University of Khartoum
Faculty of Forestry

Oil Palm (*Elaeis guineensis* Jacq)

Seedlings Growth

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Dedication:

To my wife and my children
To my Mother and Father
To all whom I love … Sudanese People
To all who can benefit from this study …
Acknowledgement

I would like to express my sincere thanks and appreciation to my supervisor Prof. Hashim Ali Alatta, for his encouragement, guidance, patience and constructive criticism throughout the course of the study.

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Summary

Oil palms are naturally found scattered and Northern and Southern Sudan and potentially source for improving socio-economically the lives of farmers. However, problems are faced in raising them in the nursery because they are dioecious, may require large sources of containers and they take a long time in the nursery to produce suitable seedling for planting in the field.

2000 pregerminated seeds of the oil palms were imported from Malaysia and grown in the nursery at 25%, 50%, 75% and 100% shade intensity two watering regimes (daily and three time per week) and grown in containers of 20x10 cm and 40x50 cm. Monthly records of shoot and root length, shoot and root, fresh and dry weight and number of leaves were taken, and the measurements continuous for twelve months.

The measurements showed that after one year growth the seedling produce were comparable to those produced in Malaysia were fertilizes are commonly used, so no fertilizers were used in the Sudan. The soil used was river silt. The best growth of seedlings was obtained under 75% shade intensity and daily watering. Those seedlings grown in the Sudan attain 82% of shoot-root dry weight where is those grown in Malaysia measured 93%.
ملخص الأطروحة

بنيت هذه الدراسة على انتشار أشجار نخيل الزيت في السودان في مناطق مختلفة شمالاً وجنوباً ويعتبر السودان من أحد الدول الأفريقية التي يوجد فيها نخيل الزيت ويشكل إنتاج النبات البذور وتربيته الشتل من المشاكل الأساسية للزراعة.

أجرت الدراسة في مسح الغابات بسودانياً حيث استخلصت ألفاً بذرة نامية من نخيل الزيت من دولة ماليزيا (جنوب شرق آسيا)، حيث تم توزيعها على ثمان مجموعات كل مجموعة تحوي 150 شجرة اعتماداً على الزراعة ووضع الشمس (الروطية) وأحجام النمو وتبدو قراءات شهيرة لعدد الأوراق ومساحتها وطول الساق ودرجة اختصار الأوراق وذلك لتحقيق نسبة البقاء والنمو في أحسن وضع. كانت المجموعات تحوي أكياس نمو بمقاس (50×40 سم) وأكياس نمو (10×20 سم) وري في حديث التصريف في ظل دام وأخرى في درجة ظل متغير بنسبة (75% + 50% + أقل من 25%) وأخذت القياسات لمدة عام. بعد ذلك تم أخذ عينات لتحديد الوزن الجاف للجزء الخضري والوزن الجاف للجزء الجذري وذلك لمقارنتها مع دراسة تمت في ماليزيا نفس أنواع البذور ولكن استعمال السماد الذي يعتبر أساسيًا لنمو تلك الشجرة في الالتزام النهائي وجه أن نسبة البقاء عالية لكل الشتل في المجموعات الثمان أما أحسن نمو فقد تم حصره في درجة ظل تصل 75% وتصريف مائي جيد وداد. مقارنة التجربة في السودان بدون استعمال سماد مع الموجودة في ماليزيا أوضحت أن نسبة الجزء الخضري للجذري (93%) بينما في السودان (82%) مما يؤكد إمكانية الاستغناء عن السماد في مرحلة المشتل.

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Chapter I

Introduction

1. Background:

Oil palms are known to be indigenous since 1900. It was planted on a commercial level in Zande Scheme in southern Sudan at the borders with the Democratic Republic of Congo (Zaire). However, recently plans were prepared to introduce the species in some other areas of Sudan as irrigated plantations. Sudan produces a wide range of rain-fed crops and has a large diversity of ecological zones with variable rains and soil types, ranging from arid and semi-arid conditions in the north to low rainfall and high rainfall savanna towards the south. Sudan has long experience of producing a wide variety of vegetable oils. Due to the promising and satisfactory performance of the local varieties of oil palms, it was decided to expand on planting oil palms using indigenous and exotic varieties. Oil palm trees were found along the Blue Nile at Elgazair and Bunzoga forests in Sennar State as scattered trees producing bunches. In South Khartoum at Soba and North Khartoum at
Khartoum Hospital and in Shambat some trees were found with bunches.

Seedlings of oil palms were distributed since 1996 as follows:

1) Elgizera State.

(2) Sennar State.

(3) Blue Nile State.

(4) South Kordofan State.

(5) South Darfur State.

This plantation programme was established to investigate the possibility of crop establishment using supplementary irrigation and without using fertilizers, the records indicate the following:

(1) Elgizera State: the trees can withstand flooding (Hantoob forest); the possibility of not using fertilizers with supplementary irrigation proved viable since some trees started having bunches.

(2) Sennar and Blue Nile States: using supplementary irrigation with agro-pastro-forestry, the survival rate was high.

(3) South Kordofan – Darfur: the only system used was agro-pastro-forestry without fertilizers, and the survival rate was high.

Introducing Malaysian seedlings in the areas of Blue Nile, White Nile, south Darfur, south Kordofan for growth and survival will give
only a picture of vegetative growth at this early stage. Production of fruits, which is the economic aspect should be considered at later stages of development.

2. Problem Statement:

The Ministry of Agriculture and Forests started to develop important crops for improving and increasing the national income together with developing farmers finance and social status. The National Oil Palm Project was proposed in 1993 by the National Oil Seed Processing Research Institute (NOPRI) at the University of Gezira. The Federal Ministry of Agriculture accepted the proposal and formed the Sudan National Oil Palm Committee, (SNOPC), composed of:

Ministry of Agriculture
Forests National Corporation
University of Khartoum
University of Gezira
Sudanese Oil Seeds Company

3. Justification of this work:
This work concentrated mainly in the literature review part on summarizing the known characteristics of the oil palm ecology and silviculture. The experimental part concentrated on developing suitable seedlings of the species for planting out in the field for assessment of their growth and production potential at later stages. Comparison with suitable nursery developed seedlings in Malaysia was taken as indicator of suitability of the seedlings for planting out. This concentration on the nursery stage was necessitated by the following reasons:

A. The development of suitable seedlings from seeds takes comparatively long time (i.e. year) whereas developing suitable seedlings from other species (Acacia eucalypts etc) takes about six months.

B. The species is dioecious and seedlings grown in the nursery must be confirmed to be females which necessitates introduction of pregerminated seeds from Malaysia.

C. The seedlings are large in size which forced the use of large containers.

D. Potting mixture of soil used is not known in Sudan and therefore the response of the growth of the species in usually used soil (river
silt) was necessary to be known together with the lack of use of fertilizers which are not normally used in Sudan.

E. The response to shade or otherwise was not known and hence be investigated.

4. Objectives:

A part from the general literature survey on the ecology and silviculture of the species, the general objective of the work was to produce suitable seedlings of the species for growing in the Sudan. The specific objectives were:

1. To assess the survival rates at the nursery stage.

2. To assess the growth characteristics of the species at the nursery stage.

3. Depending on the response of the species as it grows, to attempt to improve nursery conditions for better growth.
Chapter II

Literature Review

1. History of the family Palmae

The family Palmae or Arecaceae, to which the genus *Elaeis* belongs, is considered as old as any other family of flowering plants with fossils discovered in Cretaceous rocks dating back some 120 million years (Purseglove, 1972). Many plant taxonomists believe it to be the first monocotyledon to have branched out from primitive dicotyledon stock, and as such, the progenitor of all monocotyledons. A phylogenetic lineage for the genus *Elaeis* therefore looks like the schematic diagram presented in Figure (1).

2. Evolution and Speciation of the Genus *Elaeis*

The genus *Elaeis*, which belongs to the subfamily *Cocoideae*, also includes the coconut, is believed to have originated either in Africa or America and is one of the 240 genera of the family *Arecaccae* and cannot be viewed in isolation from the other genera because of high degree of homogeneity among the chromosomes of the palms.
Primitive dicots (extinct)

Ancestral complex of monocots (extinct)

Superorder Arecidae

Order Arecales

Family Arecaceae

Subfamily Cocoideae

Genus *Elaeis*

Species

*E. guieneensis* Jacq. (West Africa)

*E. oleifera* (H.B.K). Cortes (Central and South America)

Figure (1)
2.1 Species Occurring in Africa:

The first species of the genus, *E. guineensis*, the African oil palm was described by (Jacquin, 1763). The second species is *E. oleifera* Cortes, the South American oil palm initially described as *E. melanococca* and applied by (Gaertner, 1788) to be a form of *E. guineensis*, was officially described by (Cortes, 1897) (the basionym was formerly described as *Alfonsia oleifera*, by (H. B. K., 1816). This species is distinguished from *E. guineensis* by its trunk which, at first is erect, soon becomes decumbent, and is slower growing. The leaflets lie in one plane and have no basal swellings; spines on the petioles are short and thick; the spathe persistent in the female inflorescence; fruit bunch conical, with thin mesocarp, ripening from pale yellow to bright orange. Later, it was placed in another genus and referred to as *Corozo oleifera* Bailey. (Purseglove, 1972), however doubted this classification as *E. oleifera* hybridizes easily with *E. guineensis* and the degree of divergence between the two species rather justifies separation on a specific level rather than generic level. The third species, *E. odora*, otherwise known as *Barcella odora* was added by (Wessels-Boer, 1965). The fourth species, *E. madagascariensis*, was described by
Beccari but is still controversial. Some taxonomists believe that this species is a variant of *E. guineensis* which was introduced around the 10\textsuperscript{th} century when African influence entered Madagascar (Purseglove, 1972). The species is distinguished from *E. guineensis* by its male flower in which the fused filaments of the staminal tube are shorter and the anthers erect, instead of spreading, at anthesis while the fruits are smaller and rounded and surrounded by larger bracts. (Uhl and Dransfield, 1987) recognized only two species, namely *E. guineensis* and *E. oleifera*, the third species as belonging to *Barcella odora* (Trail) Trail exdrude and the fourth species as a variant of *E. guineensis* which was introduced to Madagascar, as mentioned above. (Corley, 1976) gave a comprehensive account on the genus *Elaeis*.

### 2.2 Species Occurring in America:

(Cook, 1942) suggested that the oil palm originated in Brazil where natural populations can be found growing wild or semi-wild along river banks. In addition, a great majority of the species in the palm subfamily Cocoideae, including the other species of *Elaeis*, viz. *E. oleifera* and a related species, *B. odora*, are also found in South
America. On the other hand, (Zeven, 1964) and (Rees, 1965) argued that *E. guineensis* originated in Africa, since one of the other species, *E. madagaseariensis* also has its origin in the African continent. The above authors based their arguments on both historical and linguistic evidence. The fact that Portuguese explorers like Ca' da Mosto (1435-1460) and Pereira (1505-1560) who visited West Africa have recorded and mentioned the oil palm thus provided evidence in support of the above claims (Purseglove, 1972).

2.3 The Origin of Species:
In Africa, the oil palm has been cultivated on a village scale for its oil, and its range of cultivation extended from the probable origin in Guinea to the west and centre of Africa. In fact, (Chevalier, 1943) considered the centre of origin of the oil palm to be the tropical rain forest region of West Africa. From West Africa, the palms spread from 16° N in Senegal to 15° S in Angola and eastwards to Zanzibar and Madagascar. However, (Corley, 1976), quoting the findings of (Zeven, 1967) said that the exact centre of origin within Africa is not known.
3. Classification of the family of palms:

The palm has always formed a distinct group of plants among the monocotyledons. Although (Bentham and Hookers *Genera plantarum*) placed the palms with the Flagellariaceae and Juncaceae under the series Calycinae, Engler and Prantle’s system allowed them a place by themselves under the order Principes. In the comparatively recent classification of Hutchinson, the Palmae remain alone, though in the order Palmales. Here the oil palm, *Elaeis guineensis* Jacq, is grouped with *Cacos* and other genera under the tribe Cocoineae. The anatomical studies of (Tomlinson, 1965) support this grouping.

The genus *Elaeis* was founded on palms introduced into Martinique, the oil palm receiving its botanical name from (Jacquin, 1763) in an account of American plants. *Elaeis* is derived from the Greek word “elaion” oil, while the specific name *guineensis* shows that Jacquin attributed its origin to the Guinea Coast. From time to time other specific names have been attached to supposed species of *Elaeis*, but none has shown any signs of permanency other than *E. melanococca*, now named *E. oleifera*, and *E. madagascariensis*. 
The early descriptions of the oil palm have been reviewed by (Opsomer, 1965) who claims that (Mathias de Lobel) had the earliest botanical description and illustration of the fruit which he named *Nucula indica*. (Lobelius, 1536-1616) reported that the palm was found in Guinea. His brief descriptions were published in his Planarium seu Stirpium Historia of 1570 (London) and 1576 (Antwerp) and this Kruydtboeck of 1581 (Oil Palm. Hortely Second Edition, 1976).

Mention of the oil palm is scattered throughout the works of de l’Escluse (Clusius, 1526-1609); the descriptions in the revised edition of the herbal of 1608 of de Dodoens and in Bauhin’s *Histories des plantes* of 1650 are also attributed to him. There is some confusion over description and nomenclature in the earlier works but in the later ones the palm in called *Nucula Indica Secunda* and *Palma Guineenis*. The descriptions taken together are remarkably complete and it is recorded that thin-shelled nuts appear among the more numerous thick-shelled ones. A dried spikelet was illustrated in Glusius’s last word and in (Dodonaeus’s *Cruydt-boeck*) and this probably accounts for (Clusius’s) erroneous belief that palm
oil was extracted from the kernel, turning red on the journey from Africa.

(Opsomer, 1965) stated that nothing of consequence was written on the oil palm for over 150 years between the time of Clusius and the first, and lasting, modern botanical description of (Jacquin, 1763). However Sloane’s *Catalogus Plantarum* (London), 1696), besides making first mention of the spiny petioles, records the importation of the palm from the Guinea coast into Jamaica. It was from material from another West India island, Martinique, that Jacquin was to write his description and to name the plant. Jacquin's description is detailed, but he describes the flowers as either female or 'hermaphroditi steriles' and seemed unaware that flowers of the two sexes were in separate inflorescences. The production of male and female bunches was first recorded by Miller in his *Cardener's Dictionary* (London, 1768). Before the end of the century Caertner, in his *De Fructibits et Seminibus Plantrum* (Stuttgart, 1788), gave a more detailed description of the flower parts, recording that the male and female flowers are on separate inflorescences.

*Elaeis guineensis* is a large feather-palm having a solitary columnar stem with short internodes. It is unarmed except for short spines on
the leaf base and within the fruit bunch. The irregular set of the leaflets on the leaf gives the palm its characteristic appearance. The palm is normally, dioecious with male or female flowers, but is sometimes monoecious, inflorescences developing in the axils of the leaves. The fruit is a drupe which is borne on a large compact bunch. The fruit pulp which provides palm oil surrounds a nut the shell of which encloses the palm kernel.

The distinguishing of varieties of the oil palm has been attempted by many workers. These attempts have in most cases been unsatisfactory, since in the wild state each palm is a hybrid in respect of certain of its characters. Most of the early attempts at classification are unworthy of mention since they were based on a very small acquaintance with the palm, and no knowledge of the inheritance of the characters described. Of interest, however, is the first description by (Preuss, 1902) of the Lisombe palm, a name used in the Congo, Cameroons and Nigeria for the thin-shelled tenera fruit form and employed to denote parental stock in quite recent times. Both (Chevalier and Jumelle, 1910 and 1918) divided the species into subspecies according to the outer appearance of the fruit, while Becarri extended Chevalier's classification. These
classifications were unsatisfactory owing to their failure to attribute all the possible fruit variations to each subspecies, and it was left to (Janssens, 1927) and (Smith, 1935) to provide the first simple classifications, which, in their essentials, have stood the test of time. Although nothing was known of the inheritance of the characters described, Janssens recognized that the fruit forms *dura* and *tenera*, distinguished by the thickness of shell, could be found among fruit types of different external appearance. Thus both the common fruit type *nigrescens* and the green-fruitied *virescens* were divided by Janssens into three forms *dura*, *tenera* and *pisifera* (the latter called *gracilinux* - following Chevalier - when *virescens*). The white-fruitied, *albescens* was also recognized but only a *dura albescens* had been found. Similarly, although *dura* and *tenera* forms of the mantled-fruitied *Poissoni* were found, no green-fruitied mantled specimens were discovered. Smith, however, recognized both mantled and unmantled *nigrescens* and *virescens* fruit, called them 'types', and divided all four into thick-shelled and thin-shelled 'forms'. This simple procedure, described by (Beirnaert and Vanderweyen, 1941) as the most complete and logical of the empirical classifications, established the use, {in English
publications, of the fruit-type and fruit-form classification}, thus eliminating the need of the term variety for material, which might be heterozygous in many of its characters. That 'variety' was inappropriately used for the *tenera* form was recognized by (Biernaert, 1941). In the Far East Schmole used the term fruit form as early as 1929.

4. Key to the Species

There is considerable information available about the two cultivated *Elaeis* species, namely, *Eguineensis* and *E.oleifera* (A. Latiff, 2000)

1. Trunk short if erect, or prostrate; frond flat, with bigger pinnae arranged on one plane at regular intervals; bracts subtending lower lip of flower pits in female inflorescence not prolonged into a long spine; at anthesis female inflorescence remains covered with protective fibrous inflorescence spathe.

2. Trunk tall; frond crisp, with clustered pinnae arranged in upper and lower rank on each side of rachis; thorny bracts subtending lower lip of flower pits in female inflorescence prolonged into a long, spine; at anthesis the female
inflorescence remains uncovered with protective fibrous inflorescence spathe.

5. Geographical Distribution in Africa

The distribution before the First World War was summarized by (Schad, 1914) and this has been brought up to date by (Zeven, 1967). On the west side of the continent the oil palm occurs at 16°N near St Louis in Senegal; inland it has been recorded on the upper Niger at 13°N near Bamako. Though there are planted palms around Dakar and in the Gambia, no extensive areas of palms are found in the countries of the coast until the Fouta Djallon district of Guinea is reached at the 10°-11°N parallel. From here the real palm belt of Africa runs through the southern latitudes of Sierra Leone, Liberia, the Ivory Coast, Ghana, Togoland, Dahomey, Nigeria, Cameroon and into the equatorial regions of the Republics of Congo and Zaire. The northern limit of this belt varies with the height and with topography. On the coast there is a small area surrounding Accra where rainfall falls to 65 mm per annum and the presence of grass savannah excludes the oil palm.
Except in the heavy summer rain areas of Guinea and Sierra Leone the oil palm only spreads beyond about 7°N into favoured river valleys under escarpments (e.g. west of the Jos plateau in Nigeria) or where underground water supplies are available. Beyond this latitude the oil palm gradually gives place to the palmyra palm (*Borassus aethiopicum*). However, small groups of palms occur in relatively dry areas in the Central African Republic and south of the Sudan.

In Central Africa the main area of spread of the oil palm lies between 3°N and 7°S and covers huge areas of Zaire together with parts of the Republic of Congo and Angola. The groves are most concentrated in the Kwilu and Kwango districts between 4° and 7°S and in Cabinda in Angola. In the coastal districts of Angola the climate is too dry to support palms though palms are found as far south as Mocamedes (15°S). Groves in the north are contiguous with those of southern Zaire, and plantations have been established south of the Rio Cuanza.

The spread of the oil palm into East Africa is believed to have been from Zaire. Dense stands of palms are found in the Senaliki valley on the Zaire-Uganda border, in the Ruzizi plain between Lakes Kivu and Tanganyika and in a belt about 19 km wide on the eastern shore
of Lake Tanganyika. Most of East and South-east Africa is far too dry for the oil palm and it appears only at altitudes below 1,067 m near lakes or water courses where a reasonable rainfall is assured. It exists on the west shore of Lake Malawi as far as 13°S and is also to be found on Lake Bangweulu and Lake Mweru in Zambia and scattered about in the south-eastern regions of Zaire at about 10°S wherever moisture conditions are favourable (Hartly, 1977).

These areas are separated from the coast by belts of very dry territory and it seems not unlikely that the oil palm was brought to the coast during the long period of the slave trade. Today, oil palms are to be found sporadically from the Tana river in Kenya to Dar es Salaam in Tanzania and on the islands of Zanzibar and Pemba (between 3° and 7°S).

The oil palm is also found on the island of Madagascar (Malagasy Republic) on a stretch of the west coast from south of Cap St Andre to the basins of the Manambolo and Tsiribihina rivers and as far south as 21° of latitude where it is known as Tsingilo. Climatically, the east coast of Madagascar seems more suited to the oil palm and although at one time it was thought to be indigenous on the west coast it seems more probable that it was brought across the sea by
Africans of continental Africa when they entered the island and that its distribution is largely due to chance introduction (Hartley, 1977). From before the beginning of the century there have been many reports of the planting of palms in parts of Africa where the plant was hitherto unknown. These include planting on Government stations in most of the East African countries and in Angola. The oil palm is a plant of the lowlands and in the great areas of productive groves it is found from sea level to about 300 m. However, when mountainous country adjoins these areas or where the oil palm has been transported to high tablelands having sufficient rainfall, it has been able to survive at much greater heights. The most interesting mountainous habitat is the Cameroon Mountain which is not far removed from the greatest grove area of Africa in eastern Nigeria. Here palms occur at over 1,300 m. In Guinea, the palm grows at 1,000 m in the mountains of the Fouta Djillon, and in East Cameroon it is found in abundance at 1,000 m in two favoured localities. Most of the East African inland localities are at a height of around 1,000 m. Nothing is known of the relation of altitude to bunch production in Africa, though production is said to be low in the high-altitude areas of Cameroon (Hartley, 1977).
Within 7° of the equator and in some exceptional areas at higher latitudes, wherever a large population is to be found, the typical palm groves of West and West Central Africa have arisen. Dense groves are found most continuously and extensively in eastern Nigeria, but the palm is so widespread that it is true to say that it would be difficult to stand anywhere in the palm belt except in the heart of a forest reserve and not be able to see a few palms. The dominant position of Nigeria in the export of oil and kernels from Africa was due to a rapid increase in population taking place near to the coast in a region with fair communications and suitable climatic conditions.

In Zaire, the groves are to be found mainly in the south of the country. In some areas dense groves comparable to those of eastern Nigeria exist, but in general the groves are less uniform and occur in long narrow belts or in patches alternating with forest or derived savannah (Hartley, 1977).

Before the establishment of plantations in the Far East and, later, in Zaire, the groves of Africa formed the sole source of supply of palm oil and kernels. It has been said that when the palm is considered in its West African setting it is first and foremost a food crop. Large
quantities of palm oil are consumed locally in all West African countries and, while it is impossible to obtain exact figures, there is good reason to believe that, even in Nigeria, more palm oil is consumed within the country than was ever exported. In countries with smaller populations and lower production, e.g. Sierra Leone, Ghana, Dahomey and the ivory Coast, the bulk of the palm oil is consumed locally or moves to adjoining territories.

In certain circumstances palm kernels are extracted from fruit without the prior extraction of the mesocarp oil; this together with local consumption of oil accounts for the very high export figures for palm kernels compared with those of palm oil. In some parts of West Africa the fruit quality, as judged by the thickness of the mesocarp layer, is so poor that there is little encouragement to extract the oil; this is the case in Sierra Leone and some parts of Ghana, Dahomey and western Nigeria.

6. Morphology and Taxonomy:

The seed

The embryo of palm seeds is always small and the cotyledon is never erected as a green photosynthetic organ. Instead, the cotyledon
apex becomes enlarged as the haustorium, absorbs the food reserves of the endosperm (Tom Lin Son, 1960). Thus in the oil palm the seed is adapted to support a developing seedling for many weeks after germination.

The oil palm seed (Hussey, 1955 and 1958) is the nut, which remains after the soft oily mesocarp has been removed, usually by retting, from the fruit. It consists of a shell, or endocarp, and one, two or three kernels. In the great majority of cases, however, the seed contains only one kernel since two of the three ovules in the tricarpelate ovary usually abort. Abnormal ovaries sometimes occur and four- or five-seeded nuts may, very rarely, arise from these. Nut size varies very greatly and depends both on the thickness of the shell and the size of the kernel. Typical African *dura* nuts may be 2 to 3 cm in length and average 4 g in weight (100 to the lb). Deli *dura* and large African nuts are larger, weighing up to 13 g. African *tenera* nuts are usually 2 cm or less in length and average 2 g (200 to the lb). Very small nuts weighing 1 g are not uncommon.

The shell has fibres passing longitudinally through it and adhering to it. The latter are drawn into a tuft at the base; this factor has been made use of in the construction of modern nut-cracking machinery.
Each shell has three germ pores corresponding to three parts of the tricarpellate ovary, though the number of functional pores will of course correspond with the number of kernels developed. A plug of fibre is formed in each germ pore and these fibres are cemented together at the base to form a plate-like structure continuous with the inner surface of the shell.

Inside the shell lies the kernel. This consists of layers of hard oily endosperm, greyish-white in colour, surrounded by a dark brown testa covered with a network of fibres. Embedded in the endosperm and opposite one of the germ pores, lies the embryo.

The embryo is straight and about 3 mm in length, its distal end lies opposite the germ pore but is separated from it by a thin layer of endosperm cells, the testa and the plate-like structure referred to above. These three structures have been together called the operculum, but they are separate. In the quiescent state the bud is already well-developed laterally within the distal end of the embryo. In longitudinal section the apex with two differentiated leaves and the rudiments of a third can be distinguished, though the radicle is only poorly differentiated (Vallade, Jand Lucien, 1966). Opposite the bud there is a longitudinal split in the wall of the embryo (the
'fente cotyledonaire'). This part of the embryo is separated by a small constriction from the cotyledon which will develop into the haustorium. Within the cotyledon a system of procambial strands has developed.

The endosperm above the embryo is demarcated by a ring of cells of small size. When germination takes place the endosperm ruptures in this region and a disc consisting of endosperm, testa and the germ-pore plate is extruded from the germ pore together with the fibre plug.

The emerging embryo forms a 'button' (commonly called the hypocotyl but considered by (Henry, 1951) to represent the petiole of the cotyledon), which rapidly gains a plumular projection, while from the end of the embryo itself the persistent radicle emerges. The plumule and radicle both emerge through a cylindrical, persistent ligule close to the seed.

Within the seed the haustorium develops steadily. This organ has a yellow pigment and is convoluted along the long axis of the nut thus providing a greater surface area for absorption. After about 3 months the spongy haustorium has absorbed the endosperm and completely fills the nut cavity.
The Seedling

The seedling (Hussey, 1956) has 3 months to establish itself as an organism capable of photosynthesis and absorption of nutrients from the soil.

The plumule does not emerge from the plumular projection until the radicle has reached 1 cm in length. The first adventitious roots are produced in a ring just above the radicle-hypocotyl junction and they give rise to secondary roots before the first foliage leaf has emerged. The radicle continues to grow for about 6 months by which time it has reached about 15 cm in length. Thereafter the numerous primary roots develop in its place.

Two bladeless plumular sheaths are produced before a green leaf emerges. The latter is recognized by the presence of a lamina, and it emerges about 1 month after germination. Thereafter, one leaf per month is produced until the seedling is 6 months old. The 'four-leaf stage', usually regarded as suitable for transplanting as prenursery seedling to the nursery, is reached 4 months after germination.

After 3 to 4 months the base of the stem becomes a swollen 'bulb' and the first true primary roots emerge from it. These are thicker than the radicle and grow at an angle of 45° from the vertical.
Secondary roots grow out in all directions. During this second period in the seedling's life the leaves become successively larger and change in shape. The leaves of the adult palm are pinnate, but this form is only reached in stages. The first few leaves are lanceolate with a midrib to half their length; two veins proceed from the end of this midrib to the tip of the leaf, in later leaves a split appears between these veins and the leaf becomes bifurcate. This type of leaf is quickly followed by leaves in which splits divide the laminae between the veins into leaflets or pinnae, although the latter are still joined to one another at the apex. Later still the leaflets become entirely free, though when the leaf opens the tip of the leaflet is always the last part to become entirely unattached.

Young pinnate leaves differ from maturer leaves - the leaflets are inserted directly on to the midrib, without pulvin; the lower leaflets do not degenerate into spines; they are less xeromorphic than mature leaves (Hartley, 1977).

The Leaf

The mature leaf is simply-pinnate, bearing linear leaflets or pinnae on each side of the leaf stalk (Hussey, 1962). The latter may be divided into two zones, the rachis bearing the leaflets, and the petiole
which is much shorter than the rachis and bears only short lateral spines. At the junction of petiole and rachis small leaflets with vestigial laminae (leaf blades) are found. Petioles vary greatly in length and in the Deli palm may be as long as 4 feet. Some petioles remain green for a considerable period.

The spines have been shown to be of two kinds which are named fibre spines and midrib spines. The former are those on the petiole; they are very regular and are formed from the base of the fibres of the leaf heath. The point at which these fibres break off is very regular, so the spines are nearly all the same length. Where the leaflets begin to occur they are poorly developed although they have the basal swellings of fully developed leaflets. The lamina of these poorly-developed leaflets frequently becomes torn away, leaving a spine which was originally the leaflet midrib. These spines have the same irregularity of set as have the fully developed leaflets on the leaf (Henry, 1955).

The leaf stalk is a hard fibrous body which may be as long as 8 m. At the tip it is almost circular in cross section, but in the centre of the rachis it is asymmetrical with lateral faces where the leaflets are inserted. In the petiole the lateral faces disappear. The lower or
abaxial face is much more strongly curved than the upper or adaxial face.

After the leaf has opened it is progressively displaced centrifugally as younger leaves emerge. Middle-aged leaves lie parallel to the ground with the tip bearing slightly downward. Usually the adaxial face of the rachis faces upwards, but sometimes the leaf twists into a vertical plane or intermediate position (Rees, A. R., 1963).

Typically, the leaflets inserted on the lateral faces alternate in upper and lower ranks. There is no exact regularity however, and two or more consecutive leaflets may appear in the same rank. Similarly within each rank the angle of insertion is often irregular, and very occasionally there is almost no 'ranking effect'. Generally, however, it is the provision of two ranks and the irregularity of leaflet insertion which gives the palm its shaggy appearance and distinguishes it, from a distance, from the coconut palm or *E. oleifera*. Individual leaflets are linear in shape and each leaf has a terminal pair. Leaflets number some 250-300 per mature leaf and are up to 1.3 m long and 6 cm broad. The leaflet midrib is often very rigid and the laminae sometimes tear backwards from the tip. This increases the 'untidy' appearance of the leaf. There is a small basal
swelling, resembling a pulvinus but with no motor function, at the insertion of the leaflet on the rachis (Yampolsky, 1922).

The number of leaves produced annually by a plantation palm increases to between thirty and forty at 5 or 6 years of age. Thereafter the production declines to a level of twenty to twenty-five per annum. Leaf production of grove palms is much lower (Yampolsky, 1922).

The Root System

The seedling radicle is soon replaced by adventitious primary roots emanating from the radicle hypocotyl junction and then from the lower 17 nodes of the stem which are formed into a massive basal cone or bole. The latter retains the capacity for producing roots well above ground level. Roots sometimes develop on the stem up to 1 m above ground but these normally dry out before reaching the soil.

In the mature palm thousands of primary roots spread rapidly from the bole. New primaries are continually replacing dead ones. A number of studies of the root system have been made (Yampolsky and Henry, 1924, 1948) and it has been shown that its vertical extent depends very largely on the presence or absence of a water table. Two extremes may be cited. In Malaysia, (Lambourne, 1935)
studied the roots of 11-year-old palms growing in soil where the water table was as high as 1 m from the surface in dry weather. In these circumstances no primaries penetrated below this depth and the majority of roots were in the surface 45 cm. Individual primaries were found to a distance of 19 m from the stem and absorbing portions of roots were found at all intermediate distances. In contrast, (Vine and Purvis, 1945, 1956) examined root systems in free-draining sandy soils and found that primary roots may descend to great depths; it is this unimpeded root system which will now be described.

Primary roots extend either downwards from the base of the palm or radically in a more or less horizontal direction. The descending primaries, which proceed directly from under the base of the palm are fewer in number than the radiating primaries and carry much fewer secondaries. (Ruer, 1967) has shown that these descending roots are for anchorage and play little or no part in the absorption of water.

The anatomy of palm roots is described by (Tomlinson, 1970) and that of the oil palm in particular has been studied by (Purvis, 1957). The primary root consists of an outer epidermis and lignified
hypodermis surrounding a cortex in which well-developed air lacunae are to be found. Within the cortex lies the central stele or vascular cylinder consisting of the surrounding lignified endodermis, the inner vascular strands of xylem and phloem and the pith or medulla which rapidly lignifies in old roots. The stele also contains lacunae. The secondary and tertiary roots have essentially the same structure as the primary roots. The un lignified tips of the growing primary, secondary and tertiary roots measure 3-4, 5-6 and 2-3 cm respectively. The quaternary roots are only 1-3 cm long, are produced in large numbers and are almost wholly un lignified. There are no root hairs and it is therefore reasonable to suppose that quaternary roots play the main part in the absorption of nutrients.

(Moreau, 1945) has studied in some detail the lignification of oil palm roots and the anatomy of production of the substituting roots which are formed when a seedling root is damaged or affected by disease. Such roots appear from just behind the point of damage or zone of disease and proceed in the same direction as the original root.

The roots of E. guineensis (and other palms) are characterized by the presence of pneumathodes. These, although appearing on both
underground and aerial roots, have been supposed to ventilate the underground roots: direct physiological evidence for this is lacking. (Yampolsky, 1924) found more pneumathodes on aerial than on underground roots in Sumatra, but the reverse is the case in West Africa. Moreover, they are commonest on seedlings grown in glasshouses or wherever the root system has been kept under water or in very moist conditions.

In pneumathode-forming root shoots the epidermis and hypodermis rupture and the stele and cortex extrude. The latter then proliferates and its parenchymatous cells become suberised or, if the pneumathode is aerial or subjected to dry conditions, lignified. If the growing point is unharmed after the rupture of the epidermis it remains attached as a cap and sometimes a normal root may develop again.

The firm anchorage of the adult palm is not only due to the descending primary roots. The old roots are strong and elastic and persist in the soil long after they have died. When death of a root occurs the cortex degenerates leaving a tubular hypodermis with cortical fibres and the woody stele loose within (Hartley, 1977).
The female inflorescence and flower

The female inflorescence reaches a length of 30 cm or more before opening. The female spikelets are thick and fleshy and develop in the axil of a spinous bract. The flowers are arranged spirally around the rachis of the spikelet; each is housed in a shallow cavity and subtended by a bract which is drawn up into a spine. At the end of the spikelet there is a spine of very variable length. The number of flowers in an inflorescence varies from palm to palm but in all cases there is a much larger number (twelve to thirty) on the central spikelets than on the lower or upper spikelets (twelve or less). The inflorescences will thus contain several thousand flowers (C. W. S. Hartley, 1977).

The male inflorescence and flower

The male inflorescence is borne on a longer peduncle than that of the female inflorescence and contains long finger-like cylindrical spikelets. It is not spiny. The spikelet has bracts and terminal projections but these are much reduced in size. Spikelets measure between 10 and 20 cm in length (C. W. S. Hartley, 1977).
A spikelet or finger of average size will have between 700 and 1,200 male flowers which are much shorter than the female flowers. Before opening, the sessile flower is completely enclosed in a triangular bract; it consists of a perianth of six minute segments, a tubular androecium with six, or rarely seven, anthers, and a rudimentary gynaecium with three projections corresponding to the trilobed stigma. Flowers begin to open from the base of the spikelet.

**The fruit and fruit bunch**

The fruit is a sessile drupe varying in shape from nearly spherical to ovoid or elongated and bulging somewhat at the top. In length it varies from about 2 to more than 5 cm, in weight from 3 g to over 30 g. The Deli fruit of the Far East are usually considerably larger than the fruit of Africa, though contrary to general belief fruit as large as Deli fruit are not uncommonly encountered in Africa (White More, 1973).

The *pericarp* of the fruit consists of the outer *exocarp* or skin, the *mesocarp* or pulp and the *endocarp* or shell. When measuring the pulp, the exocarp is included with the mesocarp. The endocarp together with the kernel forms the seed (Vaughug, 1970).
In external appearance the fruit varies considerably, particularly when ripening. Moreover, the exocarp of the external fruit tends to be more pigmented than that of the internal fruit. By far the commonest type of fruit is deep violet to black at the apex and colourless at the base before ripening. Such fruit has been described as 'ordinary' or *nigrescens*. A relatively uncommon type is green before ripening, and this is called green-fruited or *virescens*. The latter changes at maturity to a light reddish-orange though the apex of the external fruit remains greenish. The frequency of the *virescens* type was found to be 50 in 10,000 bunches in a grove area in Nigeria and 72 in 10,000 in Angola (Corley, 1976).

The colour of the ordinary or *nigrescens* fruit varies to an appreciable extent on ripening and there is evidence that this is connected with carotene content. This colour difference in ripening was recognized at an early date by Chevaliers who gave the names *communis* to 'fruit entirely red when ripe or with a small black or brown halo at the tip' and *sempernigra* to 'fruit when ripe, black over the upper half but red at the base'. These differences are also recognized by some of the peoples in West Africa where different vernacular names are allotted to them (e.g. Abepa and Abetuntum in
the Fanti and Twi languages of Ghana). The names *rubro-nigrescens* and *rutilo-nigresceiis* have been proposed by (Purvis, 1952), the former fruit, when ripe, are defined as 'Cap - 00918, Garnet brown, sometimes tending to be darker, rarely extending over half the fruit; Base -713, Indian orange, colour uniform to the base'. *Rutilo-nigrescens* is defined as 'Cap - Black, though it may show a brownish tinge at the edges, usually covering more than half the fruit; base - colour not constant, tending to lighten towards base, the deepest being 13, Saturn Red'. The colours and colour numbers refer to the Wilson Horticultural Colour Chart. Nevertheless it is not a simple matter to allot fruit with any certainty to one or other of these subtypes and fruit of intermediate appearance can invariably be found. Moreover, the cap colour is deceptive; there are no real black caps since even the darkest when seen through transmitted light are reddish in colour.

The above description refers to (Thomas and Chan, 1970) the colour appearance of fruit commonly or occasionally found in palm groves and plantations. There is, however, a much more fundamental colour variation due to presence or absence of carotenoids. The *albescens* fruit, characterized by 'absence' of carotene in the mesocarp, is
extremely rare. Actually, this fruit does contain a very small quantity of carotene. It was first noted in Ghana, under the name Abefita, but was later named *albescens* by (Beccari, 1953). It has been subsequently found in Zaire, Angola, Nigeria, the ivory Coast and other parts of Africa. in Angola the frequency was found to be only 3 in 10,000 and it may be rarer in other parts of Africa.

*Albescens* fruit may be of *nigrescens* or *virescens* type. In Zaire the fruits are referred to as *albo-nigrescens* and *albo-virescens*. The difference is only in the cap of the fruit, the former's cap being dark brown to black in appearance, the latter's green. The rest of the fruit is ivory coloured, ripening pale yellow. Only a very few *albo-virescens* palms have been found. *Nigrescens* and *virescens* fruit contain varying quantities of carotenoids in the mesocarp. Exterior fruit may have as much as twice the carotene content of interior fruit.

In internal structure the most important differences are to be found in thickness of shell.

In 1935 Smith recorded that internal fruit form may therefore be described as being either:
(a) *Dura*: shell usually 2-8 mm thick though occasionally less, low to medium mesocarp content (35-55 per cent but sometimes, in the Deli *dura*, up to 65 per cent); no fibre ring;

(b) *Tenera*: shell 0.3-4 mm thick, medium to high mesocarp content (60-96 per cent, but occasionally as low as 65 per cent); fibre ring; or

(c) *Pisifera*: shell-less.

**Production of DxP seeds**

In the process of production of DxP seeds normally, not more than one inflorescence on a palm will anthesize at any one time, so self-pollination is comparatively rare. The oil palm is therefore, functionally cross-pollinated. Each inflorescence is a compound spike or spadix carried on a stout peduncle or stalk. About 200 spikelets are spirally arranged on the central stalk. An inner and outer spathe or bract tightly enclosed the inflorescence until about a month after it has fully emerged above the base of the frond petiole. About six weeks before anthesis, the outer spathe begins to open. The number of spikelets is roughly the same for both sexes but the number of flowers per spikelet is many times greater in the female
inflorescence, being 700-1200, as compared with 5-30 in the male inflorescence.

In controlled pollination, while complete isolation can be routinely achieved when correct methods are adhered to, the problem of self-pollination sometimes remains. All flowers are bisexual in origin, but either the male or the female part remains rudimentary. Two males accompany each female flower. The males are vestigial and dysfunctional in the female while the reverse happens in the male inflorescence. Occasionally, but very rarely, persistent male flowers on either side of the sessile female flower may develop to maturity. Such flowers, especially those located on the lower part of spikelets and inflorescence produce pollen, causing severe damage in seed production due to self-fertilization. To reduce such risks, besides careful observation of female inflorescences of potential mother palms, it is recommended that the first few inflorescences of such palms be used for dummy pollinations to detect the phenomenon (Rao and Kushairi, 1999). If fruits develop from the dummy pollinations, the palms are immediately discarded.

The most important requirement in seed production being that extreme care must be exercised to prevent contamination by
illegitimate pollen source. This precaution has become even more crucial with the introduction of the pollinating weevil, *Elaeidobius kamerunicus*, into Malaysia. Prior to the introduction of the pollinating weevil, neither growers nor producers were alert to the problem, though *dura* contamination levels were noteworthy (Rao and Kushairi, 1999). (Chin, 1994) described the necessary quality control measures that should be followed during crossings. In addition, the MS157 has drawn the minimum requirements in control pollination for the production of DxP seeds. Despite all the precautionary measure, there is however, bound to be slip-ups in the controlled crossings, as implied by the MS 157 requirement of 95% purity. A census of planting materials in 1998 suggests that the level of *dura* contamination was less than 1%. However, Agency G had 6.03% *dura* contamination from a total of 2853 palms, which exceeds the 5% permissible contamination limit of the MS157 Standard. The agency had been informed and the necessary corrective measures had since then been improved.

On the practical aspects of controlled pollination, data collection, evaluation and selection in oil palm breeding trials is a long process, 10 years per cycle. In all instances, by the time the palms are
selected, they have grown to an appreciable height, and palms of 10m are quite common in crossing programmes. Generally, selected pisifera palms are taller than the duras because the former awaits the progeny test results, namely, another generation of evaluation. The dura parents are selected based on their own merits. Inflorescences on tall palms are not easily accessible without the use of ladders. Further, for safety reasons, field workers (pollinators) are grouped in pairs and they are equipped with climbing gear. The pollinators routinely scout for male inflorescences on selected pisifera palm that would anthesize in the next five to seven days. Experienced workers and supervisors usually correctly judge the timing. Upon locating a suitable inflorescence, the palm is climbed and the surrounding fronds are bent downwards and other inflorescences or bunches in the vicinity, obstructing the bagging process, are removed for access. The fronds are bent using jacks or alternatively by cutting a groove at the bottom of the petiole and applying pressure by standing and jerking the frond. The fibres and spines of the subtending petioles are discharged, the bracts removed and the inflorescence cleaned off debris, dirt, etc. cleaned off the inflorescence. The inflorescence is surface sterilized with disinfectant mist-sprays of 2% formalin
solution to kill any stray pollen and pollinating agents such as weevils, insects, thrips and earwigs. The male inflorescence is isolated in situ with a pollen collection bag.

The bag for controlled crossings is durable, usually 74cm x 86cm, and porous, to allow moisture evaporation. It has a celluloid or plastic observation window, 16cm x 16cm at the front, and in another design, an additional window is located at the top rear end. Pollination bags have been made of many kinds of material, such as canvas, three-ply heavy-duty paper or tyrelene. There have been doubts on the quality of canvas bags, as pollinating weevils, *Elaeidobius kanierunicus* could penetrate through sewing on such bags. From accounts of the nationwide *dura* contamination caused by the weevil in 1983, most seed producers, including (MPOB) had resorted to using only quality tyrelene bag in seed production.

During the bagging process, the stalk at the bottom of the bag is wrapped round with a layer of rolled cotton wool dusted with insecticide, then secured with a strong fine wire, tightened with a pair of pliers. Insecticide impregnated cotton collars are used to prevent entry at this base and liquid insecticides were generally found more effective than traditional powder type (Rao and
Kushairi, 1992). The neat stout tying of the gathered base of the bag to the short stalk with thin gauge wire is a skillful exercise. This step is very crucial as improper tying enables pollinating insects and weevils to penetrate the bag. On the other hand, over tightening and damage in the form of nicks and gashes can influence successful growth of the bunch and seed growth (Rao and Kushairi, 1999). For palms where the stalk is especially short or if more working space is desired, then modified car jacks may be employed (Rao, 1986). Additional precautionary measures, such as covering the bagged inflorescence with galvanised wire to prevent rodent attack are sometimes adopted. The inflorescence is inspected within the first week following bagging to detect for evidence of intrusion, such as tears to the bag, and the presence of weevils and insects. In addition, the surveillance also serves to ascertain the time of anthesis. The male inflorescence comprises thousands of flowers that anthesize over a week. Male flowers begin to open from the base of the spikelets and all flowers in an inflorescence usually open within two days, but this may be prolonged to four days in rainy weather (Purseglove, 1988). Most of the pollen is shed during the two to three days following the start of anthesis and production ceases.
within five days. Viability of late-produced pollen is usually low. Pollen is shed principally in the afternoon and shedding is reduced during rain. Anthesizing male flowers are aniseed-scented. The smell attracts weevils and insects, during which period the pollen is most vulnerable to contamination caused by these agents. In quality control, an inflorescence is discarded whenever there are infringements such as torn bags, or uncertainty about the quality of pollen.

A large male inflorescence on a mature palm produces some 20g-45g pollen, averaging 30g. An inflorescence with 100g had been harvested from an AVROS pisifera palm. Male inflorescence is harvested together with the bag after 80%-90% of the flowers have anthesized. The remaining flowers are expected to open during the drying process in the laboratory. All weevils and insects found outside the bag, whether dead or alive, are removed by tapping the bag. Harvested inflorescence, still securely enclosed in the bag, is brought to the laboratory for processing, and further inspected for possible contamination. A 2% formalin solution is spayed all over the bag to ensure any undetected weevils, insects and stray pollen are killed. The bag is left to air-dry, followed by another inspection.
through the observation windows. The inflorescence still contained in the bag is then placed in an oven or heating room (germinator) at 38°C-40°C for 24hr for preliminary drying of the pollen. Upon completion, the bag is repeatedly shaken to release the pollen from the florets. Inspection of bags, inflorescence and floral debris for defective isolation is a routine quality control procedure. While these procedures are carried out in an open space, the transfer of pollen from the pollination bag to an envelope is done in a confined, pollenfree environment.

Within the controlled environment of the pollen processing room, a top corner of the bag is cut after being disinfected with industrial grade methylated spirits. (Chin, 1995) has reported that the use of laminar flows provides good safeguards. The pollen is poured into a 150pm brass-sieve under a laminar flow, or in other laboratories, the process is carried out within an enclosed bench chamber with two inwards subtending gloves. While sieving, particular attention is paid in detecting pollinating agents among the debris caught on the sieve; should such agents be found, the pollen is immediately discarded. The empty inflorescences may even be incubated to allow birth of weevils if it is suspected that isolation has been ineffective
and visiting weevils have escaped (Rao and Kushairi, 1999). Contaminant-free pollen is poured into an envelope, followed with a second 24-hour oven drying at 38°C-40°C. The pollen is packed in air-tight or in vacuum packed vials with the date of harvest, palm number (pedigree) and fruit type properly labelled, then stored in a deep freezer at 3°C.

Between processing different batches of pollen, the room or chamber and utensils in the laboratory are disinfected with formalin to kill all atmospheric pollen that might have escaped from the previous transfer. Ideally, pollen viability should be determined at regular internals. However, for practical reasons, viability tests are usually carried out before storage and prior to pollination to ensure that only good pollen is used. Pollen are usually tested for viability on maltose agar medium or 10% sucrose solution at ambient temperature for 24hr and examined under a microscope. Fresh pollen has a viability of 70%-90%. Pollen in air-tight vials can be kept for six months without a significant loss in viability. Occasionally, a viability of 60% is maintained even after one year of storage. It is advisable not to use pollen of below 50% viability as this may result in poor fruit set, seeds of low germination rate and low vigour of nursery
seedlings. However, pollen germination on stigmas is better than on artificial medium, and good fruit set may still be obtained when the pollen viability in the laboratory is as low as 10% (Brockmans, 1957).

For controlled pollination, a pair of pollinators will locate female inflorescences on selected dura palms, 7-10 days before the stigmas become receptive. The female inflorescence is bagged in a similar procedure to that of the male. However, the female inflorescence is not harvested until it becomes a ripe bunch. The objective of isolating the inflorescence is to prevent entry of pollen especially via insect pollinators some quite microscopic, so that pollination with selected *pisifera* pollen can be achieved. Before the actual pollination, a supervisor will make at least one round of quality inspection. Only inflorescences that pass the quality inspection are pollinated with selected *pisifera* pollen mixed with tale in a 1: 10 ratio by weight. For monitoring, the names of pollinators, date of pollination and palm numbers of the dura and *pisifera* are recorded. A second round of inspection is carried out a few days after pollination. As with the anthesizing male inflorescence, the female
inflorescence is aniseed-scented, during this time it is most vulnerable to contamination by visiting weevils and insects.

As with the male inflorescence, the flowers in a female inflorescence do not all anthesize at the same time, but over a period of about a week. Anthesis begins from the base of the inflorescence. Female flowers remain receptive for 36-48hr. during which time the stigma lobes are well separated, secrete moisture and remain pink. The second day of anthesis is the most suitable for pollination with about 82% of the flowers receptive. Pollination is done with extreme care, imposing high quality control measures in accordance with the MS157 Standards. Before pollination, 2% formalin is thoroughly mist sprayed on the bag to kill stray pollen and other possible contamination agents. A single small opening, merely large enough for the nozzle of the pollen puffer to enter, is made at the observation window with a pre-sterilized budding knife. The nozzle is disinfected with formalin spray before insertion through the opening. The pollen-talc mixture is puffed in, onto the receptive flowers. The opening is then sealed with a high quality adhesive tape and the bag repeatedly shaken for thorough pollen dispersal. Sometimes pollination is carried out on 2-3 successive days for
maximum fertilization, though this may be unnecessary as pollen falling on the stigma as long as six days before it becomes receptive is still capable of effecting a good fruit set (Purseglove, 1988). At two days after anthesis, the stigma changes from pink to red and is no longer receptive (Hartley, 1988). Within the first week of pollination, a round of quality inspection is carried out. A single pollination will yield about 200 to 3000 fruits depending on age of the palm. Older palms give better fruit set. A palm therefore, may produce up to 20 000 seeds/yr. The pollination bags may be removed four weeks after pollination, by which time the stigma has long withered and turned black.

In addition to the standard quality control measures. dummy crosses are carried out to monitor the standards of bagging and pollination. Dummy crosses are performed once a month, without knowledge of the pollinators. Two methods are employed, first, bagging the female inflorescence in accordance with the prescribed standards, but instead of pollinating the inflorescence, it is left to development without pollination. This tests the quality of bagging. Second, and of greater importance, is the supply of dead pollen (after oven drying at 105'C for 24hr) or pure talc for the normal pollination. Discrepancies
in the quality control measures in both the dummy crosses are detected if fertile fruits develop.

Occasionally, pollinated inflorescences fail to develop to maturity, with all the hard work of pollination gone to waste. This bunch failure and its incidence is usually higher in periods of high sex-ratio or when a large number of bunches are developing (Purseglove, 1988). Pollinated bunches are harvested fully ripe with one loose fruit detached, or, alternatively, as soon as there is sign of ripening. Harvesting of over ripe bunches is avoided as the loose fruits may get mixed up with other fruits on the ground. Generally, fruit bunches ripen approximately five to six months after pollination. Although at just 15 weeks after fertilization, the embryos are fully developed and can germinate normally, harvesting at this stage produces 'white seeds' which are not preferred by planters.

7. Pests and Diseases of Oil palms:

1) Bag worms – metisa plana, pterma pendula (Mohd Basri and Norman Kamarudin, 2000)

2) Nettle caterpillar

Darna trima

Setora nitens
Dama diducta

Setothosea asigna

3) Rhinoceros Bettles:

Oryctes rhinoceros

4) Bunch moths tirathaba rufivena

5) Lockchafers:

Adoretus

Apogonia

Vertebrate pest of oil palm (Chung Gait Fee, 2000)

1) Rats

2) Squirrels

3) Porcupine

4) Morkeys

5) Wild pigs

6) Elements

7) Domestic livestock (cattle, goat, sheep).

8) Bird pests.

Major Diseases of oils palm (Ariffim Darus, 2000):

1) Vascular wilt

2) Basal stem rot
3) Bud and spear rot
4) Red ring disease
5) Sudden wilt

**Diseases:**

It will be most convenient to deal with diseases according to the stage of growth at which the palm is attached and the organs affected.

**Germinating seeds** (Ariffim Darus, 1998):

Brown germ cause: Aspergillus sp.

Distribution: this disease is common in Africa.

Symptoms: Brown spots appear on the emerging bottom. These spread and coaksce as the embryo develops, and the tissue becomes slimy and rotten.

Control: The fungus grows best under moist conditions at a temp. of 38°-40°C. Use of the wet heat treatment for germination, therefore encourages its development and spread. Though sanitary measures in the germination may reduce incidence, the best method of control is to adopt the dry heat treatment of germination.
8. Uses of Oil Palm:

FOOD USES:

Nutritional effects of palm oil

General nutritional properties

Palm oil has a rather unique fatty acid composition with 45% saturates (40% palmitic, 5% stearic) 43% monounsaturated oleic acid and 11% polyunsaturated linoleic acid (Table 1). This oil, like other vegetable oils is cholesterol free (Table 2). Palm oil has been consumed by man for more than 5000 years" as a food component in the diet. Its digestion and absorption rates in the human body are in excess of 97% and very similar to other common edible oils and fats. In many communities palm oil is a concentrated source of dietary energy and provides sufficient quantities of the essential fatty acid, linoleic acid (182, n-6) for normal healthy metabolic functions.

Vitamin E In Palm Oil:

Palm oil, both crude and refined, is a rich source of Vitamin E.

Non-food uses:
Soap Making

One of the most major non-food applications for palm oil/palm oil products is still in the production of soaps. Basically, there are 3 main soap making processes. Soaps could be produced industrially and directly from oils/fats through saponification process of oils/fats. This can be carried either batch-wise in kettles or via a continuous process.

The other two processes are (a) neutralisation of fatty acids and (b) saponification of methyl esters of fatty acids:- These processes will be described in the subsequent sections.

Epoxidised Palm Oil/Palm Oil Products (Epop)

Epoxidized palm oil and palm oil products (EPOP) can be produced by reacting palm oil, palm stearin or palm olein with peracids. Preformed peroxyacetic and peroxymalonic acids, as well as peroxyacetic acid and peroxyformic acid generated in situ were studied in PORIM to find suitable methods for the production of EPOP. The best procedures were found to be preformed peroxyacetic acid and peroxyformic acid generated in situ.
Epoxidized oils, especially epoxidized soyabean oil (ESBO), are used extensively as plasticizers and stabilizers for plastics, particularly polyvinylchloride (PVC). A plasticizer increases the workability of a plastic while a stabilizer reduces the rate of degradation of a plastic by heat, light or microorganisms. Epoxidized oils can fulfill both functions, and their compatibility with a plastic increases with their epoxide content.

Because palm oil and its products have lower iodine values, the epoxide contents of EPOP are lower than that of epoxidized soyabean oil. As plasticizers or stabilizers, EPOP are therefore not expected to perform better than ESBO, but their performance could be made comparable by slight modifications of the formulations.

PVC jungle and rain boots plasticized and/or stabilized with EPOP have been produced which are comparable in performance to those plasticized and/or stabilized with ES30. EPOP were also found to be a good rubber processing agent especially in providing external lubrication.

Use Of Palm Oil As Motor Fuel
The possibility to use vegetable oils for motor fuel was demonstrated already in the early part of the century by Rudolf Diesel. In this connection, PORT-m has also successfully experimented on cars fitted with Elsbett vegetable fuel engine and crude palm oil (CPO) has been used as the vegetable fuel in the studies. The experimental cars has been running for over 100,000 km with no technical problems. One of the advantages of using palm oil as motor fuel is that the handling of this fuel is safer and requires no stringent safer precautions.

**Printing Ink**

The four major materials for an ink are solvent, resin, pigment and additives. The amount of these ingredients required depend on the type of ink to be produced. The research results of PORIM and a local multinational ink manufacturer shows that palm oil based ink has a better tack and print stability over that of the conventional petroleum ink. The colour of the printed image is also brighter and cleaner. Table 2 shows the performance comparison between the two types of inks. Currently, the manufacturer is producing the ink commercially and supply the inks to several publishers.
**Engineering Thermoplastics**

Nylon-9 is a new nylon polymer and is a potential engineering thermoplastics. It can be made from any vegetable oil having fatty acids with unsaturation in the 9,10 position.

This particularly favours palm oil since palm oil has about 40% of the oleic acid. Nylon-9 absorbs less moisture than nylon-6 and subsequently has better dimensional stability and dielectric properties under moist environment. Its other properties are comparable with nylon-6.
Chapter III

Experimental Work

The Study Area and Methodology:

One hectares area for this experiment was selected at Soba Nursery. The nursery belongs to the Forests National Corporation (FNC) at Soba south east of Khartoum in semi-desert region with rainfall below 100 mm and temperature range between 20-46°C. The irrigation system in the nursery followed two systems namely; flood irrigation and hand watering by cans with fine nozzles.

A total of 2000 pregerminated seeds of *E. guineensis* (Dura), which represented the second patch from Malaysia (May 1998), were sown in 50x40 cm (50%) and 10x20 cm (50%) polythene bags. Highly fertile silt soil was used as a potting medium. Plants were subjected to the following treatments in the nursery:

1) Four levels of shading under trees namely: 25, 50, 75 and 100%.
2) Two types of potting soil volume expressed as two different sizes of polythene bags (10x20 and 50x40 cm) and that makes 0.002 and 0.063 m³ of soil, respectively.

3) Two levels of watering namely; daily and three times/week

4) The experimental design:

1. Random block design

2. The one hectare divided into 8 blocks each 10x2m.

3. The block divided into sub-block each 5x2m²

4. The number of pregerminated seedling of *E. guineensis* for each block was 150 seedlings

5. Each sub-block contain 75 seedlings.

Shoot and root length, shoot and root weight, number of leaves and leaf area and seedling diameter were measured at the base of the seedlings on monthly basis for twelve months. Shoot and root length were measured by a ruler in cm. Shoot and root were weighed using an analytical balance. Dry shoot and root weight were determined on oven dry basis. Leaf area was measured by multiplying the maximum leaf length by its width and then multiplied by a factor (0.5) according to PORIM (Palm Oil Research Institute of Malaysia).
Data was analyzed using a computer SAS package.
Results

A) The Effect of Shade on Growth:

1- The Effect of Shade on Shoot length

A significant positive correlation \((r=0.99)\) was recorded between shade intensity and shoot length Table (1) and Fig. (1). Shoot length was maximum at 100% shade, whereas it was minimum at 25% shade intensity table (2).

2- The effect of shade on root length:

A significant \((p=0.04)\) was recorded between shade density and root length (Table 3). Maximum root length occur at shade intensity (50%) Table (4).

3- The effect of shade on shoot weight:

Similarly a significant correlation \((r=0.89)\) was recorded between shade intensity and shoot weight. Shoot weight was maximum at shade intensity 100%, when it was minimum at 25% shade intensity (Fig. 2).
4- **The effect of shade on root weight:**

A significant correlation ($r=0.73$) was recorded between shade intensity and shoot weight. Shoot weight was maximum at shade intensity 75%, when it was minimum at 25% shade intensity (Fig. 3).

5- **The Effect of Shade on seedling diameter**

Similarly a significant correlation ($r=0.52$) was recorded between shade intensity and seedling diameter, though it was comparatively less significant as compared to the impact on shoot length. However, at 100% shade seedling diameter started to drop indicating that the best shade intensity was 75%. Fig. (4).

6- **The Effect of Shade on number of leaves produced.**

As shade intensity increases, leaf area increases and this correlation was significant ($r=0.81$). Nevertheless, at 100% shade, leaf area dropped slightly, which implies that maximum leaf area, occurred at 75% shade. Fig. (5)
The effect of watering and polythene bag size on:

1. **Shoot length and root length:**

   Watering interval and the size of the polythene bag significantly affected shoot and root length. The maximum shoot length was recorded in seedlings which were irrigated daily and grown in large bags (131.4 and 108.3 cm, respectively) (Tables 4). However, significantly less shoot length was recorded in seedlings which received less watering and were grown in smaller bags (73.8 and 82.5 cm, respectively). The maximum root length occurred in seedlings which were grown in big bags regardless of the frequency of watering (68.6 cm and 68.3 cm in less frequently and daily irrigated seedlings, respectively) (Table 6), whereas significantly less root length occurred in seedlings grown in smaller bags irrespective of the watering interval (18.6 cm and 13.5 cm, respectively) (Table 6).

2. **Fresh and dry shoot weight:**

   Fresh and dry shoot weight were significantly affected by watering frequency and bag size (Table 7). Maximum shoot fresh weight occurred in daily and less frequently irrigated seedlings in larger bags (297.1 and 239.6 g, respectively). Nevertheless, seedlings
grown in smaller bags attained much less shoot fresh weight irrespective of the frequency of watering (31.2 and 26.6 g, respectively) (Table 7).

A similar trend was recorded for dry shoot weight where maximum values occurred in seedlings grown in big bags regardless of the watering frequency (172.7 and 138.8 g for daily and less frequently irrigated seedlings, respectively) (Table 8).

3. Fresh and dry root weight:

Fresh and dry root weight were significantly affected by watering frequency and bag size (Tables 9 and 10). Maximum root fresh weight occurred in seedlings grown in larger bags irrespective of the watering frequency (57.9 and 57.0 g, respectively). Nevertheless, seedlings grown in smaller bags attained much less root fresh weight irrespective of the frequency of watering (0.6 and 2.0 g, respectively) (Table 9). A similar trend was recorded for dry root weight where maximum values occurred in seedlings grown in big bags regardless of the watering frequency (40.9 g and 35.8 g for daily and less frequently irrigated seedlings, respectively) (Table 10).
4- The effect polythene bag size on leaf area:

The size of the polythene bag (soil volume) significantly affected leaf area of seedlings (Table 7). Mean leaf area was significantly greater (386.0 cm²) in seedlings grown in bigger bags as compared to those in smaller bags (36.4 cm²).

5- The effect of dry root weight and dry shoot weight ratio:

The growth of shoot to root ratio is highly significant (p=0.0001) and the R square is 82% (Table 13, 14).

6- The effect of shade on number of leaves produced:

The number of leave was remained the same at the nursery stage within 12 month (Table 12).
Table (1) The effect of shade on shoot length of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Source</th>
<th>Shoot Length</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>7</td>
<td>5187.4</td>
<td>741.05654</td>
<td>19.22</td>
<td>0.0503</td>
</tr>
<tr>
<td>Error</td>
<td>2</td>
<td>77.1</td>
<td>38.55492</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table (2) Maximum shoot length at shade 100% of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Mean</th>
<th>N</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>113.5 a</td>
<td>5</td>
<td>Daily water</td>
</tr>
<tr>
<td>96.4 b</td>
<td>5</td>
<td>Water three times/week</td>
</tr>
</tbody>
</table>
Table (3) The effect of shade on root length of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Source</th>
<th>Root Length</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>7</td>
<td>6496.0</td>
<td>928.01112</td>
<td>21.92</td>
<td>0.0443</td>
</tr>
<tr>
<td>Error</td>
<td>2</td>
<td>84.7</td>
<td>42.3301</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table (4) Maximum root length occurs at shade 50% of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Mean</th>
<th>N</th>
<th>Shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.1a</td>
<td>2</td>
<td>Par5</td>
</tr>
<tr>
<td>43.8b</td>
<td>4</td>
<td>Full</td>
</tr>
<tr>
<td>42.0b</td>
<td>4</td>
<td>Par7</td>
</tr>
</tbody>
</table>

(Means with the same letters are not significant)
Table (5) The effect of water and polythene bags on shoot length of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Water</th>
<th>Polythene bag size</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily water</td>
<td>B1</td>
<td>131.4 a</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>B1</td>
<td>108.3 b</td>
</tr>
<tr>
<td>Daily water</td>
<td>B2</td>
<td>82.5 c</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>B2</td>
<td>73.9 c</td>
</tr>
</tbody>
</table>

*Means with the same letter are not significant.*
Table (6) The effect of water and polythene bags on root length of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Water</th>
<th>Polythene bag size</th>
<th>Root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water three times/week</td>
<td>Big size</td>
<td>68.6 a</td>
</tr>
<tr>
<td>Daily water</td>
<td>Big size</td>
<td>68.3 a</td>
</tr>
<tr>
<td>Daily water</td>
<td>Small size</td>
<td>18.6 b</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Small size</td>
<td>13.5 b</td>
</tr>
</tbody>
</table>
Table (7) The effect of water and polythene bags on fresh shoot weight of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Water</th>
<th>Polythene bag size</th>
<th>Shoot fresh Weight (gr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily water</td>
<td>Big size</td>
<td>297.1 a</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Big size</td>
<td>239.6 a</td>
</tr>
<tr>
<td>Daily water</td>
<td>Small size</td>
<td>31.3 b</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Small size</td>
<td>26.6 b</td>
</tr>
</tbody>
</table>
Table (8) The effect of water and polythene bags on dry shoot weight of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Water</th>
<th>Polythene bag size</th>
<th>Shoot dry weight (gr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily water</td>
<td>Big size</td>
<td>172.7 a</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Big size</td>
<td>138.8 b</td>
</tr>
<tr>
<td>Daily water</td>
<td>Small size</td>
<td>20.9 c</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Small size</td>
<td>17.2 c</td>
</tr>
</tbody>
</table>
Table (9) The effect of water and polythene bag size on root weight of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Water</th>
<th>Polythene bag size</th>
<th>Root Weight (gr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water three times/week</td>
<td>Big size</td>
<td>57.9 a</td>
</tr>
<tr>
<td>Daily water</td>
<td>Big size</td>
<td>57.0 a</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Small size</td>
<td>0.6 b</td>
</tr>
<tr>
<td>Daily water</td>
<td>Small size</td>
<td>-2.0 c</td>
</tr>
</tbody>
</table>
Table (10) The effect of water and polythene bag size on dry root weight of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Water</th>
<th>Polythene bag size</th>
<th>Root dry weight (gr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily water</td>
<td>Big size</td>
<td>40.9 a</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Big size</td>
<td>35.8 b</td>
</tr>
<tr>
<td>Water three times/week</td>
<td>Small size</td>
<td>0.9 c</td>
</tr>
<tr>
<td>Daily water</td>
<td>Small size</td>
<td>2.9 d</td>
</tr>
</tbody>
</table>
Table (11) The effect of polythene bag size on leaf-area of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Level of Polythene bag size</th>
<th>Leaf Area</th>
<th>Mean (cm²)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>7</td>
<td>386.003</td>
<td>256.25</td>
</tr>
<tr>
<td>Big size</td>
<td>6</td>
<td>36.360</td>
<td>12.88</td>
</tr>
<tr>
<td>Small size</td>
<td>6</td>
<td>36.360</td>
<td>12.88</td>
</tr>
</tbody>
</table>
Table (12) The effect of variables on leave number of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Mean</th>
<th>N</th>
<th>Shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5400a</td>
<td>2</td>
<td>par25</td>
</tr>
<tr>
<td>5.2250a</td>
<td>4</td>
<td>par5</td>
</tr>
<tr>
<td>4.4550a</td>
<td>4</td>
<td>full</td>
</tr>
<tr>
<td>4.4165a</td>
<td>4</td>
<td>par7</td>
</tr>
</tbody>
</table>

Means with the same letter are not significantly different.
Table (13) The difference between root and stem weight of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Mean square</th>
<th>F value</th>
<th>Pr&gt;f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>1</td>
<td>58225.97</td>
<td>92.43</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

The weight is highly significant difference at (P=0.0001) (r=0.82) in Sudan.
Table (14) The difference between stem weight and root weight of seedlings of *Elaeis guineensis* (twelve months after planting) grown at Soba Nursery.

<table>
<thead>
<tr>
<th>Mean</th>
<th>Number</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.70 a</td>
<td>11</td>
<td>Shoot weight</td>
</tr>
<tr>
<td>69.81 b</td>
<td>11</td>
<td>Root weight</td>
</tr>
</tbody>
</table>

The means with the same letter are not significantly different

R – square is = 82%
Fig. (1) The effect of shade on shoot length of seedlings of Elaeis guineensis (twelve months after planting) grown at Soba Nursery.
Fig. (2) the effect of shade on shoot weight of seedlings of Elaeis guineensis (twelve months after planting) grown at Soba Nursery.
Fig. (3) The effect of shade on root weight of seedlings of Elaeis guineensis (twelve months after planting) grown at Soba Nursery.
Fig. (4) The effect of shade on seedling diameter of seedlings of Elaeis guineensis (twelve months after planting) grown at Soba Nursery.
Fig. (5) The effect of shade on leaf area of seedlings of Elaeis guineensis (twelve months after planting) grown at Soba Nursery.
First patch of Malaysian oil palm seedling at South Kordofan

Second patch of Malaysian oil palm seedling at Soba Nursery (1 month age)

10 months age at Soba Nursery

Polythene bags size after 6 months

Oil palm seedling 1 month from South of Sudan (Juba)
Discussion

The present study investigated the suitability of the nursery conditions in Soba to the various growth characteristics measured namely; shoot length, root length, Leaf number, Leaf area and root and shoot fresh and dry weight of *E. quineensis* according to (Wormer, 1958 and MARDI, 1973).

Seedlings growth at 75% shade and daily watering with good drainage is the best. This result agrees with Rees (1963) and the findings of Oil Palm Genetic Laboratory (1968). They Stated that (The results showed that in plants which are not already adapted to shade i.e. not maintained under various levels of shade from germination, there was a reduction of net assimilation rate and relative growth rate and an increase in leaf area ratio with increasing shade). *E. guineensis* is a moisture loving crop, so its growth is better under adequate water supply with good drainage system. Henson and Elaeis (1996) mentioned that water supply is of the greatest importance for the growth of seedlings, whether in polybags or field nursery. Water shortage in the field or nursery is most
serious on light soils in the seasonal climate of West Africa. Watering is usually required at some periods in nurseries in all oil palm growing regions. With the advent of the polybags for nursery work, watering has become of even greater importance.

Using the bigger polybags size (50cmx40cm), in the present study, is the important factor for growth because the soil volume increases the growth and development of the root system. This is in agreement with Hew Chong, Kean and Tam Tai Kin (1969) who found that in Malaysian experiments, omitting the pre-nursery stage and planting germinated seeds directly into large polybags (50cmx38cm) gave more vigorous seedlings. This practice reduced both time and cost.

Bevan and Grey (1966), have set out the advantages and disadvantages of polybags and field nurseries, the polythene bag provide asite in asimple way regardless of the land condition i.e. fertile site or marginal site. Also using polythene bags assures independence from weather condition. All the silvicultural operations can be controlled e.g. weeding, root cutting, watering and disease control. With these advantages the study concluded that the
benefits of using polythene bags are more than those of the field nursery.

Total seedling dry weight recorded in the present study (295 g/plant) is higher than that recorded in Malaysia (258 g/plant) (El Ozer, 1999) for the same variety of oil palm for the same period of time despite the use of fertilizers in Malaysia. This indicates that the river silt used in the present study produced even more vigorous plants as compared to those produced in Malaysia where fertilizers are used.

The ratio of shoot dry weight to root dry weight recorded in the present study is the same as that in Malaysia using the same Malaysian pregerminated seeds for 12 months in the nursery despite non use of fertilizers in the present study. Also total dry weight is greater in the present study (295 g/plant) as compared to that of Malaysia (258 g/plant).

Most probably the increase in seedlings root length during the study was due to the increase of temperature at light intensity 50%. An increase in temperature might have increased evapotranspiration so
the seedlings developed longer roots to compensate for the loss of water.

Leaf number remained not significantly different at all levels of growth factors in the present study. This agrees with the findings of Hartly (1977) who mentioned that the number of leaves of *E. guineensis* remains the same at the nursery stage within 12 months.
Conclusion and Recommendations:

Conclusion:

Sudan can potentially be a palm oil producing country as the species occurs naturally in both north and Southern Sudan though it is occurrence is more prevalent in Southern Sudan because of higher rainfall.

Since this work proved that suitable seedlings of *elaeis guineenses* comparable to those produced in Malaysia could be produced in North Sudan form pregerminated seeds imported form Malaysia using river silt and without using fertilizers, as in the case in Malaysia, it is recommended that importation of pregermininated seeds of the species for raising in the nurseries be continued.

Also further socio-economic investigations will be carried out to set the stage for further economic development if feasible.

The indigenous species of oil palms in Southern Sudan in particular deserve special attention for further developments together with those introduced earlier in plantations, graves or as individual trees.
Particular attention is needed on diseases and marketing for various products that can be produced.

All these require continuous support for Sudan National Oil Palm Committee and the researches at universities and research organizations for more collaboration and cooperation for further development.
Recommendations:

1. Seedlings production programmes should be conducted.

2. Economic aspects e.g. cost of seedlings production, nurseries establishments cost and others labours costs should be investigated.

3. More protection measurements and studies should be carried out on diseases hazards at least nurseries stage.

4. Sudan National Oil Palm Committee (SNOPC) encroached either by researches or (NOPRI).

5. Reports and data for growing seedlings along Sudan should be collected and more study on growth in fields must be investigated.
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