

Chapter 9

Organic Farming in Oil Palm

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1. Introduction

The *Elaeis* (Greek for "oil"), from the genus of palms, comprises two species, both called oil palms. The *Elaeis guineensis* Jacq, originally from West Coast Africa, which is the main source of palm oil; and the *Elaeis oleifera* (HBK) Cortes ("oil producing") originally from Central and South America. Though the genus *Elaeis* of the family Arecaceae contains two tropical species, only *E.guineensis* is of economic importance due to the high oil content in the mesocarp and in the kernel oil. The oil palm growing regions house vast areas of tropical rainforest rich in biodiversity on the continents of Asia, Africa and South America. The first cultivation of oil palm and use was started around 5,000 years ago and then Arab traders brought the oil palm to Egypt. It was not until the early 20th century that oil palm was planted commercially in South East Asia.

Oil palm produces two different types of oils: palm oil (from the pulp of fruit) and palm kernel oil. The oil palm provides one of the leading vegetable oils produced globally, accounting for 25 per cent of global consumption and approximately 60 per cent of international trade in vegetable oils. An estimated 74 per cent of global palm oil usage is for food products and 26 per cent is for industrial purposes. Palm oil is used in a wide variety of food products such as cooking oil, shortenings and margarine, while palm kernel oil is a raw material in the production of non-food products which include soaps, detergents, toiletries, cosmetics and candles.

For many tropical countries, oil palm is an economically important crop, fulfilling local demand for vegetable oil and generating large export incomes. It is grown by plantation companies and smallholder families, where the smallholders supply oil palm fruit to a centralised mill. As demand for vegetable oil increases, due to growing and increasingly wealthy populations, the industry is expanding

rapidly onto new land and there is an increasing need for ecological intensification of production. Oil palm is among the most productive and profitable of tropical crops for bio fuel production. Production of biodiesel from oil palm has been increasing in recent years, particularly in Africa and Latin America.

2. Production Scenario

2.1. Global Scenario

Oil palms are restricted to the tropics and have mainly been cultivated in Indonesia, Malaysia and Thailand in Southeast Asia, Nigeria in Africa, Colombia and Ecuador in South America and Papua New Guinea in Oceania. Since 1980, palm oil production has increased tenfold and as per report of FAO, the global demand for palm oil will double in 2020, and triple by 2050. With global production of 62.4 million tonnes of palm oil in 2015, oil palm is grown in 43 countries of the world covering an area of 17 million ha of mature palm oil plantations across the equator. Although, it is planted on only 5 per cent of the total world vegetable oil acreage, palm oil accounts for 33 per cent of vegetable oil and 45 per cent of edible oil worldwide. Oil palm satisfies 30 per cent of the world edible oil and fat requirements with little fewer than seven per cent of the areas planted to oil crops. Indonesia and Malaysia lead the production front accounting for about 85 per cent, totaling to 53.3 million tonnes (Table 9. 1). The third largest producer of palm oil is Thailand, followed by Colombia, Nigeria, Ecuador, Guatemala and Papua New Guinea. There has recently been an increase in palm oil production in South America via Colombia, Ecuador and Guatemala. The world average yield of palm oil is reported to be 12.2 tonnes fresh fruit bunch (FFB) per ha, and Guatemala, Nicaragua and Malaysia top the yield chart with 24.6, 24.3 and 21.1 tonnes per ha, respectively. Since 2006, Indonesia had exceeded Malaysia in producing oil palm, leading it to the biggest oil palm producing country in the world. Big Private Plantation dominates the total area of oil palm and Riau is the most oil palm contributor province in Indonesia.

Table 9.1: Oil Palm Production in different Countries of the World (2015)

<i>Name of Country</i>	<i>Production (million tonnes)</i>
Indonesia	33.4 (53.5)
Malaysia	19.9 (31.9)
Thailand	1.8 (2.9)
Colombia	1.2 (1.9)
Nigeria	0.94 (1.5)
Ecuador	0.53 (0.9)
Guatemala	0.52 (0.8)
Papua New Guinea	0.5 (0.8)
Others	3.6 (5.8)
Total	62.39

Source: Oil World June 2016 data base. Figures in bracket is the percentage.

According to recent estimate by the United States Department of Agriculture (USDA) the estimated world palm oil production during 2016-17 will be 64.5 million tonnes (World Palm Oil production.com).

2.2. International Trade: Exports and Imports

The international palm oil exports by country during 2015 totaled US\$29.1 billion. Among the continents, Asian countries accounted for the highest export of palm oil during 2015 valued at \$25.2 billion (86.6 per cent). In the second place were European Union exporters at 6 per cent while 4.3 per cent of worldwide palm oil export originated from Latin American and the Caribbean. Indonesia was the leading country exporting palm oil to other consuming countries and they exported 52.9 per cent of their total production, worth US\$15.4 billion and it was followed by Malaysia (32.7 per cent - \$9.5 billion) and Netherlands (3.8 per cent - \$1.1 billion). Exports are dominated by Indonesia and Malaysia, which account about 90 percent of the palm oil traded internationally. The three main importers, India, China and the European Union, account for slightly over half of total imports of palm oil (50.7 per cent).

2.3. Organic Palm Oil

As per the statistics available for 2011 (SSI Report, 2014), the global production of organic certified palm oil fruit was 150,750 metric tonnes (Table 9.2). If 25 per cent of the palm oil fruit is considered to be composed of palm oil and that 6.5 per cent is composed of the palm kernel, organic palm oil accounted for approximately 38,000 metric tonnes, while organic palm kernel accounted for about 10,000 metric tonnes. Organic certified palm oil accounted for approximately 0.07 per cent of global palm oil production. Organic palm oil fruit production has fluctuated around the 150,000 metric tonne over the last three years, while certified organic area under cultivation has decreased considerably from 16,700 hectares in 2008 to 7,200 hectares in 2011. Ecuador and Colombia together represented 97 per cent of total organic palm oil fruit production in the world, with Colombia alone representing 89 per cent. Indonesia and Malaysia do not have any organic penetration in the palm oil sector.

Table 9.2: Organic Palm Oil Area Harvested, Production and Sale Volumes by different Countries (2011)

	<i>Area Harvested (ha)</i>	<i>Production (mt)</i>	<i>Sales (mt)</i>
Colombia	5,500	133,950 (88.9 per cent)	110,000
Côte d'Ivoire	100	1,100 (0.7 per cent)	400
Ecuador	1,000	13,000 (8.6 per cent)	10,000
Ghana	600	2,700 (1.8 per cent)	2,200
Total	7,200	1,50,750 (37,688 mt palm oil)	1,22,600 (30,650 mt palm oil)

Quoted from Palm Oil Market (SSI Review 2014).

In response to the urgent and pressing global call for sustainably produced palm oil, the Round Table on Sustainable Palm Oil (RSPO) was set up in 2003-04.

RSPO is multi stakeholder forum, bringing together seven sectors of palm oil, oil palm producers, palm oil processors, environmental and nature conservation NGOs and social or developmental NGOs – to develop and implement global standards for sustainable palm oil. Green palm is a certificate trading programme that allows consumers the flexibility to purchase sustainable palm oil certificates under the book and chain supply chain system. These certificates are issued to producers who are members of RSPO and certified to produce palm oil in a sustainable manner.

2.4. Indian Scenario

Oil palm was introduced into India as a small-holders' irrigated crop during 1989 to meet the growing demand for vegetable oils. India's vegetable oil economy is the world's fourth largest after USA, China and Brazil. With per capita consumption of vegetable oils @ 16 kg per year per person and for the present population of 1276 million, the total vegetable oil demand is likely to touch 20.4 million tonnes by 2017. A substantial portion of edible oil is met through import of palm oil from Indonesia and Malaysia. Palm oil has dominated Indian imports since the last two decades for its logistical advantages, contractual flexibility and consumer acceptance. India's palm oil consumption has increased from 13 per cent in 2007-2008 to 15 per cent in 2011-2012. India is also the largest importer of palm oil amounting to 44 per cent of world imports and Malaysia was the leading supplier of oil palm constituting over 20 per cent of the total imports. Other countries supplying refined and crude oil palm to India include Indonesia, Germany, Italy and China. India is the largest consumer of palm oil in the world, consuming around 17 per cent of total world consumption.

India holds only a tiny share in area and production of palm oil in the world. As per the statistics for 2014-15, the area under oil palm cultivation in India was 2.3 lakh ha with production of 1.7 lakh tonnes. Andhra Pradesh is the leading palm oil producing state in India contributing approximately 86 per cent of country's production followed by Kerala (10 per cent) and Karnataka (2 per cent). Unlike in Indonesia or Malaysia, in Andhra Pradesh, palm oil cultivation is mostly irrigated. Other important oil palm producing states include Odisha, Tamil Nadu, Goa and Gujarat.

2.4.1. Schemes for Development of Oil Palm Cultivation in India

The consumption and import of oil palm has been constantly rising while there has been a negligible increase in domestic production. Creation of adverse price atmosphere due to heavy price fluctuations, availability of cheaper imported oil palm and lack of processing facilities has affected the area expansion under oilseeds particularly in the states of Odisha, Tamil Nadu, Goa and Gujarat.

The Indian Government has undertaken various schemes and programmes to increase oil palm production in India considering the heavy dependence of the country on edible oil imports. Oil Palm Development Programme (OPDP) under Technology Mission on Oilseeds and Pulses and Programme of oil palm area expansion (OPAE) under Rashtriya Krishi Vikas Yojana (RKVY) are some of the ambitious schemes of the Government. Organizations such as Oil Palm India Ltd,

a joint venture between the Government of Kerala and Government of India have been promoting oil palm cultivation among the small holders. Godrej Agrovet is one of the leading private companies involved in oil palm production and has developed over 35,000 ha of oil palm in eight states. Ruchi Soya Industries Ltd. and Foods Fats and Fertilisers are the other companies engaged in oil palm business.

Oil palm development in India is undertaken recently through Mini Mission II from 2014-15 to increase the production and productivity of oil palm through area expansion in potential regions of the country. While there is a need to promote oil palm by the way of area expansion and better cultivation practices, it is equally important to focus on innovative growth strategies such as marketing of high grade derivatives and nutraceuticals, bio-mass utilization and branding of palm oil as healthy cooking medium.

3. Climatic Requirements

3.1. Geographical Position

Oil palm is a crop of the tropics, and is found abundantly in South East Asia, like Malaysia and Indonesia, on the African continent (Western and Central) and South America. From as far as 16° north in Senegal to 13° south in Malawi, and 20° south in Madagascar, isolated oil palm plantations could be found. However, it is grown commercially in more than 20 countries with most areas within 10° north and 10° south of the equator. The elevation and slope of an area intended for oil palm cultivation are also important factors that determine its suitability. In general, oil palms are not recommended for planting in areas with an elevation of more than 200 m above MSL.

3.2. Temperature

Temperature can be a limiting factor for oil palm production. The best oil palm yields are obtained in places where a maximum average temperature of 29-33°C and minimum average temperature of 22-24°C are available. Higher diurnal temperature variation causes floral abortion in regions with a dry season. If the temperature drops, the oil palm produces fewer leaves and is more often attacked by diseases. It therefore yields less.

A hot temperature enables the oil palm to make many leaves and to produce many clusters of fruit. However, the growth rate of young seedlings will be inhibited at temperatures of 15°C or lower. Night temperatures below 15 °C (sometimes experienced in Congo and Guinea) might cause "heart rot", a disease which develops in trees of five to eight years old, starting at the centre of the crown and leading often to a dying of the palm. As it is difficult to replant trees in an affected plantation because of the reduced sunlight interception, this results in a loss of production for at least 20 years.

3.3. Rainfall

Oil palm is a humid crop and requires annual evenly distributed annual rain fall of 2,500 mm to 4,000 mm or monthly rain fall of 100 to 150 mm with dry periods

not exceeding 2-3 months. On average, a minimum annual rain fall of 1,800 mm is considered optimal, ranging up to 2,500 mm without harm. However, rain fall above 2,500 mm is considered unfavorable because this interferes with a lower solar radiation. In areas with dry spell, a deep soil with high water holding capacity and a shallow water table supplemented with adequate irrigation is required to meet the water requirement of the palm.

An almost continuous moisture supply is a critical factor for high oil palm yields. A water deficit greater than 30-40 cm/annum will significantly reduce fresh fruit bunch (FFB) yield. A moisture deficit affects the yield in four main ways:

1. It causes abortion of inflorescences, both male and female, about four months prior to anthesis, which results in crop reduction some 10 months after the period of stress;
2. Physiological stress at the time of sex determination of the floral initials results in the formation of higher number of male inflorescences, which adversely affects yields of mature palms about 26 months or later;
3. During periods of severe moisture stress, abortion of newly-produced inflorescences can occur, together with drying out and death of developing fruit bunches;
4. Also affects production adversely three years later.

The relative humidity should be between 75 and 100 percent throughout the year. Relative humidity of more than 80 percent is required for optimum growth. Rain fall distribution in India is not even and adequate, and hence, oil palm is to be cultivated under assured irrigation conditions by adopting recommended practices.

3.4. Solar Radiation

A high level of solar radiation is important for growth and fruit bunch production. The daily requirement of sunlight is between 5 and 7 daylight hours and at least 2,000 hours of sunshine annually. In Malaysia, the high rate of annual growth is the result of high levels of annual light interception. The sex ratio will be the highest with long periods of sunshine two years previously at the time of flower differentiation and when the dry season rainfall is at its maximum. In areas where there is a lot of sunshine and the palms are grown in soil which gives adequate water and nutrients, there will be strong photosynthesis. The leaves grow large, the fruit ripens well, and there is more oil in the fruits.

4. Soil Requirements

Oil palm can be grown in wide range of soils. The most ideal soil will be well-drained, deep, medium textured loamy alluvial soils, rich in humus content, easily penetrable with good moisture retention. The primary tap root descends deeply from the base of the trunk, but remains short when the water table is high. The finer secondary roots are in the top one meter of soil and hence, at least one-meter depth of soil is required.

Gravelly and sandy soils, particularly the coastal sands are not ideal for oil palm cultivation. Highly alkaline, highly saline, heavy clay soils with poor drainage are to be avoided. Though the crop supports water logging for short periods, areas with prolonged waterlogging are to be avoided. The soils should not be heavy with large amounts of clay, which during the monsoon season leads to water logging due to impeded drainage. Lateritic, sandy, or peat soils are problematic soils that need proper manuring and maintenance for optimum palm growth. The crop should be planted, wherever possible, on flat or undulating land: steep slopes increase both the risk of erosion and the cost of establishment and production, including the more difficult and more costly construction of access roads.

5. Botany

The oil palm tree is a member of the family *Palmae*, subfamily *Cocoideae* (which also includes the coconut), genus *Elaeis*. The genus contains two main species viz., *E. guineensis* or African oil palm, and *E. melanococca* or American oil palm; the latter valuable only for hybridization purpose. The trees are unbranched with a long stout single stem, or trunk, terminating in a crown of 7–100 fronds. On an average, the fronds are produced at the rate of two per month in a regular sequence. The length of the frond is about 7 m, and each frond consists of a petiole, which is 150 cm long, and a rachis bearing 250–350 leaflets. Each leaflet may be about 130 cm long. The leaflets are arranged on two lateral planes. The root system of oil palm is relatively shallow, coarse and inefficient, with most of the active roots found in the upper 30 cm of the soil. The trees may grow to a height of 20-30 m, and a tree can live up to 50 years, but it is usually replanted at 20-25 years because of declining yields and because their height makes harvesting difficult.

The oil palm is a monoecious plant, and produces both male and female flowers separately on the same palm. The male flowers provide pollen while the female flowers develop - over a period of 5-6 months - into fruits commonly referred to as



Figure 9.1: Young Oil Palm Plantation



Figure 9.2: Yielding Oil Palm Tree.

fresh fruit bunches (FFB). The trees come to flowering 14-18 months after planting. The development of the inflorescence to the fruit regime takes 42 months, including 10 months from establishment to initial sexual differentiation, 24-26 months between sex development and flowering, and 5-6 months from flowering to yield. Hence, ecological conditions which affect earlier phases of inflorescence and flowering appear only in the yields 18 to 24 months afterwards.

Being a perennial crop, it yields continuously throughout the year. The tree produces large, spherical red fruits in bunches. Up to 200 fruits can be produced per bunch. In each productive year, an oil palm tree may produce between 8 to 12 bunches of fruit and each bunch weighs between 10 and 25 kg and contains between 1,000 and 3,000 individual fruitlets. The fruit is reddish in colour, as it contains high amounts of beta-carotene, and grows in large bunches. It consists of a hard seed (kernel) enclosed in a shell (endocarp) which is surrounded by fleshy husk (mesocarp). Palm oil is extracted from the mesocarp, while palm kernel oil is derived from the kernel after being separated from the mesocarp.

The oil palms are very efficient producers of oil. Oil content in the fruit pulp is about 50-60 percent or 20-22 percent of bunch weight; oil content in the fruit kernels is about 48-52 percent or 2-3 percent of bunch weight. Fresh fruit bunches, once harvested, must be processed in an oil mill within 24 hours to avoid deterioration of oil quality.

There are 3 oil palm varieties: *Dura*, *Pisifera* and *Tenera*, with the latter being mainly selected for economic production. The *dura* palms have kernels with a thick shell; the *pisifera* palms have kernels with no shell; while the fruits of the *tenera* palm have a lot of pulp, a thin shell and a big kernel.

6. Nursery Management

The success of a commercial oil palm plantation begins with the selection of the best planting material available from a recognized source, excellent seedling management in the nursery and subsequent sound agronomic management of the crop in the field. Adoption of the best nursery management will allow shortening the period between transplanting in the field and the first harvests (increased precocity), increasing the initial accumulated yield, and reducing initial maintenance costs in the field, particularly weed and pest control. Replacement of plants in the field will also be minimized with efficient culling/selection in the nursery. It is, therefore, important that proper nursery practices are strictly followed in order to ensure healthy growth of seedlings. The practices include: use of good top soil, shade for young seedlings, watering, weeding, manuring, pest and disease control, and culling/selection. Different systems for raising oil palm seedlings are practiced. They are as follows.

6.1. Single Stage Nursery

The single stage nursery involves planting the sprouts (germinated seeds) directly into large polybags (500 gauge and 40 cm x 45 cm size), avoiding the pre-nursery stage, and raising the nursery up to the stage of transplanting of one year. On the lower half of the bag, perforations are made at an interval of 7.5 cm for drainage. A bag can carry 15 - 18 kg of nursery soil depending on the type of potting mixture used. The water requirement for different stages of growth of seedlings is as follows: 0 - 2 months at 4 mm/day, 2 - 4 months at 5 mm/day, 4 - 6 months at 7 mm/day and 6 - 8 months at 10 mm/day. It is better to supply, if feasible, the daily requirement in two halves to prevent overflow and wastage caused by one time application. Apply 9 - 18 l of water per seedling per week according to the stage of growth and soil type.

The advantages of this system are: i) Transplanting shock is totally absent in single stage nursery system, whereas, in double stage nursery system, shock is likely to occur at the time of transfer from small poly bags to large one, and ii) Relatively lesser labour force, equipments and inputs only are needed than double stage nursery. However, some of the disadvantages are: i) It is necessary to have the full nursery infrastructure ready, large bags filled and irrigation of the full nursery area functional right from the initial seed delivery, ii) In the initial critical period, seedlings spread over large area require greater volume of water over pre-nursery system, iii). This also causes difficulties to make critical observation and supervision incurs more inputs, iv) It is definitely an unsuitable system where availability of land is a constraint, and v) Culling or removal of abnormal seedlings in the last round results in very heavy monetary loss.

6.2. Double Stage Nursery

Double stage nursery is the raising of seedlings in beds or small polybags (usually 250 gauge and 23 cm x 13 cm size) up to three to five leaf stage (pre or primary nursery) and later transplanting into bigger bags (500 gauge or more thickness and preferably 40 cm x 45 cm size) (secondary nursery). The advantages

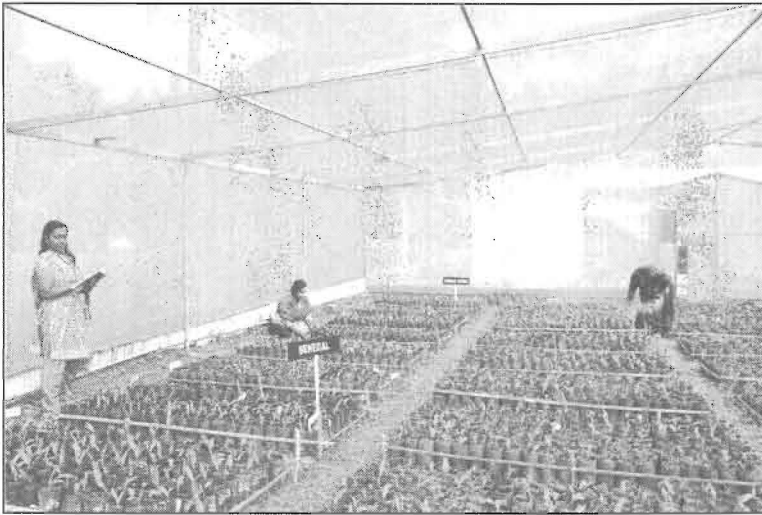


Figure 9.3: Raising Seedlings in Primary Nursery.

of this system are: i) Less irrigation requirement for very small section of nursery area. This system allows saving of maintenance cost and also conserve reserve water supply, ii) Since all the seedlings are held in small section, it is easy to observe them critically and cultural operation takes very less time, and iii) Culling is easy and can be done quickly in the first stage resulting in less wastage. The disadvantages of this system are: i) Double operation is required which is labour intensive in the initial stages, ii) Transplanting shock is inevitable in double stage nursery, especially, if transplanted at dry period. However, with proper care and supervision, transplanting shock could be avoided.



Figure 9.4: Raising Seedlings in Secondary Nursery.

6.3. Use of Advanced Planting Material

A traditional oil palm nursery consists of seedlings developed in poly bags kept in triangular fashion, the spacing on each side being 90 cm or less. The plants are maintained in these conditions for approximately 12 months and used for planting in the field. The use of advanced planting material (APM) in oil palm allows planting of more vigorous plants in the field, which have the potential for a higher initial accumulated yield than plants coming from traditional nurseries. The most important factor in nursery plant growth is the length of the nursery stage. However, in order to achieve vigorous growth, it is necessary for the plants to receive as much sunlight as possible, which can be achieved by using a bag spacing proportional in length to plant time in the nursery. The concept of advanced stage nursery implies extending the nursery stage to 18 months or more. This requires an increase in the space between bags in order to reduce etiolation. Other practices that help production of seedlings in an advanced nursery are the use of larger bags and an increase in nutrient supply.

The potting mixture is made by mixing top soil, sand and well decomposed cattle manure in equal proportions. Use of compost prepared by mixing soaked EFB and cow dung(60:40) @ 4.8 g N/plant helps better growth of seedlings in the oil palm pre-nursery (< 3 months), while unsoaked EFB and cow dung (60:40) compost improves better in later stage of growth of seedlings (3-13 months)in the nursery.

The poly bags are to be filled with the potting mixture leaving one cm at the top of the bag. A healthy germinated sprout is placed at the centre at 2.5 cm depth. While placing the sprout, care must be taken to keep the plumule of the sprout facing upwards and the radicle downwards in the soil. It is better to plant sprouts soon after the differentiation of radicle and plumule.

6.4. Culling in the Nursery

Culling/selection need special attention in view of its great influence on palm productivity. The initial culling of inferior seedlings should be carried out just before transplanting from the pre-nursery into the main nursery, or three months after planting germinated seeds in a single stage nursery. Thereafter, culling should be done at a three-monthly interval, with final critical selection immediately prior to field planting. Regular culling should be carried out or otherwise it will be difficult to do culling if it is taken up a later stage, as the plant size increases. The most crucial culling stage is after nine months of seed planting as at this stage, the seedling will express most of the abnormal characteristics.

All deformed, diseased and elongated seedlings are to be discarded. The maximum acceptable loss rates in the pre-nursery are: seedlings that have failed to develop and dead seedlings-5 per cent ; abnormal seedlings- 10 per cent, making the total of 15 per cent at the most. Thus, if 200 germinated seeds are planted per hectare, it is acceptable to keep only 170 seedlings/ha at the end of the pre nursery.

The most common types of abnormal plants at the end of the pre-nursery are: very narrow leaves (grassy appearance); twisted, crinkled, corrugated or rolled leaves; puckered leaves (collante); exaggerated upright plants; chimeras (albines)

and underdeveloped plants (dwarfs). Sick or chlorotic plants, or those that have been severely attacked by insects or by fungal diseases, together with any stunted or otherwise abnormal plants (fused leaves, leaves inserted at an acute angle, short or narrow leaves, leaves spaced too far apart), should all be discarded. Rejected seedlings should be destroyed immediately as they never yield satisfactorily.

6.5. Selection of Seedlings for Planting

Seedlings with well-developed root system, which have well bound roots with soil, with fully opened frond spread, and un-etiolated seedlings are to be selected in the nursery for the main field planting. At the time of transplanting, a normal seedling should display height of 1.0 to 1.3 m; collar girth of 18 to 22 cm and the number of functional leaves to be 10 or 12.

Avoid using seedlings which are under developed plants (dwarfs), particularly with a thin basal bulb; abnormal leaves (leaflets): rolled, twisted, too short, long or narrow, *etc*; short young leaves, giving the plant a flat appearance ; acute leaf insertion angle, given the plant a rigid and up right appearance and with juvenile character: leaflets do not differentiate for field planting.

In order to obtain high yields of crude palm oil, the most important factor at the outset is the selection of planting materials. The oil palm seeds are carefully selected and germinated under carefully controlled conditions. The seeds are then planted in polybags where they will remain for at least 12 months before planting in the field. Intensive care should be given at this period. Adequate irrigation, correct manuring, and immediate remedial treatment of any disease or pest attack are important to ensure the production of healthy, well grown seedlings for transplanting in the field.

In oil palm, being a perennial crop and with a life span of more than 25 years, it is very important for any planters to plant good quality seedlings during field planting. The planting material that was proven superior plays the most important role in ensuring a high oil yield from the plantation. Inherent genetic make-up of the planting materials determines the level of oil content in the fruitlet. Planting materials selected for planting are recommended to be obtained from proven and reputable seed suppliers or nurseries. This is to ensure only good quality planting materials with the potential to give high palm products are planted. All seedling orders should be made based on planting requirement, whereby planting policy would determine the number of seedlings to be planted. In order to obtain early high yield per hectare, high density planting is advocated unless other policies such as integration project is to be implemented. However, high yielding planting materials must be properly nurtured in the field in order to fully exploit the genetic potential of the palm as the expression of any planting material is a function of genotype and environment.

7. Land Preparation and Planting

Oil palm is mainly cultivated as an industrial estate crop, and therefore, it occupies a large area of 3,000 to 5,000ha around a central oil mill, where the harvested fresh fruit bunches (FFB) are collected and processed immediately, as any delay cause rapid deterioration of oil quality. Though the crop can also be grown

by smallholders, the oil quality, in general, is much lower and does not meet the quality standards for commercialization. Smallholders' oil palm plantations are usually intercropped during the first years with various food and cash crops to provide some food and income from the field and all these crops should also be grown following organic farming practices.

Land clearing is to be done by removing the initial vegetative cover to make the area suitable for oil palm planting. Prepare the land for oil palm plantings at least three months before transplanting the seedlings to the main field. In soils with low permeability, drainage channels are to be constructed to prevent water stagnation in upper layer of soil. Pits of 60 cm³ are to be prepared prior to planting and filled with surrounding top soil and allowed to settle. Rock phosphate is to be applied @ 200 g per planting pit.

7.1. Time of Transplanting

Transplanting to the main field has to be done during the onset of rainy season. In very impermeable soils and where there is chance for the seedlings to suffer severely during rainy season, proper drainage has to be ensured. The best season for planting is June-December *i.e.*, during monsoon. In case of planting during summer, adequate irrigation, mulching and growing cover crops like sun hemp in the basin would help in avoiding hot winds during summer. 12 -14 months old healthy seedlings with 1-1.3m height and 13 functional leaves are recommended for planting. Sowing of daincha or sun hemp in the basin is recommended which will provide favourable microclimate for the growing seedlings in the field.

7.2. Palm Density

One of the contributing factors towards achieving optimum crop productivity in oil palm is the planting density. Optimum palm density varies with terrain, soil type and weather conditions, and therefore, in order to reduce severe inter-palm competition and at the same time aim high FFB yields, palms should be planted at lower density in an environment which favors a very high level of vegetative growth. Plants should be planted at higher density in areas where conditions are less favorable for vegetative growth.

It is generally accepted that oil palm should be planted in a triangular pattern, as it allows efficient light interception and utilization of land space. For efficient utilization of solar energy the rows are to be oriented in the North-South direction. Equilateral triangular system of planting with 9 m spacing between palms, which can accommodate 143 palms/ha will allow each plant to occupy the centre of a hexagon thus allowing better use of the area. Any density higher than optimum stand would result in inter-palm competition for light, water and nutrients. Severe inter-palm competition normally results in low dry matter production which leads to depressed FFB yield through low bunch production and reduced bunch weight.

7.3. Leguminous Cover Crops

The prevailing wisdom within the oil palm industry also recommends the planting of leguminous vegetation, which increases biological nitrogen fixation,

stores nutrients, and then slowly release nutrients back into the soil as the legumes die following closure of the oil palm canopy. Legumes are also thought to help prevent beetle invasions, stem soil runoff, and reduce disease spread. Once the oil palm plants are established in the field, any one of the leguminous cover crop *viz.*, *Calopogonium mucunoides*, *Centrosema pubescens*, *Pueraria phaseoloides* or *Mucuna bracteata* can be grown in the interspaces. All these cover crops have the advantage that they rapidly establish, and thus, protect the soil surface. The establishment of leguminous covers during the immature growth phase of oil palm enriches soil organic matter status and provides added nutrients to the system, thereby enhance growth and subsequent yields. During the immature period, legumes fix large quantities of nutrients, particularly nitrogen from the atmosphere and return them to the soil through decomposition of the litter. Leaf litter accumulation commences after about six months of legume establishment. Nitrogen returns in the first year of establishment are relatively low, but large amounts of nitrogen are released from the second year onwards. It has been estimated that about 200 kg N/ha is released during this period.



Figure 9.5: Growing Green Manure Crop in Oil Palm Plantation.

Some of the other benefits of raising leguminous green manure crop include:

- a) It provides control of soil erosion and surface wash, particularly in the undulating/hilly terrain,
- b) It improves soil physical and chemical properties,
- c) it encourages the buildup of soil fauna,
- d) It helps to suppress weed growth, and

- e) It provides control of pests, particularly *Oryctes* beetles by forming vegetative barrier restricting the use of a decomposed palm residue as breeding sites.

Thus, establishment of leguminous covers is to be followed as standard practice and are maintained for at least 2 – 2 ½ years during the immature period.

7.4. Inter Cropping

Oil palm, a wide spaced perennial crop with a long juvenile period of three years, leaves considerable inter and intra row space in the field, which can be put to use to generate additional income during the juvenile phase of the crop. Commercial oil palm cultivation is generally characterized by large extent of monoculturing with palms of uniform age structure, low canopy, sparse undergrowth and intensive use of fertilizers and plant protection chemicals. The oil palm tree commences giving fruits from the third year, with the yield increasing gradually over the years until it peaks at around 20 years and thereafter, oil palm plantations are destroyed and replanted at 25 to 30 year intervals.

Inter crop selected should be compatible with the main crop and should not compete with oil palm for light, water and nutrients. Any remunerative crop can be grown, but the most suitable crops are vegetables, banana, flowers, tobacco, chillies, turmeric, ginger, pineapple *etc.* While growing inter crops in mature oil palm gardens of 8- 12 years age or palms attained a height of three meters, intercrops should be able to grow under partially shaded conditions and should not compete with oil palm for water, sunlight and nutrients (eg. cocoa, pepper, heliconia and ginger lilly). While intercropping is practiced, do not cut the oil palm fronds to accommodate the crops. Similarly, oil palm fronds should not be tied close to the stem for inter-cropping, which will reduce photosynthetic activity. Care should also be taken not to plough close to the palm base, which will cut the absorbing roots and



Figure 9.6: Growing Coffee in Oil Palm Plantation.

thereby reduce intake of water and nutrients. Maximum number of green leaves should be retained on the palm. All the intercrops should also be grown following organic cultivation practices.

7.5. Irrigation

Oil palm is a fast growing crop with high productivity and biomass production, and hence, requires sufficient irrigation. Continuous availability of soil moisture encourages vigorous growth and increased yield. Water deficiency is found to adversely affect flower initiation, sex differentiation, and therefore, results in low sex ratio due to production of more male inflorescences. Hence, oil palm cultivation is to be taken up only in areas with assured and adequate irrigation facility. In areas where perennial water source is available, basin irrigation is possible. The irrigation channels are to be prepared in such a way that the individual palms are connected separately by sub-channel. For grown up yielding palms of three years age and above, a minimum of 150 to 200 l of water per day is required. However, in older plantations, during hot summer, this quantity may be increased up to 300 l. The required quantity of water is to be applied at 4-5 days interval. For light soils, frequent irrigation with less water is to be given, whereas in heavy soils, irrigation interval can be longer. In areas with undulated terrain, and water is scarce during summer months, drip or micro sprinkler irrigation can be advantageous. If drip irrigation is installed, four drippers are to be placed in the weeded palm circle. If each dripper discharges 8 l of water per hour, 5 hr. of irrigation per day is sufficient to discharge 160 l/day. In case of micro sprinklers (180° or 360°), one each on either side of the palm can be installed. Drippers/jets should be periodically checked for proper water discharge. While irrigating, the palm basins should be adequately mulched and covered with soil to conserve moisture.

7.6. Weed control

A circular area of about 1.5 m-2 m around the tree base should be kept free of weed growth by regular weeding. It is more important for young palms, roots of which are to be kept free from competition from weed. Six rounds of weeding per year may become necessary during the immature phase of growth and three rounds per year thereafter. In addition, inter-rows are also to be weeded 2-3 times per year. The weeded materials can be used for mulching.

7.7. Soil Conservation

Soil erosion can be controlled by maintaining adequate ground cover vegetation. Perennial tree cropping systems where the trees are established along with cover crops helps in reducing soil erosion than annual crops. However, heavy rainfall can still result in high erosion rates where soil is exposed and specific erosion control measures should be taken in vulnerable areas.

Appropriate legume cover crops are to be planted as early as possible after clearing (or partial clearing with under-planting). This will also help to prevent *Oryctes* breeding in the felled palm trunk as well as improving the fertility of the soil. Spreading or stacking pruned fronds along contours, even on gently sloping



Figure 9.7: Weeding in Plant Basin.

land helps to prevent soil loss. Empty fruit bunches (EFB) should also be placed in such a way that erosion is reduced in vulnerable areas.

Constructing soil erosion prevention terraces (with or without bunds) and silt pits along roads and in fields where erosion is likely to occur, making water diversion channels, also terracing all slopes above 10 degrees help in preventing soil erosion. Use of heavy machinery where soil erosion is likely to result should be avoided. Planting in severely sloping land, where the slope is more than 25 degrees may be avoided as the cost of terracing such land and the crop obtainable is insufficient to make planting financially viable.

7.8. Pruning of Fronds

It is the removal of non-functional fronds in order to facilitate harvesting. In oil palm, two leaves are produced per month, and therefore, it becomes necessary to prune excess leaves so as to enable easy harvest of bunches. Severe pruning will adversely affect both growth and yield of palm, cause abortion of female flowers and also reduce the size of the leaves. Leaf pruning is carried out in India using chisels so that leaf base that is retained on the palm is as short as possible or otherwise it may catch loose fruits, allow growth of epiphytes and the leaf axils form a potential site for pathogens. The leaf petioles are removed by giving a clear cut at a sufficient distance from the base of the petiole using a sharp chisel for young palms and with the long sickle in taller palms.

Pruning is preferably carried out at the end of the rainy season. It is also better to carry it out during the low crop season when labourers are also available. Pruning is confined to only lower senile leaves during initial harvests but when canopy closes in later years, leaves are cut so as to retain two whorls of fronds below the ripe

bunch. However, in normal practice, some of the green fronds are also removed. It is evident that FFB yield is significantly reduced if fewer than 32 fronds/palm are retained at any one time. Over-pruning influences sex differentiation which favours the formation of male inflorescence. This will lead to yield decline for about two years after heavy pruning. Increase in inflorescence abortion rate which is manifested within 9 - 11 months after heavy pruning is also a factor contributing to yield decline.

It takes more than 2 years for FFB yields to reach normal level of production. These results clearly demonstrate the need to strictly supervise pruning operations in order to avoid unnecessary yield losses. In practice, the following pruning policy should be followed.

Young palms: removal of desiccated frond only

4 - 7 years: pruning to retain 56 - 48 fronds/palm

8 -14 years: pruning to retain 48 - 40 fronds/palm

> 15 years: pruning to retain 40 - 32 fronds/palm

7.9. Pollination

Oil palm is a highly cross-pollinated crop. Though wind and insects assist pollination, wind pollination is not adequate for economical crop production. Effective pollinating insects like *Elaeidobius kamerunicus* helps in good pollination and fruit set. Release of this weevil after 2-1/2 year of planting is advisable. If the plants are not having good girth and vigour, release the weevils after three years. For introduction, cut male flowers from palms which have the weevils and transferred to a plantation where it is to be introduced. Care should be taken to see that they are not carrying any plant pathogens to other areas.

7.10. Ablation

The initial bunches produced will be very small and have low oil content. Removal of such inflorescences is called ablation. Removal of all inflorescences during the initial years is found to improve vegetative growth of young palms so that regular harvesting can commence after three and half years of planting. Ablation enables the plant to gain adequate stem girth, vigour and improves drought resistance capacity of young palms by improving shoot and root growth especially in low production areas where dry condition exists. Ablation can be extended up to 30 to 36 months depending upon the plant growth and vigour. Ablation is done at monthly interval by hand pulling out the young inflorescence using gloves or with the help of specially developed devices such as narrow bladed chisels.

7.11. Zero Burning

Open burning of felled palms during replanting is prohibited in Malaysia, and zero burning has been practiced by all plantations in the country. Zero burning involves shredding of oil palm trunks to make them 5-10 cm thick and stacking the shredded trunks in the inter rows. Decomposition of the shredded biomass takes place within two years of application, after which it does not serve as breeding



Figure 9.8: Ablation.

substrate for the rhinoceros beetles. In addition, this technique has advantages in terms of recycling large quantities of plant nutrients through decomposition and improving soil physical properties. The nutrient reserves could provide to the palms N, K, and Mg for six to seven years and P for about two years. Traditionally, empty fruit bunches (EFB) were burnt to produce bunch ash, which is a good source of K fertilizer. However, burning is also prohibited because it causes air pollution, and to overcome the problem, EFB are to be applied in the plantations as mulch within palm circles and inter rows as partial sources of nutrients.

8. Nutrient Management

Oil palm is a high nutrient demanding crop, and therefore, adequate supply of plant nutrients is essential to maintain optimum productivity. Hence, all organic materials that have nutritional value are to be applied to the field. The prehistory of the site, whether it is opened from jungle or is a replant will also determine the nutrient requirement of oil palms. The availability of soil nutrients may change appreciably with time due to removal by the crop or build up from repeated nutrient applications or through mulching of crop residues. The type of crop cover will also affect the soil nutrients available to oil palms.

In order to build up organic matter, during planting/replanting, all vegetation to be cleared should be raked together into a broad swathe, thereby leaving only the area cleared for taking up planting. In sloppy areas, place the old trunks along contours. On terraced slopes, keep the trunks on terrace edges where ever possible. Any burning of biomass should be avoided, unless serious pest and disease problems warrant it. Good legume covers should be maintained for as long as possible after planting. During the early years of planting, maintenance of a vigorous legume cover helps to supply sufficient nitrogen during 4th to 6th year. In some environments, it will be possible to maintain legume cover throughout the life of the palms.

Ground cover slows the depletion of soil organic matter from the effects of sunlight and erosion. It also adds to the organic matter content through leaf and plant litters. Thus, while clearing areas for new planting, maintain ground cover wherever needed. In case ground cover is not available, it can be provided by felled trunks and trunk chippings. It should be followed by rapid establishment of leguminous cover crops. During harvesting or pruning, the fronds should be cut into two and the petiole or frond base half stacked between palms in the palm row. Spread the upper or leafy half in the non-harvesting inter-row. Where fronds are not cut into two, the petiole base or frond stalk end should be placed squarely in the windrow with the frond tip pointing outwards. On slopes, apply the frond stacks in contours and on terraces they should be placed along the terrace edge. Loss of nitrate and phosphate by surface run-off and to ground water must be avoided. This is important on shallow soils or where heavy rainfall causes surface run-off/soil erosion.

8.1. Organic Waste Recycling

A site-specific recycling plan should be drawn up in the oil palm plantation. Besides applying organic manures from sources such as animal, fish *etc.*, all palm residues can be effectively recycled for supplying nutrients, particularly of potassium. The oil palm wastes include palm oil mill effluent(POME), empty fruit bunch(EFB), palm oil mill sludge(POMS), oil palm fronds(OPF), oil palm trunks(OPT), decanter cake, seed shells and palm pressed fibers(PPF). In order to extract one tonne of palm oil, it is estimated to produce six tonnes of old leaves, one tonne each of trunk and peel fiber, five tonnes of EFB, 0.5 tonne of palm kernel shell, 0.25 tonne of pomace and three tonnes of POME. Palm oil waste management is a serious issue in most of the producing countries. Using palm oil wastes as raw materials for organic manures can not only reduce environment pollution issues, but also help in safe disposal, supply of nutrients as well as improve soil structure.

Some of the residues are:

a) Empty Fruit Bunch (EFB)

It contains a high amount of plant nutrients, and based on the nutrient composition, one tonne of EFB can supply various nutrients equivalent of 8 kg Urea, 2.9kg Rock Phosphate, 18.3kg MOP and 4.7kg Mg SO₄. It may be applied @ 250 kg/palm/year. Besides providing nutrients, it also increases soil organic matter content, improves soil structure, increases infiltration and aeration, improves soil moisture retention, and also increases cation exchange capacity. A yield of 25 t/year of FFB per hectare gives approximately six tonnes of EFB. The EFB contain about half the potassium from the FFB. Although application cost of EFB per unit of nutrient is generally higher than for inorganic fertilizers, it helps to return organic matter and conserve soil moisture. EFB should be applied preferentially in areas with low soil organic matter.

b) Palm Oil Mill Effluent

This also contains a high amount of nutrients. It may be applied @ 360 l/palm/year in the inland environment. At these application rates, each palm will receive

nutrients equivalent to Urea - 2.0 to 3.0 kg, Rock Phosphate- 1.8 to 2.8 kg, MOP - 1.5 to 2.2 kg and Mg SO₄ - 2.3 to 3.5 kg. Application of factory effluent to the entire plantation could also be practiced. About 16 tonnes of effluent from 25 tonnes of FFB could be obtained. Efficient utilization of factory water will help to reduce costs involved in storage/pumping *etc.* Application of effluent must be avoided where contamination of streams/groundwater may occur.

c) Pruned Fronds

Fronds contribute about 70 per cent of the total dry matter through regular harvests and annual pruning and the remaining 30 per cent is contributed by rest of the palm parts. Pruned fronds are rich in plant nutrients - 2.75 per cent N, 0.223 per cent P, 1.99 per cent K and 0.45 per cent Mg. In term of fertilizer equivalent, one tonne of dried fronds contain 59.8 kg Urea, 14 kg Rock Phosphate, 39.8 kg MOP and 27.8 kg Mg SO₄. Placing these fronds to cover as much ground surface as possible except the palm circles and harvesting paths allows wider and uniform distribution of organic matter and plant nutrients. This placement method creates a better environment for the development of feeding roots resulting in greater efficiency in nutrient uptake from both the decaying fronds and applied manures. Proper placement of pruned fronds helps in higher moisture retention, general improvement in porosity of soil resulting in higher infiltration rates, and thus reducing soil erosion and surface wash. In the rolling/hilly terrain, placement of pruned fronds in the direction of slopes would also act as a physical barrier to soil erosion.

d) Oil Palm Trunk

Considering a planting density of 143 palms in a hectare, 163 tonnes of total dry matter can be expected at the end of the crop. The trunk contributes more than 50 per cent of the total dry matter followed by the underground bole mass. At felling stage, nutrients to the extent of 1,500 kg N, 129 kg P, 2,345 kg K, 513 kg Ca and 438 kg Mg could be expected from the available biomass. Recycling trunk helps to supply these nutrients to soil. Shredding gives a faster breakdown, with all nutrients released within 2-3 years of application. On an average, most of the oil palm residues will decompose within 12-18 months while some of the hardier materials, particularly roots, take much longer than 18 months to decompose.

Table 9.3: Nutrient Contents of Biomass from One Hectare of Plantation

Parts of Palm	Nutrient Content (kg/ha/year)				
	N	P	K	Mg	Ca
Annual pruning	108.0	10.0	139.4	17.2	25.6
Empty fruit bunches	5.4	0.4	35.3	2.7	2.3
Fibre	5.2	1.3	7.6	2.0	1.8
Shell	3.0	0.1	0.8	0.2	0.2
Factory effluent	12.9	2.1	26.6	4.7	5.4

The compost prepared mainly from fronds and empty fruit bunches contain on an average 1.8-2 per cent N, 0.2-0.3 per cent P and 0.9-1.2 per cent K. The quantity

of nutrients that can be obtained from various biomass of one ha of oil palm is given in Table 9.3.

Proper residue management improves the spatial integration of nutrient release and uptake by the rooting systems of young palms. The supply of nutrient requirement that is partly provided by the recycling of biomass can help to optimize growth rates of the immature palms.

9. Plant Protection

Oil palm is very sensitive to pests and diseases, from the nursery stage to the trees in full production. Pest and disease control in an oil palm estate is, therefore, as important as the care and management for vegetative growth and production. In poorly controlled infected plantations yield losses can be as high as 50 per cent or more as compared to the potential yields.

9.1. Pests and their Management

There is growing awareness among the planters in Malaysia that palms which meet the minimum environmental standards alone be grown. A number of plantations have been accorded the ISO 14001 certification. This ensures production in a clean environment. This has important implications on the trade of palm oil in the future in the sense that developed countries would prefer importing palm oil from companies that address environmental concerns. The important pests of oil palm, their damage symptoms and control measures that are to be adopted under organic cultivation are listed in Table 9.4.

9.2. Diseases and their Management

The important diseases of oil palm, their symptoms and management practices are given in Table 9.5.

10. Harvesting

During the first three to four years, the production of the young palms is often small, of poor quality, and sometimes even not economic to be harvested. Full production starts from the sixth year onwards; it reaches its maximum four to six years later, and remains high for another 10 years. Proper and timely harvesting of fruit bunches is an important operation which determines the quality of oil to a great extent. The yield is expressed as fresh fruit bunches (FFB) in kg per hectare per year or as oil per hectare per year. The bunches usually ripen in six months after anthesis. Unripe fruits contain high water and carbohydrate and very little oil. As the fruit ripens oil content increases to 80 - 85 per cent in mesocarp. Usually the ripe fruits, attached to the bunches, contain 0.2 to 0.9 per cent FFA and when it comes out of extraction plant, the FFA content is above 3 per cent.

Over ripe fruit contains more free fatty acids (FFA) due to decomposition, and thus, increases the acidity. The fruit bunches should be handled carefully and processed as soon as possible in order to keep the FFA level low. Harvesting rounds should be made as frequent as possible to avoid over ripening of bunches. A bunch which is almost ripe but not ready for harvest for a particular harvesting round

Table 9.4: Symptoms and Management Practices of Important Pests of Oil Palm

Name of the Pest	Damage Symptoms	Management Practices
Spindle bug (<i>Carvalhoia arecae</i> (Miller))	<p>Spindle bug - generally noticed in nursery seedlings and plantation planted young seedlings</p> <ul style="list-style-type: none"> ☆ Adults and nymphs of spindle bug live in the innermost two to three leaf axils ☆ Suck sap from the spindle of leaves ☆ Necrotic lesions which later on turn into dry brown patches ☆ In severe infestation the spindle fails to open 	<p>Cultural control</p> <ul style="list-style-type: none"> ☆ Digging and forking of the soil before and after the monsoon will help in eliminating the various developmental stages of the beetle <p>Biological control</p> <ul style="list-style-type: none"> ☆ Conserve predators such as wasps, green lacewings, earwigs, ground beetles, rove beetles, spiders, coccinellids, syrphids <i>etc.</i>
Mealy bug (<i>Dysmicoccus</i> <i>brevipes</i> (Cockerell) and Scales (<i>Spidiotus destructor</i> (Signoret))	<p>Scales can cause considerable damage. They like aphids have proboscis, stylet or straw like mouth part which they insert into the phloem or inner cells of a plant. Upon insertion the scales draw the plants juices or sap.</p>	<p>Cultural control:</p> <ul style="list-style-type: none"> ☆ Collection and destruction of infested plant parts ☆ Collect planting material from unaffected plantation ☆ Insecticidal soap is a safe and effective alternative to conventional insecticides. You can use bleach-freedishwashingliquid (1 and 1/2 teaspoons per one quart of water) in place of commercial insecticide soaps. Homemade control of plant scale can also be achieved with oil spray. Mix two tablespoons of cooking oil and two tablespoons of baby shampoo in one gallon of water. This can also be mixed with one cup of alcohol to help penetrate the shell of insect <p>Biological control:</p> <ul style="list-style-type: none"> ☆ Conservation and augmentation of natural enemies such as ladybird beetle <i>etc.</i> ☆ For mealybug: release coccinellid beetle, <i>Cryptolaemus montrouzieri</i> @ 10/tree
Root grub (<i>Leucopholis</i> <i>burmeisteri</i> (Brenske))	<p>Root grubs or white grubs occur mostly in sandy and sandy loam soils.</p> <ul style="list-style-type: none"> ☆ They are voracious feeders on roots. Adult beetles emerge during May-June few days after receipt of pre-monsoon showers, between 6.30 to 7.30 PM ☆ The early instar grubs feed on the roots of grasses and other humus. The second and third instar grubs of these 	<p>Cultural control:</p> <ul style="list-style-type: none"> ☆ Fill the seedling bags with the soil free from root grub infestation ☆ Exposure of grubs by ploughing or digging the soil during pre and post monsoon periods <p>Mechanical control:</p> <ul style="list-style-type: none"> ☆ Collection and destruction of beetles during their emergence from the soil in the evening hours

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Table 9.4–Contd...

Name of the Pest	Damage Symptoms	Management Practices
Red palm weevil (<i>Rhynchophorus ferrugineus</i> (Olivier))	<p>beetles feed on tender and mature roots of the palm. In severe cases, the bole of the palm is also eaten up. They feed on roots of intercrops like banana, cocoa, tapioca, yams <i>etc.</i></p> <ul style="list-style-type: none"> ☆ In oil palm seedlings, the feeding on roots results in dropping and drying of leaves ☆ Affected seedlings come off easily since the entire root system is usually eaten up. Palms with few years of infestation show a sickly appearance, with yellowing of leaves, tapering of stem, and reduction in yield ☆ The palms may topple in case of severe loss of root system ☆ It is very difficult to detect <i>R. ferrugineus</i> in the early stages of infestation. Generally, it is detected only after the palm has been severely damaged. Careful observation may reveal the following signs which are indicative of the presence of the pest <ul style="list-style-type: none"> ☆ Some holes in the crown or trunk from which chewed-up fibres are ejected. This may be accompanied by the oozing of brown viscous liquid ☆ Crunching noise produced by the feeding grubs can be heard when the ear is placed to the trunk of the palm ☆ A withered bud/crown ☆ Chewed plant tissues in and around opening of tunnels with a typical fermented odour ☆ Fallen empty pupal cases and dead adults around a heavily infested palm ☆ Breaking or toppling of the trunk 	<ul style="list-style-type: none"> ☆ Install light traps @ 1 trap/acre and operate between 6 PM and 10 PM <p>Biological control:</p> <ul style="list-style-type: none"> ☆ Conserve entomopathogenic nematodes such as <i>Heterorhabditis</i> spp. and <i>Steinernema</i> spp. <p>Mechanical control:</p> <ul style="list-style-type: none"> ☆ Remove and burn all wilting or damaged palms in coconut gardens to prevent further perpetuation of the pest ☆ Avoid injuries on stems of palms as the wounds may serve as oviposition sites for the weevil. Fill all holes in the stem with cement ☆ Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem. ☆ Setting up of attractant traps (mud pots) containing sugarcane molasses 2½ kg or toddy 2½ l + acetic acid 5 ml + yeast 5 g + longitudinally split tender oil palm stem/logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils in large numbers. ☆ Install pheromone trap @ 1/2 ha <p>Biological control:</p> <ul style="list-style-type: none"> ☆ Fill the crown and the axils of top most three leaves with a mixture of fine sand and neem seed powder or neem seed kernel powder (2:1) once in three months to prevent the attack of rhinoceros beetle damage in which the red palm weevil lays eggs

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Table 9.4–Contd...

Name of the Pest	Damage Symptoms	Management Practices
Rhinoceros beetle (<i>Oryctes rhinoceros</i> (Linnaeus))	<p><i>O. rhinoceros</i> adults feed in the crown region of both coconut and oil palm.</p> <ul style="list-style-type: none"> ☆ They bore through petiole bases into the central unopened leaves. This causes tissue maceration and the presence of a fibrous frass inside the feeding hole is an indication of its activity within ☆ Usually, a single attack is often followed by others on the same palm ☆ These attacks subsequently produce fronds which have wedge-shaped gaps or the characteristic serrated cut (fan-shaped fronds) 	<p>Mechanical control:</p> <ul style="list-style-type: none"> ☆ Remove and burn all dead coconut trees in the garden (which are likely to serve as breeding ground) to maintain good sanitation ☆ Plant a cover crop to deter egg laying by females as they do not lay eggs in areas covered by vegetation ☆ Collect and destroy the various bio-stages of the beetle from the manure pits (breeding ground of the pest) whenever manure is lifted from the pits ☆ Examine the crowns of tree at every harvest and hook out and kill the adults ☆ Set up light traps following the first rains in summer and monsoon 200 period to attract and kill the adult beetles ☆ Set up rhinolure pheromone trap @ 1/ac to trap and kill the beetles
Bag worm (<i>Metisa plana</i>, <i>Pteroma pendula</i>, and <i>Mahasena corbettii</i>)	<ul style="list-style-type: none"> ☆ The bagworms build and live within a portable silk case (or bag), constructed by attaching fragments of leaves ☆ The larvae remain in their individual bags until the adult stage for females and the pupal stage for males ☆ All ages of palms are susceptible to bagworm attack but more damage tends to occur on matured palms of more than eight years old 	<p>Biological control:</p> <ul style="list-style-type: none"> ☆ Soak castor cake at 1 kg in 5 l of water in small mud pots and keep them in the oil palm gardens to attract and kill the adults ☆ Treat the longitudinally split tender coconut stem and green petiole of fronds with fresh toddy and keep them in the garden to attract and trap the beetles ☆ For seedlings, apply 3 naphthalene balls/palm weighing 3.5 g each at the base of inter space in leaf sheath in the 3 inner most leaves of the crown once in 45 days ☆ Apply mixture of either neem seed powder + sand (1:2) @150g per palm or neem seed kernel powder + sand (1:2) @ 150 g per palm in the base of the 3 inner most leaves in the crown <p>Biological control:</p> <ul style="list-style-type: none"> ☆ Plant beneficial plants (in particular, <i>Cassia cobanensis</i>) in the plantations to provide a good source of nectar to the parasitoids of the bag worm and other pests, thereby extending the life span of the natural enemies in the oil palm ecosystem ☆ Apply emulsifiable suspension of <i>B. thuringiensis kurstaki</i> to coincide with the very early instar stage

Table 9.5: Important Diseases of Oil Palm, their Symptoms and Management Practices

Name of the Disease	Damage Symptoms	Management Practices
Basal stem rot (<i>Ganoderma lucidum</i> (Karst))	<p>The trees in the age group of 10-30 years are easily attacked by the pathogen. The fungus is soil-borne and infects the roots. The most usual symptoms are yellowing, withering and drooping of the outer fronds which remain hanging around the trunk for several months before shedding</p> <ul style="list-style-type: none"> ☆ The younger leaves remain green for some time and later turn yellowish brown ☆ The new fronds produced become successively smaller and yellowish in color which do not unfold properly ☆ Soft rot occurs in the bud with a bad newly formed leaves wither away. More often the spindle is blown off leaving the decapitated stem ☆ The wilting plants also show bleeding patches near the base of the trunk ☆ A brown gummy liquid oozes out from the cracks in the tree which slowly result in the death of outer tissues ☆ As the infection advances, fresh bleeding patches appear above the old once, up to 3-5 meters height ☆ The decay of the basal portion occurs slowly and tree succumbs to the diseases in 2-3 years ☆ In the advanced stages of infection, the fungus produces fruiting body (Bracket) along the side of the basal trunk ☆ The roots of wilting trees show discoloration and severe rotting 	<p>Mechanical control:</p> <ul style="list-style-type: none"> ☆ Plantation sanitation: Removal and destruction of the dead and diseased palms in order to prevent the spread of the disease ☆ Isolation of diseased palms: The palms in the early or middle stages of the disease should be isolated from the neighboring palms by taking trenches of 1 m deep and 30 cm wide ☆ Irrigate the palms at least once in a fortnight during summer months <p>Biological control:</p> <ul style="list-style-type: none"> ☆ Apply heavy doses of FYM or compost for green manure at 50 kg/tree/year along with 5 kg of neem cake
Stem wet rot/ stem bleeding (<i>Thielaviopsis</i> <i>paradoxa</i> (de Seynes))	<p>The characteristic symptom is the exudation of reddish brown fluid from the cracks in the stem.</p> <ul style="list-style-type: none"> ☆ The fluid trickles down to several feet on the stem and the exudates dries up forming a black crust ☆ The tissues below the cracks turn yellow and decay. As the disease progresses, more area underneath the bark gets decayed and the bleeding patch extends further up 	<p>Mechanical control:</p> <ul style="list-style-type: none"> ☆ Improvement in agronomic practices, providing drainage, avoid flooding of the plantation etc. ☆ Adequate fertilization ☆ Scoop out the diseased tissue with a portion of healthy tissues, burn the exposed tissue and apply molten coal tar.

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Table 9.5–Contd...

Name of the Disease	Damage Symptoms	Management Practices
Bud rot (<i>Phytophthora palmivora</i> (Butler))	<ul style="list-style-type: none"> ☆ The vigour of the tree is affected and seed yield is reduced ☆ The tree is not killed outright but become uneconomical to maintain. In extreme cases, the trees may become barren and die <p>Palms of all ages are susceptible to the disease, but it is more severe in young palms of 5-20 years. The first indication of the diseases is seen on the central shoot of the tree (spindle)</p> <ul style="list-style-type: none"> ☆ The heart leaf shows discolorations which become brown instead of yellowish brown. This is followed by drooping and breaching off the heart leaf. With the progress of diseases, more number of leaves get affected with loss of lusture and turn pale yellow ☆ The entire base of the crown may be rotten emitting a foul smell, the central shoot comes off easily on slight pulling ☆ The leaves fall in succession starting from the top of the crown. The leaf falling and bunch shedding continue until a few outer leaves are left unaffected. But within few months the infection leads to complete shedding of leaves, within subsequent wilt and death of the tree 	<p>Cultural control:</p> <ul style="list-style-type: none"> ☆ Remove and burn badly affected trees which are beyond recovery ☆ If diseases is detected in early stage, remove the infected tissue thoroughly by cutting the infected spindle along with two surrounding leaves
Bunch rot (<i>Marasmius palmivorus</i> (Sharples))	<p>In the early stages of infection, whitish or pinkish-white mycelial threads can be seen over the bunch surface, especially at the base of the subtending frond.</p> <ul style="list-style-type: none"> ☆ The fungus penetrates the mesocarp of the fruit and causes a soft, brown, wet rot which is sharply defined from healthy tissues. If affected fruits are left on the palm, the rot ultimately dries out, leaving the fibrous tissues of the mesocarp with abundant mycelia growth of the pathogen ☆ The mycelial threads spread to other bunches and grow over, and inside, the frond bases. In the later stages of infection, abundant fructifications can be seen on bunches which have been extensively colonized 	<p>Cultural control:</p> <ul style="list-style-type: none"> ☆ Sanitation: Before on-set of monsoon, crown cleaning by means of removing the dead inflorescences, bunch stalks, aborted bunches <i>etc.</i> will help in reducing the inoculum buildup and harbouring of pathogen

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Table 9.5—Contd...

Name of the Disease	Damage Symptoms	Management Practices
Leaf spot (<i>Pestalotiopsis</i> spp.)	<p>Tiny black spots on leaves which enlarge into 2 mm long elliptical, elongated lesions.</p> <ul style="list-style-type: none"> ☆ Lesions may expand and be surrounded by black tissue and chlorosis between lesions ☆ Lesions may be present on leaf petioles and rachis 	<p>Cultural control:</p> <ul style="list-style-type: none"> ☆ Severely diseased palm should be removed from plantation and destroyed ☆ Palms should be planted with adequate spacing to allow air to circulate between trees ☆ Remove weeds from around palms
Bacterial budrot/ Spear rot (<i>Erwinia</i> spp)	<p>Parts of spear leaf petiole or rachi turning brown</p> <ul style="list-style-type: none"> ☆ Discoloration may be associated with a wet rot ☆ Spear leaf may be wilted and/or chlorotic ☆ Leaves may be collapsing and hanging from the crown ☆ Infection of the bud results in buds becoming rotten and putrid, leading to death of the palm <p>Survival and spread:</p> <ul style="list-style-type: none"> ☆ Bacteria survive in crop debris and infect by water splash through damaged tissues ☆ Worse in hot wet weather. The bacteria spread in contaminated water <p>Favourable conditions:</p> <ul style="list-style-type: none"> ☆ Higher temperatures and high humidity are ideal growing conditions for the bacteria 	<p>Cultural control:</p> <ul style="list-style-type: none"> ☆ Oil palm plant varieties with resistance to the bacteria ☆ Rotting tissue on spear leaves should be removed to prevent bacteria spreading to buds
Vascular wilt disease (<i>Fusarium</i> <i>oxysporum</i> f. sp. <i>Elaeidis</i>)	<p>This disease is prevalent in Africa, the Ivory Coast, Ghana, Benin, Cameroon, the Congo, Zaire and Brazil.</p> <ul style="list-style-type: none"> ☆ The soil born pathogen penetrates the roots and grows into the xylem where it causes blockage leading to wilting and death of the palm. In certain cases infected palm survives but its growth is greatly retarded leading to little or no yield ☆ In mature palms, the disease may either exhibit chronic or acute symptoms ☆ The chronic form is more common and characterized by having the affected fronds not usually symmetrically placed in the crown with only one to three of the phyllotactic spirals showing wilting symptom 	<p>Control measure:</p> <ul style="list-style-type: none"> ☆ Inoculum location and disease incidence: During replanting, the proximity of the stump of felled palm of previous stand serves as a major source of inoculum. The farther the young palm is from a stump, the less chance it has of contracting the disease. It is the site of the stump that contains the inoculums. The inoculum potential decreases with distance from such site. The uprooting of stumps will not become necessary ☆ Breeding for resistance

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Table 9.5–Contd...

Name of the Disease	Damage Symptoms	Management Practices
	<ul style="list-style-type: none"> ☆ The older fronds gradually become less turgid, wilt and eventually changing to a brown colour and becoming desiccated ☆ The dead fronds fracture at some point forming a cloak surrounding the palm ☆ As the disease progresses the remaining green fronds become shorter and may ultimately become less than one-half of their normal size ☆ This phenomenon occurs 3 to 12 months after the first symptom of wilting and may persist for several years before the whole crown dies and falls off ☆ In the acute form death usually occurs within 2 to 3 months after the appearance of the foliar symptom ☆ In this form, the first frond to be affected is towards the centre of the crown. The outer fronds then die swiftly, and crown dieback progresses rapidly inwards and upwards. The fronds die quickly and eventually fall off ☆ The disease can also occur on nursery seedlings and young field palms ☆ Growth of infected seedling is retarded with the inner leaves being shorter and narrower than those produced previously. This gives the seedling a flat-topped appearance, or even has a depressed centre ☆ In young field palm under six years old, the infected palm is characterized by the presence of bright lemon-orange fronds with a few pinnae on one side become chlorotic. This is followed by desiccation of the entire frond 	



Figure 9.9: Harvested FFB for Processing.

should not be over-ripe by next round. In lean period of production, harvesting can be made less frequent and it should be more frequent in peak periods.

Harvesting should be done at 10-12 days interval. During rainy season, harvesting should be done at closer interval of 6-7 days as ripening is hastened after hot summer. In young plantations, one can get more bunches with less bunch weight and in adult plantations, the bunch weight is more but the bunch number is less. Other factors that determine frequency are: extraction capacity of the mill, transportation facilities, labour availability and skill of the workers.

Ripeness of the fruit is determined by the degree of detachment of the fruit from bunches, change in colour and change in texture of the fruit. Ripening of fruits start from top downwards, nigrescens fruits turning reddish orange and the virescens (green) to reddish brown. Fruits also get detached from tip downward in 11 - 20 days time. Ripeness is faster in young palms than in older palms for the bunches of equal weight. The criteria used in determining the degree of ripeness based on the fruit detachment are as follows:

- a. Fallen fruits: 10 detached or easily removable fruits for young palms and five for adult palms,
- b. Number of fruits detached after the bunch is cut; five or more fruits/kg of bunch weight,
- c. Quantity of detachment per bunch; fruit detachment on 25 per cent of visible surface of bunch.

Bunches are to be cut without damaging the petiole leaf that supports it. Narrow chisel is usually used for harvesting till the palm reaches two meters above the ground. For taller palms up to four meters, a wider chisel of 14 cm is to be used. Harvesting could be carried out with a curved knife of 6 - 9 cm width attached to

a wooden pole or light hollow aluminium pipe. In uneven stands, an adjustable, telescopic type of pole can be used. A man can harvest 100-150 bunches per day, provided the palms are not very tall and that he is assisted by somebody who carries the bunches to the field collection points.

A fresh fruit bunch (FFB) weights on average 20-30kg depending on the age of the tree. Oil content of fruit pulp is 50-60 per cent or 20-22 per cent of the bunch weight. Oil content of kernels is 48-52 per cent of the kernel weight, or 2-2.5 per cent of the bunch weight. Under optimal conditions yields may reach 25-30 tonnes FFB/ha/year, and with an average extraction rate of 21-23 per cent, this corresponds with an approximate yield of 6 tonnes of oil per hectare. Under sub-optimal conditions, the average yield drops to 4-5 tonnes of oil per hectare.

11. Utilization and Use

Oil palm gives the highest yield of oil per unit area of any crop and is, worldwide, a major supplier of vegetable oil. Oil palm gives five to seven times more oil per ha than other traditional oil crops like groundnuts or soybeans. It is used in food production and in industrial applications. Yields from commercial oil palm estates differ from those obtained by smallholders. Average yields on industrial plantations range from 12 to 18 tonnes FFB/ha/year, with a yield potential of 18 to 22 tonnes.

Palm trees produce two distinct vegetable oils, palm oil and palm kernel oil, both of which are important in world trade. Other mainly local uses include: palm wine from the tree sap, leaves for thatching, soap production. Empty fruit bunches are used as soil manure and amendment.

11.1. Palm Oil

It is obtained from the fleshy mesocarp of the fruit, which contains about 50-60 per cent oil. It is light yellow to orange red in color, the depth of color depending on the amount of carotene present, the amount of oxidation by lipoxidases before processing, and oxidation catalyzed by iron during processing and bulking. The oil melts over a range of temperatures up to 50° C.

Palm oil contains a high proportion of saturated palmitic acid, as well as considerable quantities of oleic and linoleic acids which give it a higher unsaturated acid content than coconut and palm kernel oils. High free fatty acid content will be there in poorly prepared palm oil, which renders it unsuitable for edible purposes in importing countries and, therefore, requires additional treatment before proper commercialization. Palm oil is widely used in the manufacture of soap and candles, but this use tends to decline. With the improvement in quality, now a days, it is being increasingly used for edible purposes, including the manufacture of margarine and composed cooking fats.

11.2. Palm Kernel Oil

It is obtained from the kernel or endosperm which contains about 50 per cent oil, after the shell or endocarp is removed. It is hard oil, closely resembling coconut oil with which it is readily interchangeable. It has a high proportion of saturated,

predominantly lauric acids. It is solid at ambient temperatures in temperate countries, and is nearly colorless. It is used in edible fats, in the confectionery and bakery trades, in the preparation of ice-cream and mayonnaise, and in the manufacture of toilet soaps, soap powders and detergents. The press cake, after the extraction of oil from the kernels, can be used as an important livestock feed.

11.3. Palm Wine

It is produced from the sap obtained by tapping the male inflorescence, after incising it once or twice a day and collecting the sap that is funneled by a piece of bamboo into a bottle. The fresh sap is sweet and contains about 40g per liter of sucrose and 30g per liter of glucose, but it ferments quickly by the action of bacteria and naturally yeasts into a milky palm wine with a slight sulfurous odor. Palm wine can be further distilled into a local brandy.

11.4. Biodiesel

Oil palm was also cultivated for the production of *biodiesel* in Indonesia and Malaysia, in particular. Though the Malaysian Government appeared to consider biodiesel as an alternative outlet to its oil palm production and a potential medium for future economic growth, however, when it became clear that this high demand for biodiesel was disturbing the complete oil palm industry and market, the plan was suspended, mainly because of deleterious impact on the environment as well as the pressure it was creating to open more estates by clearing virgin forest lands.

12. Site Specific Management Practices

Some of the site-specific management practices for improving oil palm productivity are given below:

1. Maintain sufficient fronds to help attain optimum leaf area for maximum yield. Remove old, dead and damaged fronds from palms. Light competition may affect yields in older palms or when planted too close together, and therefore, proper spacing is to be adopted while planting.
2. Palms which are unproductive for six years after planting should be removed to limit competition with productive palms.
3. Fill the gaps in vacant spots and in-filling unplanted areas to maximize productivity of plantation.
4. Adopt selective thinning in dense areas to reduce competition for light and thereby improve yields.
5. Pest and disease outbreaks are to be detected before they become problematic and large-scale control measures are necessary. The fungus *Ganoderma* is responsible for basal stem rot in oil palms and it is a major threat to oil palm production in South East Asia. Therefore effective monitoring and management of pests (e.g. leaf eaters) and disease (e.g. *Ganoderma*).
6. Spread the pruned fronds widely in inter-row area and between palms within rows and mulch palm basins with pruned fronds to provide

nutrients to the soil, conserve moisture, prevent weed growth and reduce soil erosion. Also use EFB for mulching in areas adjacent to the mill. Using EFB as mulch can replenish soil organic matter and provide nutrients.

7. Adopt regular weeding and eradicate woody perennial weeds to reduce competition for nutrients and water. Legume cover crops can help reduce soil erosion, fix atmospheric N₂, supply litter to replenish organic matter and provide habitat for predators of insect pests.

Some of the site-specific management practices for improving crop recovery are given below:

1. Regular harvesting ensures efficient collection of ripe fruits, which delivers maximum oil yield, and therefore adopt harvest interval of seven days.
2. When ripe, fruits start to detach from bunches and the minimum ripeness standard is that one loose fruit before harvest. Follow the correct stage of harvesting in order to extract maximum oil yield.
3. Transport the harvested crop to palm oil mill on the same day to reduce the amount of free fatty acid (FFA) in the crude palm oil. High FFA levels make palm oil unfit for human consumption, and create problems for refining oil for biodiesel.
4. Maintain proper harvest audits to ensure maximum efficiency, crop recovery and oil yield.
5. Develop good in-field accessibility (clear paths, bridges wherever needed) for easy harvesting and transportation of harvested produces, organic manures and its application *etc.*
6. Keep the circle around palms weed free to allow efficient collection of loose fruit below palms.
7. Construct and maintain palm platforms wherever needed, which improves nutrient use efficiency, prevent soil erosion and improves harvesting efficiency.

13. Environmental Issues

Mono cropping of oil palm has been criticized for its negative impacts on the natural environment, including large scale deforestation, loss of natural habitats, and increased greenhouse gas emissions. Environmental groups also find use of palm oil biofuels objectionable, due to the fact that the deforestation caused by oil palm plantations is more damaging for the climate than the benefits gained by switching to biofuel and utilizing the palms as carbon sinks.

In Indonesia, increasing demand for palm oil and timber has led to the clearing of tropical forest land in national parks. According to *United Nations Environment Programme* report during 2007, at the rate of deforestation at that time, an estimated 98 percent of Indonesian forest would be destroyed by 2022 due to legal and illegal felling, forest fires and the development of oil palm plantations. On the other hand, Malaysian government has pledged to conserve a minimum of 50 percent of its total land area as forests.

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