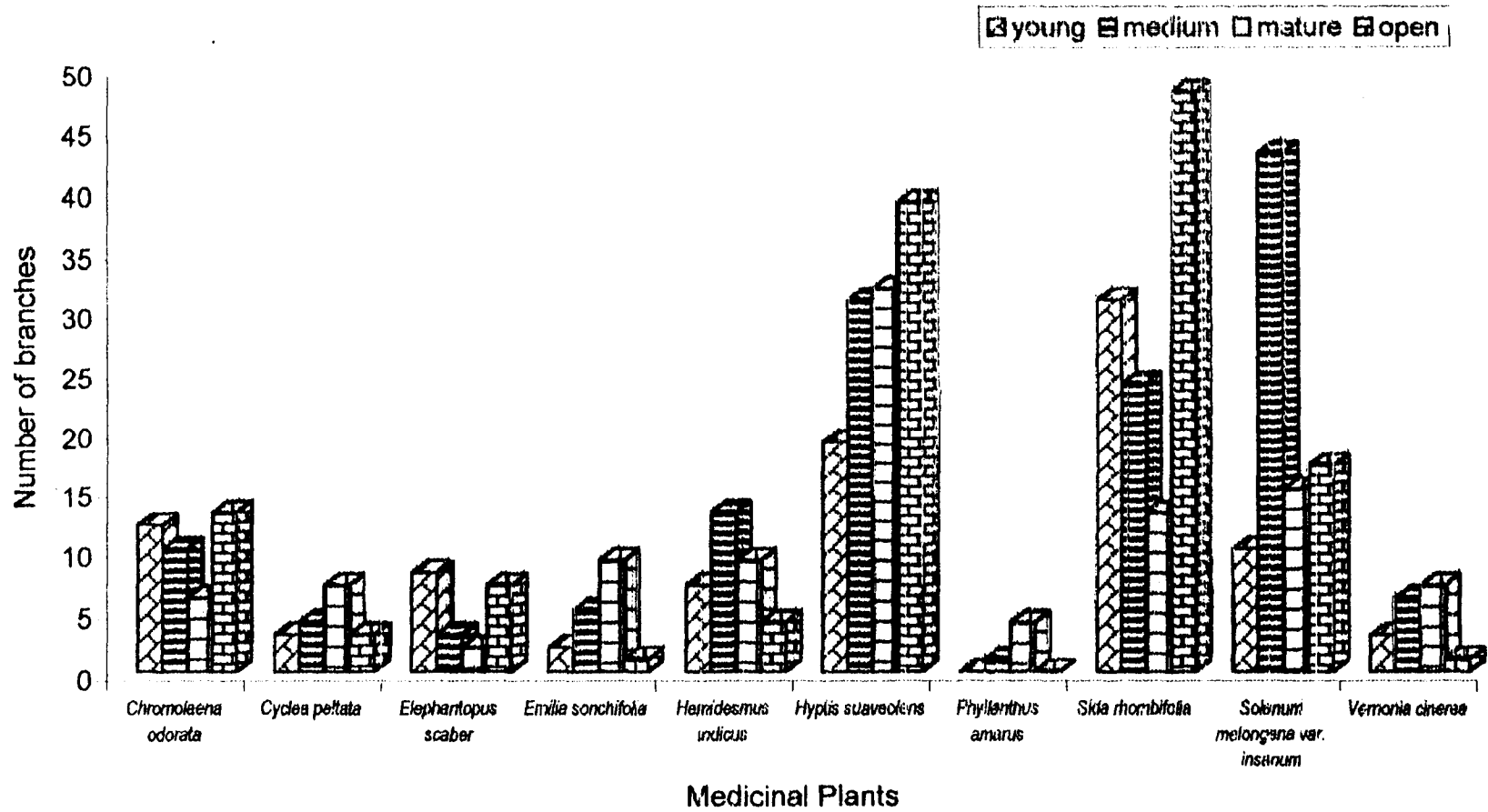


Fig. 3. Number of branches of selected medicinal plants at seed set stage in different strata

of height, more branching and sidewise growth of plants resulting from their profuse growth under open conditions (Table 17.). Greater plant spread recorded in mature than in open for *Elephantopus scaber* and *Hemidesmus indicus* can be again due to their inherent ability to tolerate partial shade.

5.2.4. Height at which first branch is produced

The height of the first branch was found to be lower under open conditions and progressively higher under young, medium and mature conditions in all the ten plant species (Table 18; Fig.4). Higher production of the first branch in medium and mature plantations is related to the lanky growth of plants compared to those in young and open conditions.

5.2.5. Number of leaves

Reduction in number of leaves from flowering to seed set stage may be due to the transition from vegetative to reproductive stage, which is characterized by leaf senescence and leaf fall (Table 19.). More number of leaves in plants of *Chromolaena odorata*, *Elephantopus scaber*, *Sida rhombifolia* and *Hemidesmus indicus* growing under young plantation may be due to the increased

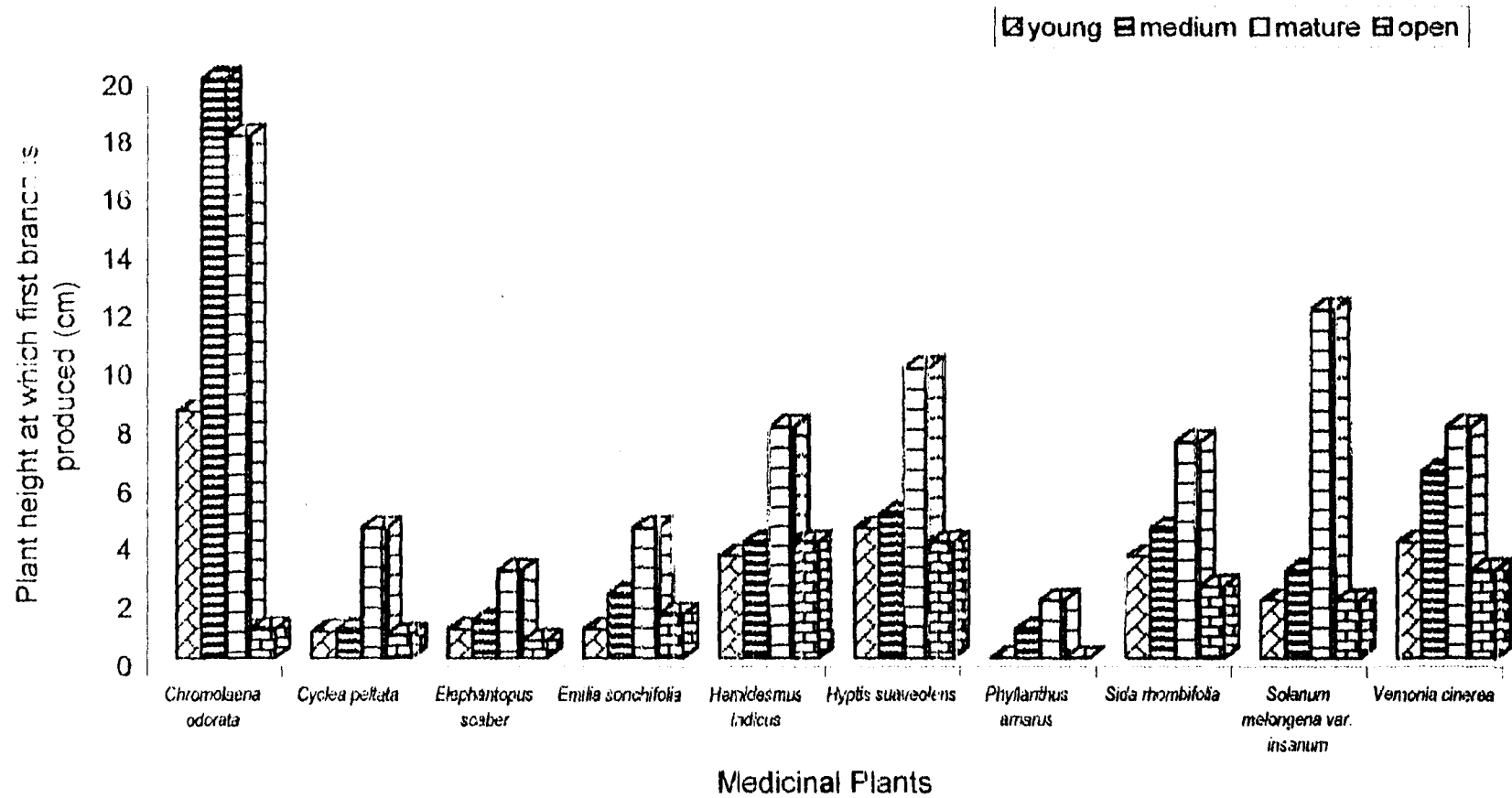


Fig. 4. Plant height at which first branch is produced (cm) for selected medicinal plants at seed set stage in different strata

vegetative growth under light than in shade. Greater number of leaves under mature conditions recorded in the other species denotes the ability of the plants to tolerate shade.

5.2.6. Season of flowering and fruiting

The data on season of flowering and fruiting of the ten important medicinal plant species are presented in Table 20. *Elephantopus scaber* and *Hyptis suaveolens* were found to flower twice in a year. *Phyllanthus amarus* flowers during July to November. All the other species flowers throughout the year. The flowering episodes in medicinal plants are species specific. In *Elephantopus scaber* and *Hyptis suaveolens*, flowering was at peak during warmer months of January to May and during winter months of October to December. *Phyllanthus amarus* flowers during rainy season. All other species studied flowered and fruited throughout the year.

5.2.7. Root characters

Root length and number of roots produced were greater under open conditions for *Sida rhombifolia*, *Hyptis suaveolens* and *Phyllanthus amarus* (Table 21 & Table 22; Fig 5.). This might be due to more vigorous and faster growth rate of these species under open

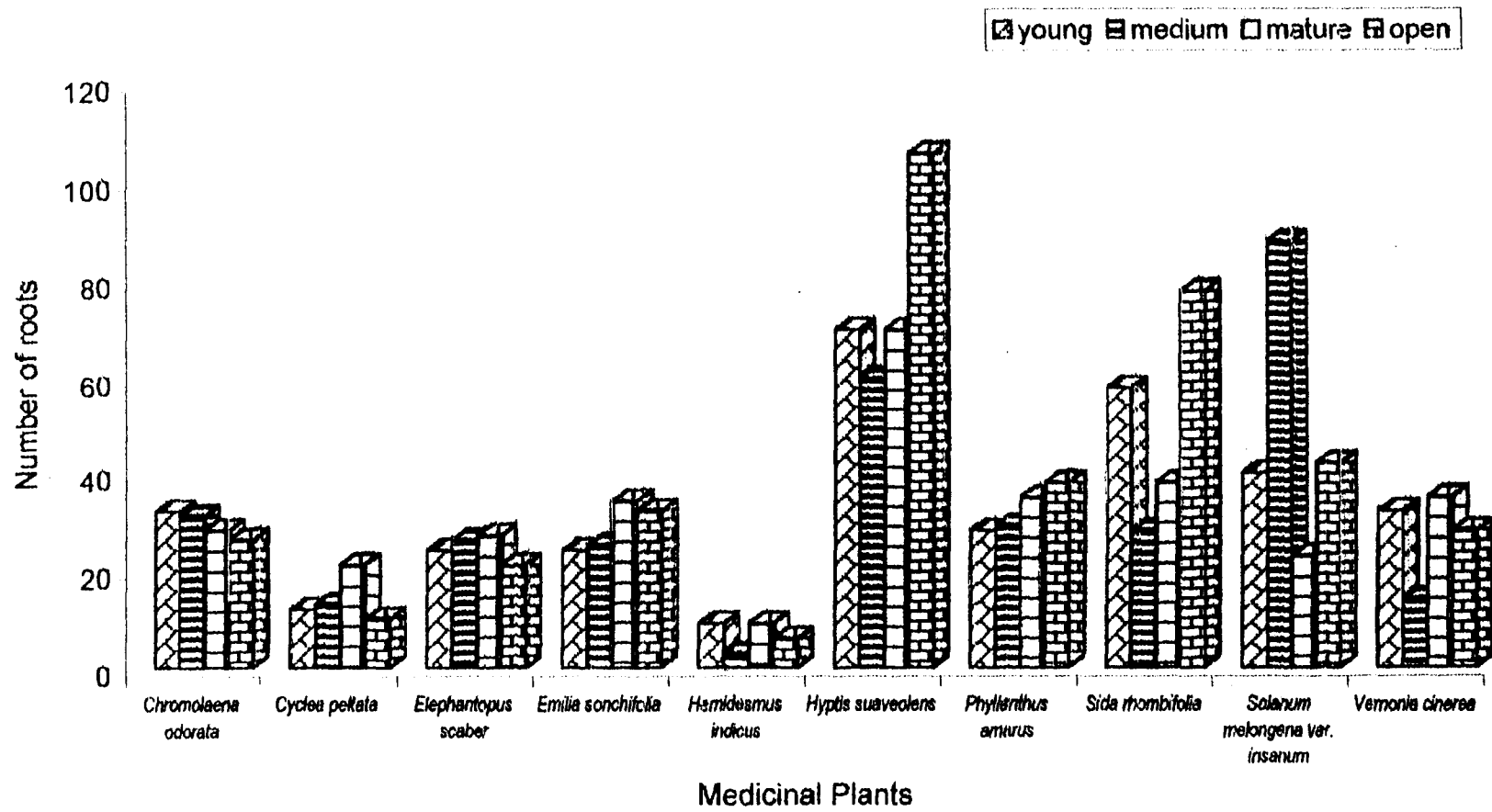


Fig. 5. Number of roots of selected medicinal plants at seed set stage in different strata

conditions when compared to that under shade in plantations. Vigorous growth also contributes to increase in root length and number of roots from the pre-flowering to the seed set stage. Increase in root length and number of roots for plants growing under medium and mature plantations may be due to the inherent ability of the plants to tolerate shade.

5.2.8. Inter nodal length and stem girth

Inter nodal length and stem girth are usually related to the height of the plants. Greater inter nodal length and lesser stem girth under mature conditions in *Cyclea peltata*, *Phyllanthus amarus*, *Emilia sonchifolia* and *Vernonia cinerea* may be attributed to the lanky growth of the plants under shaded conditions (Table 23; Fig 6 & Table 24; Fig 7.).

5.2.9. Fresh and dry weight of officinal part

Fresh and dry weight of the medicinally important part was more in plants under young plantation and open conditions (Table 25.). This is due to their better vegetative growth in terms of number of branches and number of leaves in the case of plants where shoot is

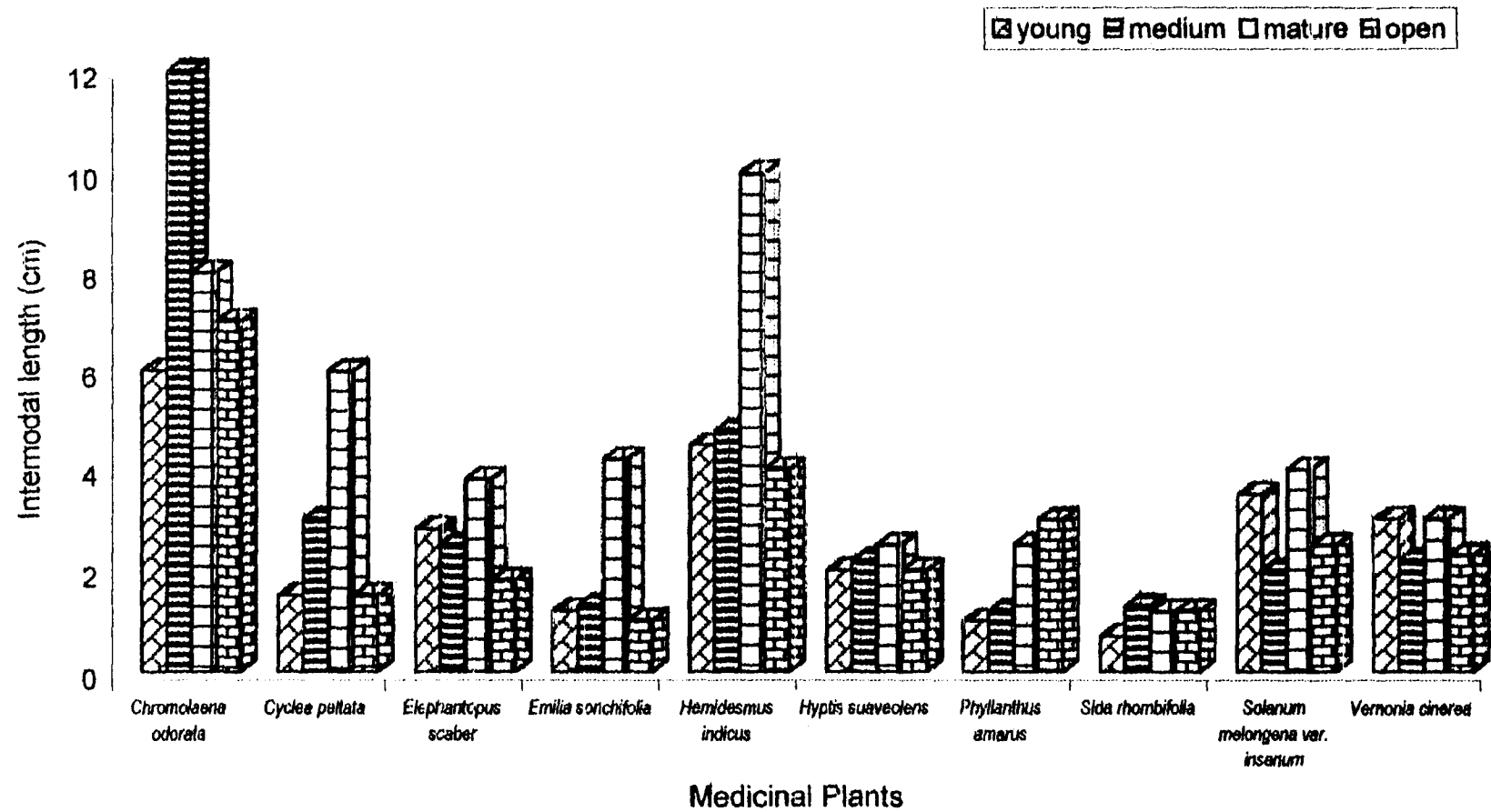


Fig. 6. Internodal length (cm) of selected medicinal plants at seed set stage in different strata

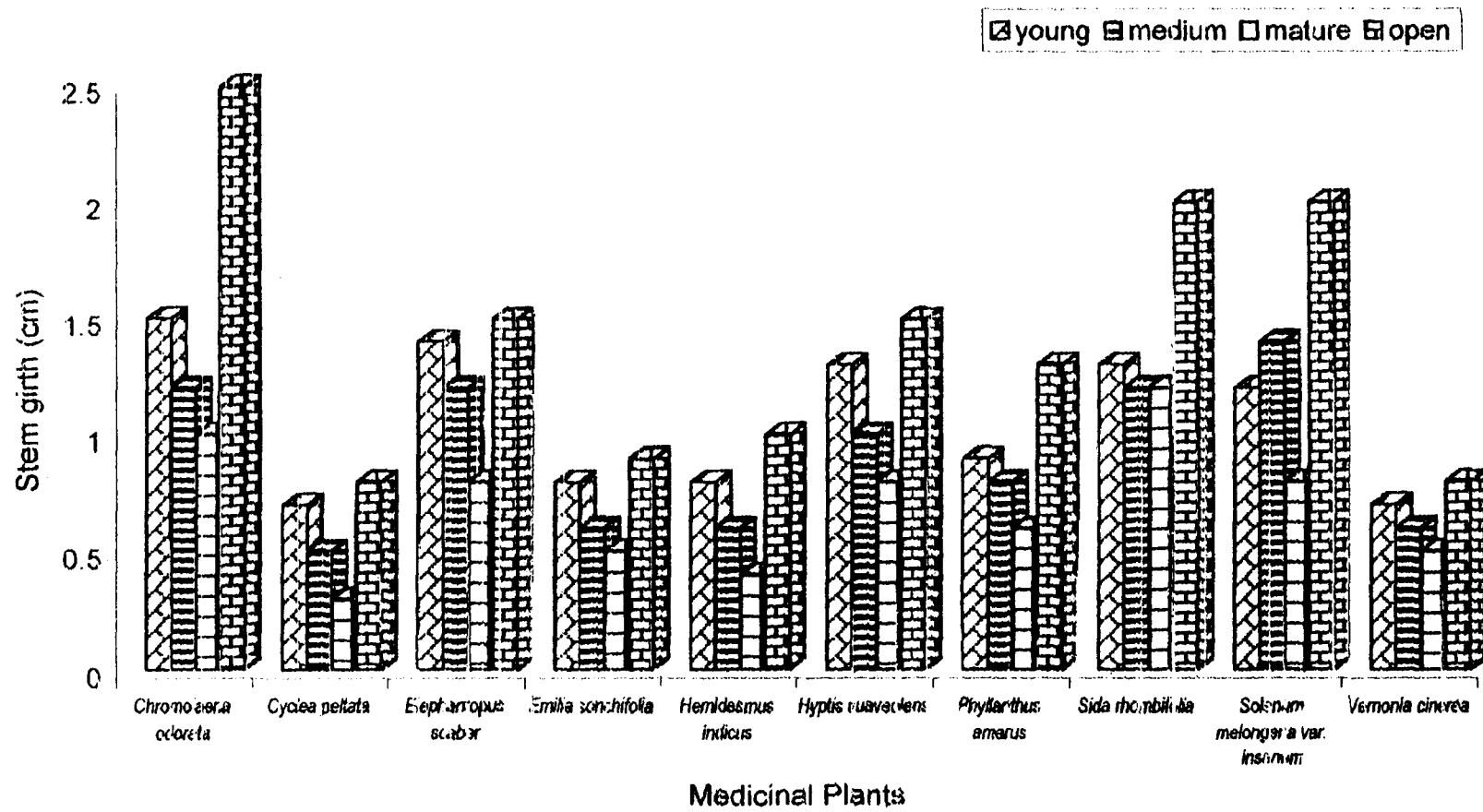


Fig. 7. Stem girth (cm) of selected medicinal plants at seed set stage in different strata

the officinal part and in terms of root growth in plants where root is the officinal part.

It is reasonable to presume that under uniform conditions of growth, the dry matter accumulation is more or less similar to that of green matter out put. This explains why the fresh weight and dry weight of shoot follow the same pattern under open and shaded conditions.

Tuberous nature of the root contributes to the increase in weight of the officinal part in the case of *Cyclea peltata*. Thick and sturdy growth of the root of *Solanum melongena* var. *insanum* contributed to its increase in weight.

5.2.10. Fresh and dry weight of non-official part.

Fresh and dry weight of the non-official part was more in the case of plants growing under young plantation and open conditions compared to medium and mature plantations (Table 26.). This is because of the vigorous vegetative growth of the plants under optimum light conditions. The weight of the berries contributed to the increased weight of non-official part in *Solanum melongena* var. *insanum* in seedset stage.

5.2.11. Shoot-root ratio

A better vegetative growth was obtained in *Chromolaena odorata*, *Elephantopus scaber*, *Sida rhonibifolia*, *Solanum melongena* var. *insanum*, *Hyptis suaveolens*, *Phyllanthus amarus*, *Emilia sonchifolia* and *Vernonia cinerea* which had a higher contribution of shoot (Table 27.). Thickened, tuberous nature of the roots as found in *Cyclea peltata* and *Hemidesmus indicus* contributes to higher proportion of shoot.

5.3. Chemical analysis of officinal part (s)

The amount of essential oil in the roots of *Hemidesmus indicus* collected from different strata (Table 28; Fig 8.) was in conformity with the per cent essential oil recorded by Iyer and Kolammal (1951). Within the plantation, essential oil in the roots of this plant was higher in young and medium oil palm plantations.

Solasodine per cent in the fruits and roots of *Solanum melongena* var. *insanum* collected from different strata (Table 28; Fig 9.) was in agreement with the results obtained by Khanna and Murthy (1974) and Goswami *et al.* (1986). Plantation wise the solasodine per

Fig. 8 Essential oil content in the roots of *Hemidesmus indicus* growing under different strata of oil palm plantation

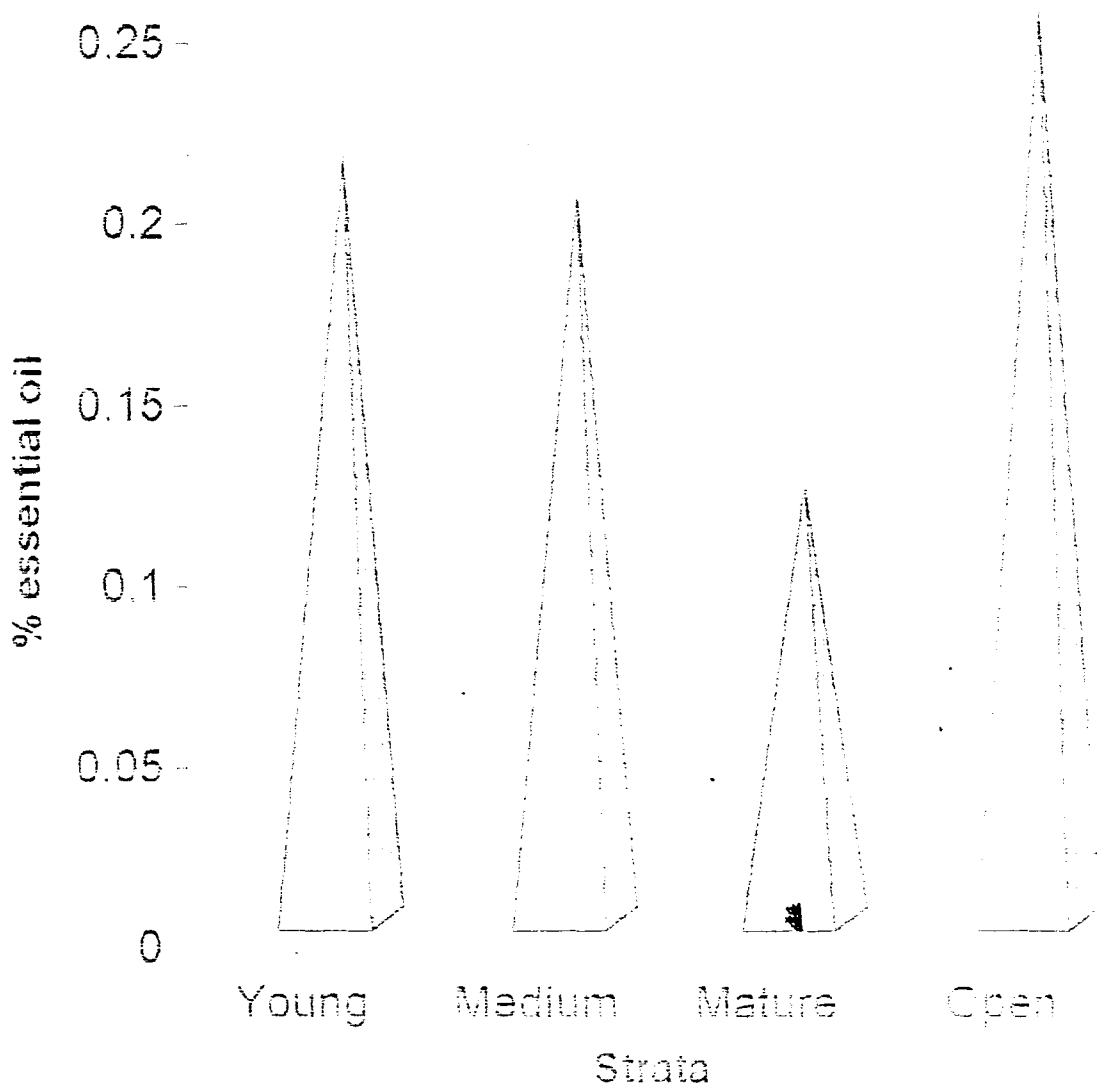
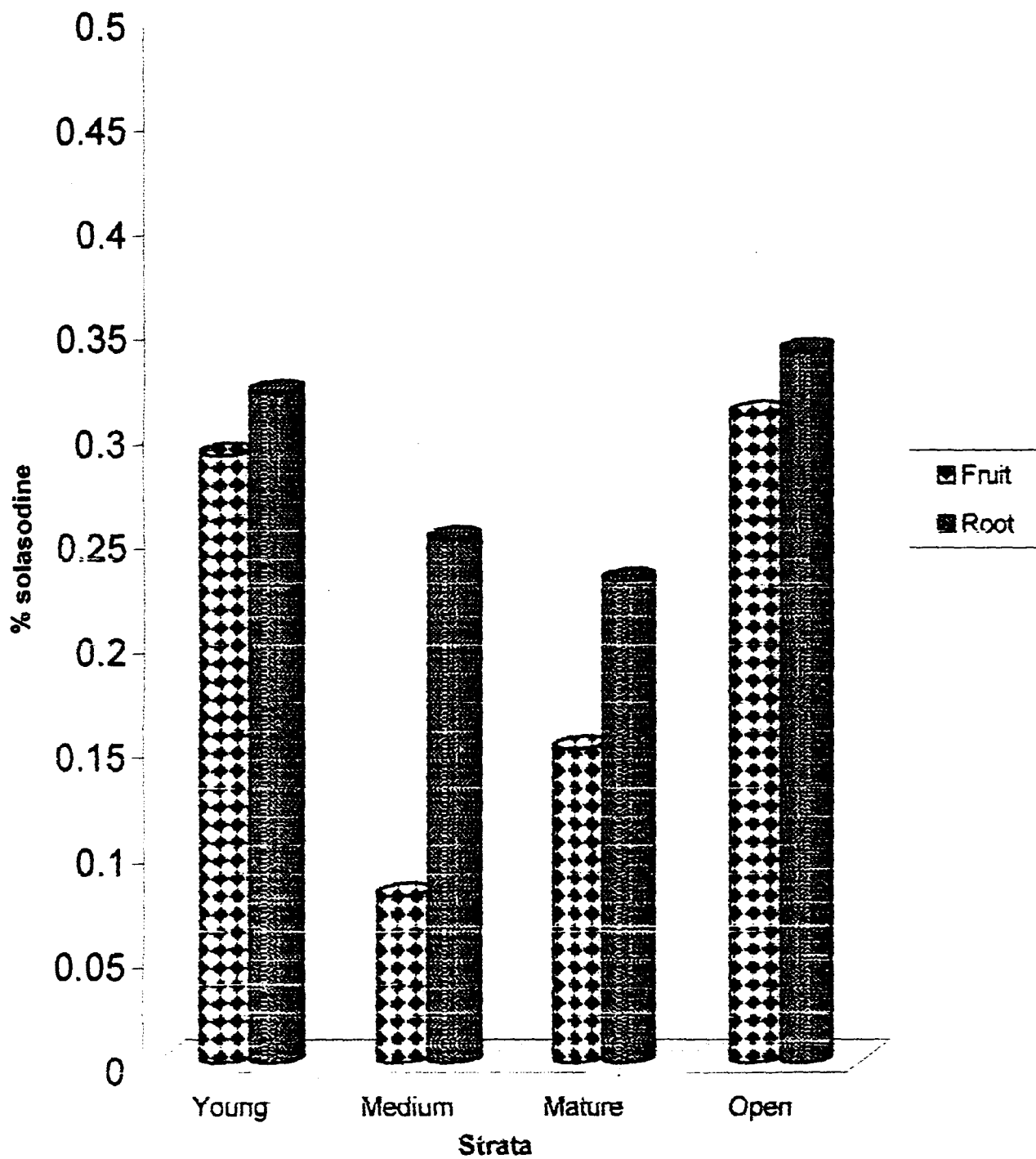


Fig. 9 Solasodine content in the fruits and roots of *Solanum melongena* var. *insanum* growing under different strata of oilpalm plantation



cent in the fruits and the roots was highest in young oil palm plantation. This can be attributed to the higher light intensity in the interspaces of young oil palm plantation, similar to open conditions. The roots of *Solanum melongena* var. *insanum* yielded more per cent of solasodine compared to fruits.

Study on medicinal flora, plant diversity, distribution, vegetation analysis, growth behaviour of selected plants and chemical analysis of officinal part in selected medicinal plants yielded interesting results. As discussed above, these results when amplified and augmented with further research data would be of tremendous application not only in the management of oil palm plantations but also in evolving suitable strategies for sustainably utilising the important plant resources, particularly medicinal and aromatic plants, occurring as indigenous or naturalised, within the oil palm plantations and their vicinity. The present study thus yielded some significant insights as to the need for emulating similar case studies in oil palm plantations elsewhere in other regions of the State and our country.



SUMMARY

SUMMARY

A study on 'Biodiversity of medicinal plants in oil palm plantations' was carried out at the oil palm plantations, Kulathupuzha of the oil palm India Ltd., , Kollam district, Kerala. The objectives of the study were to identify the medicinal plants in the oil palm plantations, to study the growth behaviour of selected medicinal plants and to assess the influence of shade on pharmacologically active constituents. The period of the study was from January 1998–January 1999.

Stratified random sampling technique was adopted, the strata being young, medium and mature oil palm plantations and open conditions. The medicinal plants in the inter spaces of young, medium and mature oil palm plantations and in the open were identified and quantified by random sampling technique using 1.0m² frame. A total of 80 such sampling units were taken randomly giving sufficient representation to the area covered. The total of 85 plant species were identified in the four different strata belonging to 79 genera and 36 families. None of the plants were endemic. There were 74 indigenous and 10 exotic/naturalized plants. Ten important medicinal plant species were selected for detailed study and their growth behaviour was monitored for one year. They were *Chromolaena odorata*, *Cyclea peltata*, *Elephantopus scaber*, *Emilia sonchifolia*, *Hemidesmus indicus*, *Hyptis suaveolens*, *Phyllanthus amarus*, *Sida rhombifolia*, *Solanum melongena* var. *insanum* and *Vernonia cinerea*. The results of the study are summarized below.

Chrysopogon aciculatus was the most dominant species in young oil palm plantation with high relative density and relative frequency. *Cassia tora* was considered as the rare species, since it was represented by a single individual *Chrysopogon aciculatus*.

Elephantopus scaber and *Hemidesmus indicus* were found most frequent in the young oil palm plantation.

Chrysopogon aciculatus was the most dominant species in medium oil palm plantation also, with high relative density and relative frequency. *Terminalia crenulata* and *Tragia involucrata* were considered as rare species, both represented by a single individual each. The more frequently observed species in medium oil palm plantation were *Chrysopogon aciculatus* and *Hemidesmus indicus*.

Chrysopogon aciculatus was the most dominant species in mature oil palm plantation also, with high relative density and relative frequency. A number of rare species represented by a single individual were recorded in mature oil palm plantation. They were *Calophyllum polyanthum*, *Calycopteris floribunda*, *Careya arborea*, *Impomoea maxima*, *Pergularia daemia*, *Terminalia paniculata*, *Torenia asiatica* and *Wrightia tinctoria*. The more frequently observed species in mature oil palm plantation were *Chrysopogon aciculatus*, *Holostemma adakodien* and *Naregamia alata*.

Chrysopogon aciculatus was the most dominant species in open conditions also, though the relative density is not as high as in the interspaces of oil palm plantation. *Calotropis gigantea* and *Desmodium gangeticum* were the rare species represented by one and two individuals respectively. *Chromolaena odorata*, *Hemidesmus indicus* and *Phyllanthus amarus* were most frequently encountered in open conditions.

Chrysopogon aciculatus thus dominated all the four strata with high relative density and frequency. *Cyrtococcum trigonum* was another dominating species with high relative density in young and

mature oil palm plantations. *Naregamia alata* was a dominant and abundant species occurring in mature plantation. *Hemidesmus indicus* was frequent in all the four strata. *Elephantopus scaber* occurred frequently in young plantation and *chromolaena odorata* in medium plantation. *Phyllanthus amarus* was more frequent in mature plantation and open condition. *Holostemma adakodien* also occurred frequently in mature plantation.

Young oil palm plantation and open conditions were found to be the most similar strata with more number of species in common. Mature oil palm plantations and open conditions were found to be the most dissimilar strata in vegetation pairwise analysis.

Medium oil palm plantation was found to have higher concentration of dominance as expressed by Simpson's Index. Abundant species occurs more in mature oil palm plantation and very abundant species occurs more in medium oil palm plantation. Evenness index was maximum in open conditions.

Growth characters like plant height, number of branches, plant spread, height of first branch, number of leaves, inter nodal length and stem girth showed the lanky growth of the selected ten medicinal plants in medium and mature oil palm plantations which was more shaded compared to young plantation and open conditions. Fresh and dry weight of officinal part was more in young plantation and open conditions compared to medium and mature oil palm plantation. Higher biomass production was also obtained in young oil palm plantation compared to medium and mature plantation.

The amount of essential oil in the roots of *Hemidesmus indicus* was highest under open conditions and lowest in mature oil palm plantation. There was no significant difference between the amount of essential oil in the roots under young and medium oil palm plantation.

The solasodine content in the fruits of *Solanum melongena* var. *insanum* was highest under open conditions and lowest in medium oil palm plantation. There was no significant difference between the content in fruits in young plantation and open conditions; medium plantation and mature plantation. The solasodine content in roots was also highest under open conditions and lowest in mature plantation. There was no significant difference between the solasodine content in roots in young plantation and open conditions; medium and mature plantations.

The results when amplified and augmented with further research data would be of tremendous application not only in the management of oil palm plantations but also in evolving suitable strategies for sustainably utilizing the important plant resources particularly medicinal and aromatic plants, occurring as indigenous or naturalized within the plantations and their vicinity.

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*Original not seen.



APPENDICES

APPENDIX 1

Parameters for obtaining site vegetation analysis indices in young oil palm plantation

Sl. No.	Scientific name of plant	$(y/n)^2$	$P_i = (n_i/N)$	$\ln P_i$	$P_i \ln P_i$
1	<i>Aristida setacea</i>	0.0063	0.1147	-2.17	-0.25
2	<i>Careya arborea.</i>	0.0004	0.0035	-5.64	-0.02
3	<i>Cassia tora</i>	-	0.002	-6.21	-0.01
4	<i>Chromolaena odorata</i>	0.0004	0.004	-5.52	-0.02
5	<i>Chrysopogon aciculatus</i>	0.0501	0.1807	-1.71	0.31
6	<i>Clerodendrum viscosum</i>	0.0001	0.0030	-5.81	0.02
7	<i>Cyclea peltata</i>	0.0002	0.0026	-5.95	-0.02
8	<i>Cyperus rotundus</i>	0.0006	0.0139	-4.28	-0.06
9	<i>Cyrtococcum trigonum</i>	0.0157	0.3769	-0.98	-0.37
10	<i>Desmodium triflorum</i>	0.0031	0.0671	-2.7	-0.18
11	<i>Elephantopus scaber</i>	0.0027	0.0423	-3.16	-0.13
12	<i>Emilia sonchifolia</i>	0.0003	0.0112	-4.49	-0.05
13	<i>Evolvulus alsinoides</i>	0.0001	0.0020	-6.21	-0.01
14	<i>Hemidesmus indicus</i>	0.0010	0.0083	-4.79	-0.04
15	<i>Hyptis suaveolens</i>	0.0010	0.0186	-3.98	-0.07
16	<i>Knoxia mollis</i>	0.0016	0.0345	-3.37	-0.12
17	<i>Lantana camara</i> <i>var. aculeata</i>	0.0001	0.0020	-6.21	-0.01
18	<i>Mimosa pudica</i>	0.0002	0.0046	-5.38	-0.02
19	<i>Oldenlandia umbellata</i>	0.0001	0.0089	-4.72	-0.04

Sl. No.	Scientific name of Plant	$(y/n)^2$	$P_i = (n_i/N)$	$\ln P_i$	$P_i \ln P_i$
20	<i>Phyllanthus amarus</i>	0.0001	0.0089	-4.72	-0.04
21	<i>Phyllanthus urinaria</i>	0.0007	0.0218	-3.83	-0.08
22	<i>Scoparia dulcis</i>	0.0004	0.0045	-5.4	-0.02
23	<i>Sida rhombifolia</i>	0.0006	0.0024	-6.03	-0.01
24	<i>Spermacoce hispida</i>	0.0008	0.0095	-4.66	-0.04
25	<i>Spermacoce latifolia</i>	-	0.0060	-5.12	-0.03
26	<i>Solanum melongena</i> var. <i>insanum</i>	0.0002	0.0033	-5.71	-0.02
27	<i>Spilanthes calva</i>	0.0001	0.0079	-4.84	-0.04
28	<i>Terminalia paniculata</i>	0.0002	0.002	-6.21	-0.01
29	<i>Urena lobata</i>	0.0008	0.0243	-3.72	-0.09
30	<i>Vernonia cinerea</i>	0.0002	0.0066	-5.02	-0.03
31	<i>Vigna trilobata</i>	0.0001	0.0020	-6.21	-0.01

APPENDIX - II

Parameters for obtaining site vegetation analysis indices in medium oil palm plantation

Sl. No	Scientific name of plant	$(y/n)^2$	$P_i = n_i/N$	$I_n P_i$	$P_i I_n P_i$
1	<i>Ageratum conyzoides</i>	0.0005	0.0200	-3.91	-0.08
2	<i>Atylosia goensis</i>	0.0001	0.0036	-5.63	-0.02
3	<i>Axonopus compressus</i>	0.0001	0.0182	-4.0	-0.07
4	<i>Calycopteris floribunda</i>	0.0003	0.0036	-5.63	-0.02
5	<i>Canthium angustifolium</i>	0.0002	0.0036	-5.63	-0.02
6	<i>Catunaregam spinosa</i>	0.0001	0.0036	-5.63	-0.02
7	<i>Chromolaena odorata</i>	0.0019	0.0182	-4.0	-0.07
8	<i>Chrysopogon aciculatus</i>	0.1117	0.2732	-1.3	-0.36
9	<i>Clerodendrum viscosum</i>	0.0003	0.0036	-5.63	-0.02
10	<i>Cyclea peltata</i>	0.0004	0.0036	-5.63	-0.02
11	<i>Desmodium gangeticum</i>	0.0002	0.0036	-5.63	-0.02
12	<i>Desmodium triflorum</i>	0.0073	0.1997	-1.61	-0.32
13	<i>Elephantopus scaber</i>	0.0006	0.0281	-3.57	-0.10
14	<i>Emilia sonchifolia</i>	-	0.0073	-4.92	-0.04
15	<i>Eragrostis ciliaris</i>	0.0001	0.0254	-3.67	-0.09
16	<i>Evolvulus alsinoides</i>	0.0010	0.0269	-3.62	-0.10
17	<i>Hemidesmus indicus</i>	0.0012	0.0119	-4.43	-0.05
18	<i>Hemionettis arafolia</i>	0.0002	0.0061	-5.1	-0.03
19	<i>Hyptis suaveolens</i>	0.0003	0.0617	-2.79	-0.17
20	<i>Knoxia mollis</i>	0.0008	0.0629	-2.77	-0.17
21	<i>Mimosa pudica</i>	0.0007	0.1997	-1.61	-0.32
22	<i>Phyllanthus amarus</i>	-	0.0290	-3.54	-0.10
23	<i>Pseudarthria viscida</i>	0.0005	0.0080	-4.83	-0.04
24	<i>Pterocarpus marsupium</i>	0.0001	0.0036	-5.63	-0.02
25	<i>Scoparia dulcis</i>	-	0.0218	-3.83	-0.08
26	<i>Sebastiania chamaelea</i>	0.0001	0.0054	-5.22	-0.03
27	<i>Sida acuta</i>	-	0.0109	-4.52	-0.05
28	<i>Sida rhombifolia</i>	0.0005	0.0073	-4.92	-0.04

29	<i>Solanum melongena</i> var. <i>insanum</i>	0.0005	0.0058	-5.15	-0.03
30	<i>Spermacoce hispida</i>	0.0002	0.0399	-3.22	-0.13
31	<i>Terminalia crenulata</i>	-	0.0036	-5.63	-0.02
32	<i>Terminalia paniculata</i>	0.0002	0.0036	-5.63	-0.02
33	<i>Tragia involucrata</i>	-	0.0036	-5.63	-0.02
34	<i>Tylophora indica</i>	0.0002	0.0085	-4.77	-0.04
35	<i>Urena lobata</i>	0.0007	0.0160	-4.14	-0.07
36	<i>Vernonia cinerea</i>	0.0003	0.1839	-1.69	-0.31
37	<i>Vigna trilobata</i>	0.0001	0.0036	-5.63	-0.02
38	<i>Zornia gibbosa</i>	0.0001	0.0091	-4.7	-0.04

APPENDIX - III

Parameters for obtaining site vegetation analysis indices in mature oil palm plantation

Sl. No	Scientifi name of plant	$(y/n)^2$	$P_i=(n_i/N)$	$I_n P_i$	$P_i I_n P_i$
1	<i>Abrus precatorius</i>	-	0.0062	-5.08	-0.03
2	<i>Aristolochia indica</i>	-	0.0062	-5.08	-0.03
3	<i>Asparagus racemosus</i>	0.0001	0.0031	-5.78	-0.02
4	<i>Atylosia goensis</i>	0.0001	0.0031	-5.78	-0.02
5	<i>Axonopus compressus</i>	0.0002	0.0206	-3.88	-0.08
6	<i>Biophytum sensitivum</i>	-	0.0062	-5.08	-0.03
7	<i>Calophyllum polyanthum</i>	-	0.0031	-5.78	-0.02
8	<i>Calycopteris floribunda</i>	-	0.0031	-5.78	-0.02
9	<i>Canthium angustifolium</i>	0.0002	0.0031	-5.78	-0.02
10	<i>Careya arborea</i>	-	0.0031	-5.78	-0.02
11	<i>Centella asiatica</i>	0.0001	0.0154	-4.17	-0.06
12	<i>Chromolaena odorata</i>	0.0006	0.0108	-4.53	-0.05
13	<i>Chrysopogon aciculatus</i>	0.0451	0.2058	-1.58	-0.33
14	<i>Cissus sp</i>	0.0002	0.0031	-5.78	-0.02
15	<i>Curuligo orchioides</i>	0.0005	0.0154	-4.17	-0.06
16	<i>Cyclea peltata</i>	0.0001	0.0062	-5.08	-0.03
17	<i>Cyrtococcum trigonum</i>	0.0323	0.3739	-0.98	-0.37
18	<i>Desmoduim triflorum</i>	0.0012	0.0278	-3.58	-0.10
19	<i>Elephantopus scaber</i>	0.0007	0.0234	-3.76	-0.09
20	<i>Emilia sonchifolia</i>	0.0005	0.0056	-5.18	-0.03
21	<i>Hemidesmus indicus</i>	0.0007	0.0123	-4.40	-0.05
22	<i>Hemionettis arafolia</i>	0.0003	0.0093	-4.68	-0.04
23	<i>Holostemma adakodien</i>	0.0011	0.0108	-4.53	-0.05
24	<i>Hyptis suaveolens</i>	0.0004	0.0201	-3.91	-0.08
25	<i>Ipomoea maxima</i>	-	0.0031	-5.78	-0.02
26	<i>Mimosa pudica</i>	0.0002	0.0134	-4.31	0.06
27	<i>Naregamia alata</i>	0.0046	0.0410	-3.19	-0.13
28	<i>Pergularia daemia</i>	-	0.0031	-5.78	-0.02

29	<i>Phyllanthus amarus</i>	0.0010	0.0129	-4.35	-0.06
30	<i>Pleopeltis lanceolata</i>	-	0.0093	-4.68	-0.04
31	<i>Rauvolfia serpentina</i>	0.0001	0.0041	-5.5	-0.02
32	<i>Scoparia dulcis</i>	0.0002	0.0077	-4.87	-0.04
33	<i>Sida acuta</i>	0.0001	0.0082	-4.80	-0.04
34	<i>Sida rhombifolia</i>	0.0001	0.0031	-5.78	-0.02
35	<i>Solanum melongena</i> var. <i>insanum</i>	0.0003	0.0085	-4.77	-0.04
36	<i>Spermacoce hispida</i>	-	0.0370	-3.3	-0.12
37	<i>Stachytarpheta indica</i>	0.0001	0.0031	-5.78	-0.02
38	<i>Terminalia paniculata</i>	-	0.0031	-5.78	-0.02
39	<i>Torenia asiatica</i>	-	0.0031	-5.78	-0.02
40	<i>Urena lobata</i>	0.0002	0.0154	-4.17	-0.06
41	<i>Vernonia cinerea</i>	0.0006	0.0103	-4.58	-0.05
42	<i>Vigna trilobata</i>	0.0001	0.0031	-5.78	-0.02
43	<i>Wrightia tinctoria</i>	-	0.0031	-5.78	-0.02
44	<i>Zornia gibbosa</i>	0.0002	0.0054	-5.22	-0.03

APPENDIX - IV

Parameters for obtaining site vegetation analysis indices in open conditions

Sl. No	Scientific name of plant	$(y/n)^2$	$P_i=(n_i/N)$	$I_n P_i$	$P_i I_n P_i$
1	<i>Acanthospermum hispidum</i>	0.0002	0.0130	-4.34	-0.06
2	<i>Ageratum conyzoides</i>	0.0018	0.0250	-3.69	-0.09
3	<i>Bulbostilis barbata</i>	0.0006	0.0245	-3.71	-0.09
4	<i>Calotropis gigantea</i>	-	0.0043	-5.45	-0.02
5	<i>Chromolaena odorata</i>	0.0016	0.0130	-4.34	-0.06
6	<i>Chrysopogon aciculatus</i>	0.0149	0.2504	-1.38	-0.35
7	<i>Clerodendrum viscosum</i>	0.0003	0.0057	-5.17	-0.03
8	<i>Cyclea peltata</i>	0.0005	0.0043	-5.45	-0.02
9	<i>Cynodon dactylon</i>	0.0011	0.0446	-3.11	-0.14
10	<i>Desmodium gangeticum</i>	0.0001	0.0043	-5.45	-0.02
11	<i>Desmodium triflorum</i>	0.0001	0.0345	-3.37	-0.12
12	<i>Elephantopus scaber</i>	0.0074	0.0864	-2.45	-0.21
13	<i>Emilia sonchifolia</i>	0.0016	0.0225	-3.79	-0.09
14	<i>Eragrostis ciliaris</i>	0.0009	0.0360	-3.32	-0.12
15	<i>Hemidesmus indicus</i>	0.0019	0.0165	-4.10	-0.07
16	<i>Hyptis suaveolens</i>	0.0018	0.0411	-3.19	-0.13
17	<i>Knoxia mollis</i>	0.0002	0.0691	-2.67	-0.18
18	<i>Lantana camara</i> var. <i>aculeata</i>	0.0003	0.0043	-5.45	-0.02
19	<i>Mimosa pudica</i>	0.0015	0.0335	-3.4	-0.11
20	<i>Oldenlandia umbellata</i>	0.0013	0.0302	-3.5	-0.11
21	<i>Phyllanthus amarus</i>	0.0053	0.0511	-2.97	-0.15
22	<i>Phyllanthus urinaria</i>	0.0002	0.0216	-3.84	-0.08
23	<i>Scopa dulcis</i>	0.0013	0.0164	-4.11	-0.07
24	<i>Sida acuta</i>	0.0005	0.0187	-3.98	-0.07
25	<i>Sida rhombifolia</i>	0.0003	0.0072	-4.93	-0.04
26	<i>Solanum melongena</i> var. <i>insanum</i>	0.0005	0.0043	-5.45	-0.02

27	<i>Spermacoce hispida</i>	0.0020	0.0443	-3.12	-0.14
28	<i>Sporobolus indicus</i>	0.0007	0.0273	-3.6	-0.10
29	<i>Urena lobata</i>	-	0.0130	-4.34	-0.06
30	<i>Vernonia cinerea</i>	0.0022	0.0320	-3.44	-0.11

BIODIVERSITY OF MEDICINAL PLANTS IN OIL PALM PLANTATIONS

By
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**ABSTRACT OF THE THESIS
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COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM**

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ABSTRACT

A study on 'Biodiversity of medicinal plants in oil palm plantations' was carried out at the oil palm plantations, Kulathupuzha of the Oil palm India Ltd., Kollam district from January 1998 to January 1999. The objectives of the study were to identify the medicinal plants in the oil palm plantations, to study the growth behaviour of selected medicinal plants and to assess the influence of shade on pharmacologically active constituents.

A total of 80 sampling units were taken using stratified random sampling technique, the strata being young, medium and mature oil palm plantations and open conditions. The medicinal plants in the inter spaces of young, medium and mature oil palm plantations and in the open were identified and quantified by random sampling technique using 1.0m² frame. A total of 85 plants species were identified in the four different strata belonging to 79 genera and 36 families. None of the plants were endemic. There were 74 indigenous and 10 exotic/naturalized plants. Ten important medicinal plant species were selected for detailed study and their growth behaviour was monitored for one year. They were *Chromolaena odorata*, *Cyclea peltata*, *Elephantopus scaber*, *Emilia sonchifolia*, *Hemidesmus indicus*, *Hyptis suaveolens*, *Phyllanthus amarus*, *Sida rhombifolia*, *Solanum melongena* var. *insanum* and *Vernonia cinerea*.

Chrysopogon aciculatus dominates all the four strata with high relative density and frequency. *Cyrtococcum trigonum* is another dominating species with high relative density in young and mature oil palm plantations. *Naregamia alata* is a dominant and abundant species occurring in mature plantation. *Hemidesmus indicus* is occurring frequently in all the four strata. *Elephantopus scaber* occurs frequently

in young plantation and *Chromolaena odorata* in medium plantation. *Phyllanthus amarus* is more frequent in mature plantation and open conditions. *Holostemma adakodien* also occur frequently in mature plantation.

Young oil palm plantation and open conditions were found to be the most similar strata with more number of species in common. Mature oil palm plantations and open conditions were found to be the most dissimilar strata in vegetation pair wise analysis.

Medium oil palm plantation was found to have higher concentration of dominance as expressed by Simpson's Index. Abundant species occurs more in mature oil palm plantation and very abundant species occurs more in medium oil palm plantation. Evenness index was maximum in open conditions.

Growth characters like plant height, number of branches, plant spread, height of first branch, number of leaves, inter nodal length and stem girth showed the lanky growth of the selected ten medical plants in medium and mature oil palm plantations which were more shaded compared to young plantation and open conditions. Fresh and dry weight of officinal part was more in young plantation and open conditions compared to medium and mature oil palm plantations. Higher biomass production was also obtained in young oil palm plantation compared to medium and mature plantations.

The amount of essential oil in the roots of *Hemidesmus indicus* was highest under open conditions and lowest in mature oil palm plantation. There was no significant difference between the amount of essential oil in the roots under young and medium oil palm plantations.

The solasodine content in the fruits of *Solanum melongena* var. *insanum* was highest under open conditions and lowest in medium oil palm plantation. There was no significant difference between the solasodine content in fruits in young plantation and open conditions; medium plantation and mature plantation. The solasodine content in roots was also highest under open conditions and lowest is mature plantation. There was no significant difference between the solasodine content in roots in young plantation and open conditions; medium plantation and mature plantation.