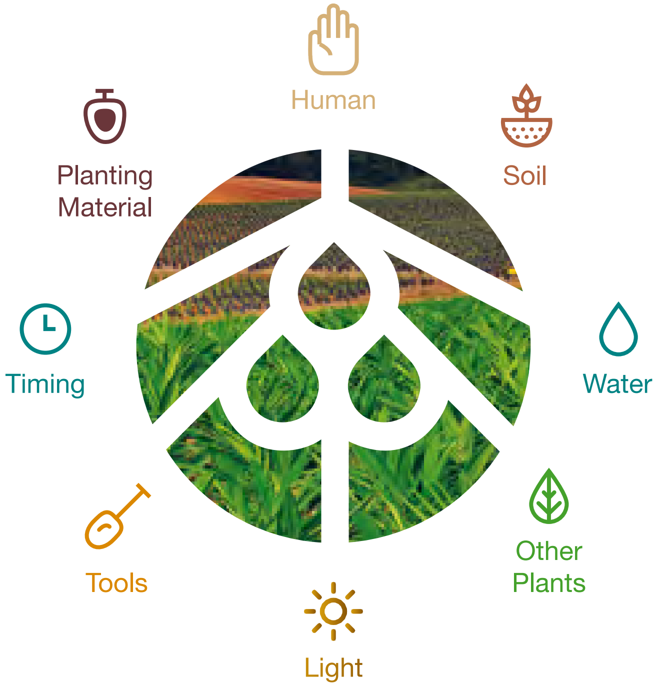
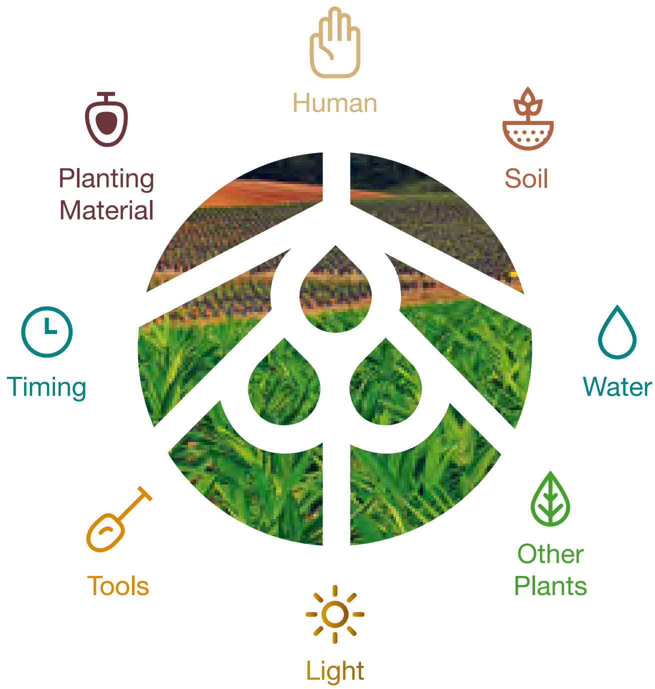


THE OIL PALM GROWER'S HANDBOOK

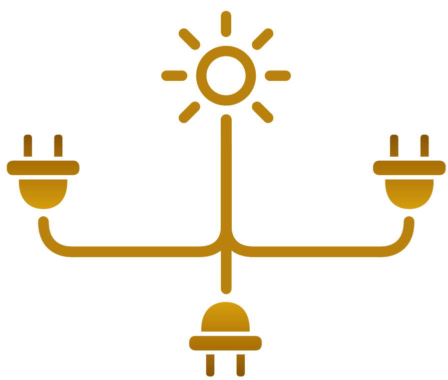
PALMELIT
OIL PALM SEEDS - CIRAD INSIDE



PALMELIT
OIL PALM SEEDS - CIRAD INSIDE

What drives life is a little electric current, kept up by the sunshine.

Albert SZENT-GYÖRGYI,
Nobel prize for medicine 1937



Over its lifetime, oil palm is one of the crops that generates most current" per unit area, from photosynthesis to oil: 5 to 10 times more oil per hectare than any other oil crop. This energy, in oil form, offers high nutritional value (vitamins, antioxidants, oleic fraction) and technological qualities (the naturally solid fraction is of interest to the agrifood industry).

The photosynthetic efficiency of the oil palm cannot be achieved without humans, who are ten times more numerous per unit area than for the production of soybean oil: an "oil palm" project is therefore first and foremost a human project, a job generating project, a project that is demanding in both skills and work quality, a project combining the sun, land and people.

These people are actively committed to producing seeds, managing prenurseries, nurseries and plantations, ensuring their upkeep and harvesting them... Their work is well rewarded, even on difficult soils.

Water is the "switch", and even the combustion agent, since every mm of rainfall gained over the water deficit generates much more than a linear response. Solar radiation feeds flow intensity, temperature modulates it.

Production is organized in a given space that obviously needs to be preserved, or even enhanced – even more over the long term (oil palm works well for those who persevere best, and rewards them most generously).

The "current" of each palm interferes with that of the other palms surrounding it, that of other plants or of the organic matter present in the soil and, more generally, the natural environment and farming practices, including fertilization.
Lastly, achieving this production calls for tools, equipment and containers.

The choice of seeds or seedlings is decisive. It governs:

- Bunch production potential and oil content in a given environment.
- The ability of the project to cope with some of the most serious diseases: *Ganoderma,* vascular wilt, Bud Rot.
- Oil quality (oil acidity is also linked to the planting material and can prove problematical if harvesting or the extraction unit is disorganized, especially during production peaks).
- The number of years that palms can easily be harvested (depending on their vertical growth rate) and the optimum number of palms per hectare (depending on their compactness).

During its productive cycle (around 25 years), a PalmElit-CIRAD® oil palm can produce:

- Over 5 tonnes of bunches and 1,300 kg of oil under optimum conditions (good agronomic practices, absence of serious disease or pest attacks, good quality soil and non-limiting climatic conditions).
- 1,700 kg of bunches and 400 kg of oil on a soil of intermediate quality, and with limiting rainfall (500 mm water deficit).

Seeds must be chosen with the greatest of care. There is a need to be very demanding of the research and production programme from which they come. It is then necessary to nurture the expression of their potential as much as possible for the duration of the project.
By buying from an approved retailer, you are sure to be purchasing seeds and seedlings displaying optimum genetic potential.

This handbook contains recommendations that help "**guarantee regular incomes for smallholders and agroindustries**". Such is PalmElit's commitment.

All **PalmElit-CIRAD®** seeds are produced under the scientific and technical supervision of **PalmElit**. Our stringent procedures guarantee growers 99.9% of *tenera* palms after proper culling in the prenursery and nursery.

For all you need to know about PalmElit-CIRAD® seeds,
check out our oil palm seeds catalogue
on line at:

www.palmelit.com

SUMMARY

Human Resources

An oil palm project is a human project that contributes to economic development in rural areas: it generates **1 full time job for every 10-20 ha** as opposed to a full-time job for every 200 ha in the case of soybean, for example.

As it also produces 5 to 10 times more oil per hectare than other oil crops, it is a particularly interesting solution for meeting the increasing demand arising from a growing population and from an increase in per capita consumption in emerging countries.

The human resources of an oil palm project may be family members or hired. Smallholdings are highly heterogeneous and it is important to offer them solutions adapted to their farming opportunities and constraints.

	Agribusiness	Family farms		
	Capitalist firms	Managerial firms	Family business	Family farms
Labour	Hired only		Mixed, presence of permanent hired labour	Family dominance, no permanent hired labour

Source: Marzin et al. (2015) and Rafflegeau et al. (2014) quoted by Oriane Plédran et al., 2016.

Based on one tonne of ripe selected oil palm bunches:

- A small-scale press can produce around 150 kg of red oil, but will require manual stripping; motorized small-scale presses mostly improve work productivity, but have little or no effect on extraction yield.
- A micro-mill processing fruits (not bunches) will produce around 200 kg of palm oil per tonne of manually stripped bunches.
- A mini-mill processing 1 to 4t/h of bunches, or an industrial mill processing 10 to 60t/h of bunches, will produce around 250 kg of palm and palm kernel oil.

The stakes involved in the choice of oil extraction unit are considerable, in terms of extraction yield, production capacity and labour requirements.


Sowing in the prenursery


Filling prenursery beds

Economy

Technical

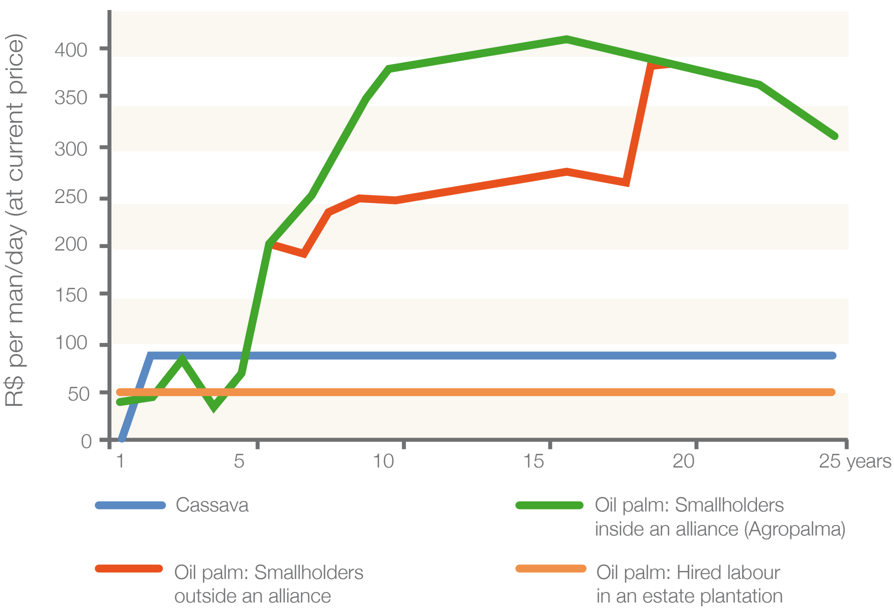
People

Investment in the most efficient oil mills, as regards extraction rates and production capacity, calls for substantial capital and maintenance skills. For instance, family businesses and family farms do not have direct access to this type of extraction unit, but they may engage in an equitable partnership between an investor owning an efficient oil mill and smallholders.

This is a very topical matter, and also the key to making an oil palm project a very fine human, technical and economic initiative.
In such partnerships, the investment made by industrialists is limited to the extraction units, while smallholders, who enter an alliance, invest their labour in setting up their oil palm plantations and benefit from greater returns on their work than a hired labourer in an estate plantation. Likewise, the alliance can provide easier access to bank loans and provide smallholders with technical support, which they might not have if they remained independent.
PalmElit supports such fair and equitable alliances and partnerships.

Figure 1 illustrates the advantage for smallholders of entering an alliance or setting up their own oil palm plantation. When farmers set up their oil palm plantations under an alliance, the benefit for them is clearly much greater.

Fig. 1 - Compared remuneration (Brazilian reals R$) of labour depending on its characteristics and the crop (Oil palm/Cassava) in the Brazilian Amazon (Brandão F and Schoneveld G. 2015).




Assessing nursery plants


Harvesting at the young age


Bunch collection

OIL PALM PEOPLE

"Oil palm" people must:

- Be fine observers of nature and take an interest in all stages of the crop:
  - seedlings and nursery plants, in order to select the best material leaving the prenursery and the nursery.
  - palms in the field, and the environment.
- Seek to understand, or contact a specialist to receive appropriate advice at the right time.
- Be continually focused on the ultimate goal, namely environment-friendly conversion of solar energy, water, labour and inputs into oil: pay careful attention to leaf area, supplies to the roots, pollination of female inflorescences, bunch ripeness, harvesting of all bunches.
- Be meticulous in their farming practices and in respecting recommendations, in the frequency of their interventions, any phytosanitary care.
- Be in good physical condition, as getting around the plantation, transporting plants and bunches and harvesting work are physically demanding.
- Engage in setting up sustainable and equitable partnerships with neighbouring growers, but also with extraction unit owners.
- Be able to "get through" the first five years of low productivity, which require financial and human investment.

Sowing in the prenursery

Planting out

Planting Material

Today, oil palm plantations mainly grow selected *Elaeis guineensis* palms of African origin, but on the American continent, a hybrid palm resulting from a cross between the African oil palm and the American oil palm, *Elaeis oleifera*, has come to the fore.

The main reason for the development of this *E. oleifera x E. guineensis* interspecific hybrid is that it is resistant to a disease, Bud Rot, which has wiped out tens of thousands of hectares of plantations in Latin America.

This hybrid also has much slower vertical growth than *Elaeis Guineensis*, and its oil is much more fluid and richer in olein.

Three forms of fruit are found in the *E. guineensis* species, which differ through the thickness of the shell surrounding their kernel.

The *dura* palm has fruits with a very thick shell, its oil extraction rate is low and its bunches are therefore downgraded by oil mills.

The *pisifera,* which does not have a shell, only very rarely produces bunches.

The *tenera* palm is a hybrid between the *dura* palm and the *pisifera* palm, selected for the shell thickness trait, and has a thin shell. For selected *tenera* palms, field and mill yields are high. Today, all professional *E. guineensis* oil palm plantations grow selected *tenera* palms.

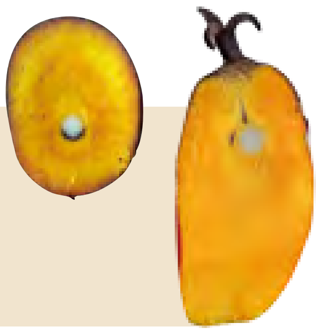
Comment: Seedlings picked up from the ground in a plantation of selected *tenera* palms, no matter how excellent, will only give around 50% *tenera* plants when replanted, along with 25% *dura* plants (hence less productive) and 25% *pisifera* plants (virtually unproductive), and there is no way of easily detecting *tenera* palms before harvesting begins (2 to 3 years after planting).

All in all, it needs to be remembered that such material obtained by open pollination will only produce 40% of the oil that selected palms would produce when grown under the same conditions.

DURA

Shell > 2 mm
Low extraction rate.
Oil mills pay less for FFB.

PISIFERA



No Shell
Usually ♀ sterile.
Only used for seed production as ♂ parent.

TENERA

Intermediate shell
Commercial seeds
Cross between pisifera and dura.
Good FFB production and good extraction rate.

cirad

seed

Commercial seeds are germinated seeds. They will have been obtained and sorted around a year after pollination of the female inflorescence from which they came. Strict protocols are applied to all the processes that seeds undergo before shipment, to guarantee their physiological qualities and good emergence in the nursery.

Before ordering:

- **Prepare to sow in the prenursery, or directly in the nursery, from 10 to 14 months before planting out in the field,** which it is essential to do at the start of the main rainy season (consult with our sales department to draw up an optimum schedule).

On arrival:

- **You must check the condition of the packaging and the seeds,** and immediately report any problems to the supplier, providing photos.
  For any delay in transport and any damage found, write your reservations on the airway bill, or on the last delivery slip, and obtain a statement of fact from the transporter.

After acceptance:

- **Transfer the seeds as quickly as possible.** All seeds should have ivory coloured sprouts. The plumules (whiter and glossier) and the radicles should be clearly differentiated (the radicles are usually between 8 and 15 mm long, unless otherwise requested by the client).
  Care should be taken to discard any seeds with broken sprouts or, more rarely, those with brown, wilted, atrophied or twisted sprouts.
- **Draw up a counting report, bearing the shipping reference, and enter the carefully counted number of seeds on the day they arrive and on the day they are sown** and, where applicable, note for each packing case the number of seeds with missing or broken sprouts, or with other abnormalities.
  If there is a problem, send the counting report to PalmElit or your supplier within ten days of the seed delivery.

Germinated seeds
in delivery packaging

Box of seeds

Germinated seeds

Culling prenursery seedlings and nursery plants is an important operation that will govern the plantation’s yield level throughout its working life.
Given the eliminations to be carried out, the following purchases per hectare are recommended:

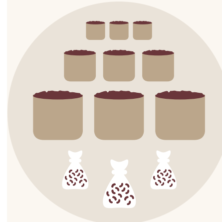
- For PalmElit-CIRAD® palms with reduced growth: 200 germinated seeds, to enable the transfer of 170 seedlings from the prenursery to the nursery and 143 plants from the nursery to the field (conventional density per hectare of plantation for PalmElit-CIRAD® palms), holding back 7 plants for replacements.
- For PalmElit-CIRAD® #C DExLM compact material, which can be planted at a density of 160 palms per hectare: 225 germinated seeds.
- For interspecific hybrids which are planted at 128 palms per hectare: 180 germinated seeds.

prenursery

Usually, the seedlings obtained are raised for 3-4 months in the prenursery, then transferred to the nursery. However, some plantations prefer to sow directly in the nursery, though this is a more technical method.

preparation

- **Have a prenursery logbook** in which all operations and events are registered in their slightest detail, from sowing to transferring seedlings to the nursery.
- **Identify each bed with a sign** indicating its number, sowing date, product name, planting material code and the number of seeds sown.
- **Fill the polybags with humus-bearing topsoil,** which can be mixed with compost (2/3 topsoil – 1/3 compost). Fill the bag to the brim, in 3 to 4 well-tamped layers, topping up the substrate in the bag if it falls below 2 to 3 cm from the brim.
- **The filled bags can be treated and weeded** before sowing, respecting the doses and times recommended for each active ingredient.



Plant

Identify

sowing

- **Sow as soon as possible** after filling the bags and placing them in the beds, with slightly moist substrate (otherwise water slightly). The filled bags can be treated and weeded before sowing, respecting the doses and times recommended for each active ingredient. Sow the seeds, grouping them by product and by PalmElit - CIRAD® code, as identified in the packing list accompanying the shipment, so that the prenursery is highly uniform, and so that it is easier to cull seedlings and nursery plants to ensure a very uniform plantation, starting out with healthy, vigorous palms.
- **To sow, make a 2 to 3 cm** deep hole in the substrate of each bag and place a seed in it, radicle downwards, cover with a maximum 1 cm of substrate; avoid placing the plumule at a slant (deformation of the seedling), burying the seed too deeply (cause of rot), placing too near the surface (desiccation and death) or breaking the sprouts.
- **Sow any seeds with several sprouts normally,** as seedlings arising from the same seed can be separated later, when transferred to the nursery.

watering and management

- **If there is an absence of rainfall while seedlings are being raised in the nursery,** they should be given the equivalent of 4 mm of irrigation water every two days (see the "Water" section). It is not necessary to provide fertilization in the prenursery when the substrate is of good quality, otherwise see the "Nutrients" section.

Transferring seeds to the prenursery

Prenursery ID sign

Direct nursery in Peru

monitoring seedling development

- Observe seedlings regularly and carefully. Act rapidly as soon as any deficiency, disease or pest symptoms appear (see "Nutrients" and "Pests & Diseases" sections).
- The first two leaves and adventitious roots form in the first month. A month after sowing, the first lanceolate leaf appears with parallel veins, along with the first primary root. At four months, the seedling has 3 to 4 leaves with a lanceolate lamina, each new leaf being longer than the previous one. The height of the plant –with stretched leaves– is 20 to 25 cm, the collar girth measures 4 cm, and the root system is well developed with primary, secondary and tertiary roots: at this stage, the seedling is ready for the nursery.

first cull: elimination of abnormal

- At the end of the prenursery, just before transfer to the nursery, destroy abnormal, poorly developed, stunted, or erect plants, those with fused laminas or with rolled and narrow leaves (often due to cultural defects): culling is carried out by bed assumed to contain uniform planting material, and by germinated seed sowing date, referring to the average for the seedlings (see also IRHO Advice Notes 325).

  The culling rate in the prenursery should normally be around 15%, dead plants included.

seedling transport

- It is important not to damage seedlings when transporting them to the nursery (water slightly before transport). Some growers use crates that can hold around fifteen polybags placed vertically to prevent the substrate from falling out.

1 phase nursery

direct sowing in the nursery

This method consists in sowing seeds directly in nursery polybags, skipping the prenursery stage, thereby gaining 1 to 1.5 months in rearing time. For 100 seeds, 90 are placed in nursery bags, 10 in prenursery bags (to replace any dead or early culled seedlings). Four to six rows of nursery bags are grouped side by side under shade, where they remain for the first two months, followed by the replacement of any dead or stunted plants before laying out the polybags in 70 cm x 70 cm equilateral triangles. The nursery is then managed like any conventional nursery.

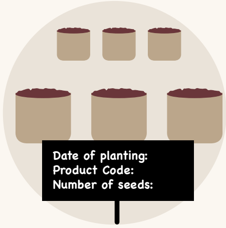

Young seedling to be culled (deformed)


Packing in crates for transport and transfer to the nursery

nursery

preparation

- **Have a nursery logbook** in which all operations and events are registered in their slightest detail, from seedling arrival to planting out.
- **Identify each bed with a sign** indicating its number, the transfer date, the name and code of the planting material, and the number of seedlings.
- **Take the substrate from a site near the nursery.** The substrate can also come from the site of a former nursery: one method consists in spreading empty bunches between the bags, which offers the advantage of keeping the bags upright, covering the soil (limiting erosion), limiting weed growth and providing good quality substrate one or two years later.
- **The filled bags can be treated and weeded** before sowing, respecting the doses and times recommended for each active ingredient.
- **It is worth sowing a legume cover crop in the alleys, or mulching them to cover the soil,** limit erosion and reduce the need to eliminate grasses that harbour the insect transmitting Blast disease (see "Pests & Diseases" section).



Identify

Make a hole
Transplant

transfer

- **Position the bags well upright** in a 70 cm x 70 cm equilateral triangle layout, top up the substrate and straighten the bags during weeding rounds. In the middle of the bags, make a hole slightly larger than the prenursery root ball, tear open the bottom of the prenursery bag and slide the seedling into the hole, add and carefully tamp down a little substrate around the root ball; the seedling collar should be level with the surface (see also the "Soil" section).
- **Divide any multiple seedlings.** Any surplus well-developed seedlings can used by transferring them, bare rooted, to large polybags (if that is not possible, eliminate the weakest of the seedlings with secateurs). Divided seedlings should be transferred to a specific bed to ensure they receive appropriate care where necessary.

monitoring seedling development

- **Observe seedlings regularly and carefully.** Act quickly as soon as any deficiency, disease or pest symptoms appear (see the "Nutrients" and "Pests & Diseases" sections).

Eight to ten months after arriving in the nursery, a normal seedling that is generally ready for planting out measures 0.6 to 1 m in height with a collar girth of 18 to 22 cm, and has seven to eight very dark green leaves with differentiated leaflets.

watering and management

- Make sure that the polybags are uniformly watered and that water requirements are well satisfied without excess (see "Water" section).

Fertilizer requirements depend on the age of the seedling and are described in the "Nutrients" section.

culling abnormal

- When the nursery is six to seven months old (any older than this and the size of the plants becomes a hindrance), the seedlings should undergo strict culling to ensure good uniformity in the plantation.
  Diseased plants, chlorotic plants, plants severely attacked by insects (*Oryctes* or dynastid beetles) or fungal diseases, stunted plants, or plants with an abnormal morphology (fused leaflets, inserted at an acute angle, short, narrow, too far apart), but also plants that have developed more than the average, should be culled.
  Culling should take place in a single round, and the culled plants destroyed. For easier culling, it is essential that seedlings of the same planting material, arising from the same transfer date, be grouped in clearly identified beds.

The culling rate in the nursery is generally 15%, including dead plants. Culling seedlings has a major effect on plantation yields: abnormal plants may give yields ranging from 0 (no yields) to 30% of normal palm yields (see also IRHO Advice Note 164).

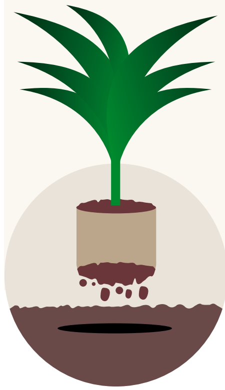
Double seedlings in the prenursery, usable after division

Abnormal plant to be culled (stunted, fused leaflets)

plantation

planting out

Plant out



- It is essential to plant out at the start of the main rainy season.
- Either mechanically, or by hand, dig a hole that is slightly larger than the nursery polybags.
- Transport the bags taking the necessary care to avoid unearthing the seedlings or damaging leaflets.
- Check the depth of each hole with a gauge so that, once in the ground, the top of the root ball is in line with the soil surface, as the collar of the seedling should be at ground level or only slightly above it at the most. If there are any risks of rodent attacks, it may be wise to surround the seedlings with a wire guard (0.50 m x 0.35 m) which will rest against the root ball.
- A basal dressing can be applied directly in the planting hole (see the "Nutrients" section, table 1).
- Cut away the bottom of the bag and slide the bag into the hole, then remove it by pulling it upwards.
- Fill the gap between the root ball and the wall of the hole with surrounding soil, tamping it carefully.
- Sow a cover crop at the beginning of the rainy season (see "Other Plants" section).

monitoring and management in the immature phase (yet to be harvested)

During this phase, which lasts between 2 and 4 years depending on agro-climatic conditions, the palms are growing and are unproductive.
Usually, after 12 to 16 months, the young palms enter a cycle of male inflorescence production, followed by a cycle of female inflorescences of low economic value.

- Phytosanitary follow-up (see "Pests and Diseases" section).
- Slash the ground vegetation, forming circles around the young palms, to limit competition for light and water, but also to prevent the cover crop from smothering the young palms. Spread empty bunches around the palms to help keep the vegetation under control, locally improve the water-holding capacity of the soil, and provide organic fertilization (it should be noted that this method may lead to the development of *Fusarium* wilt in soils that are already infected - De Franqueville H., Diabaté S., 1995).
- Fertilize the young palms: organic and mineral fertilization (see the "Nutrients" section).
- Carry out sanitation harvesting six months before the true harvest, to remove any bunches that are already old or rotten.
  Female inflorescences and young bunches can also be removed once a month, keeping male inflorescences to help pollinating insect populations to develop. This method, which is also known as "castration" or "ablation", also encourages vegetative development, but not everyone agrees with its use. Ablation and sanitation harvesting can also be carried out at the same time.


Holing prior to planting out


Weeded circle upkeep at the young age

monitoring and management in the productive phase

- Phytosanitary follow-up (see "Pests & Diseases" section).
- Continue slashing the ground vegetation in the circles, without resorting to bare soil to avoid erosion. The weeded circles make it easier to collect loose fruits fallen to the ground.
- Maintain the crowns by cutting dry or hanging fronds, especially when the palms are tall, so as to detect ripe bunches from the ground.
- Prune senescent fronds after 4 or 5 years, leaving two fronds below ripe bunches, but only one frond after 15 years: the aim is to reduce assimilate losses in senescent fronds without reducing light interception, and to facilitate the detection and harvesting of ripe bunches. Each palm produces 30 to 40 fronds per year, on average, between 2 to 4 years old. Leaf emission decreases thereafter, reaching an average of 24 fronds from 8 years onwards.
- Fertilize the plot: organic and mineral fertilization (see the "Nutrients" section).

harvesting

Depending on agro-climatic conditions, the planting material and crop management, the first harvest usually takes place from 24 to 36 months after planting. Monthly peaks can reach between 10 and 25% of annual production and the higher the water deficit, the higher that percentage becomes, because induction of the male and female cycles is climate-dependent, so if there is a high water deficit the palms can only fulfil their potential over shorter periods.
The number of bunches produced decreases with age, while the average bunch weight increases. Depending on the planting material, the average bunch weight can be under 3 kg at the start of production and exceed 25 kg from 15 years onwards.

The fruits in a bunch ripen one after the other, beginning with the top of the bunch and from the outside inwards.
Oil forms in the fruit's mesocarp in the last month of ripening; thereafter, an oil degradation process (acidification) takes place more or less quickly depending on the type of planting material and on the conditions to which the bunch is subjected.

Regarding planting material:

- *E.guineensis* PalmElit-CIRAD® #L (Low Lipase) is particularly advantageous in terms of oil acidity when the time lapse between harvesting and milling exceeds the norms, but even when operating conditions are optimum.
- OxG interspecific hybrids mostly grown in Latin America have longer harvesting cycles than *E.guineensis* (up to 3 weeks) and acidity develops slowly.

- Identifying ripe bunches. As the most reliable indicator of bunch maturity is loose fruits on the ground, crown, stem and circle upkeep makes it easier to detect and collect them.

It is generally considered that the "5 loose fruits" stage is a good compromise that avoids cutting bunches that are either not ripe enough (low extraction rate), or too ripe (incidence on oil quality with a higher free fatty acid percentage, and an incidence on harvesting costs with longer loose fruit collection times). This norm can be adapted according to plantation requirements.

- Organizing harvesting rounds. The 1 to 2-week harvesting interval can be adapted to the season, the height of the palms, their age, and also to economic criteria, such as labour costs.

Pruning a mature palm

First bunches

If the harvesting interval is too short, it is likely that unripe bunches will be harvested, which will negatively affect extraction rates. If it is too long, harvesting costs will be higher (more loose fruits, more time to collect them), there will be a risk of rotten bunches (yield loss), and oil quality will be affected (greater acidity). An interval of 10 days between two harvesting rounds is quite frequently practised, but that duration can be shortened on young palms as the bunches are smaller, hence full ripeness occurs sooner than with large bunches.

Poor harvest organization and a lack of circle and crown upkeep have a highly significant impact on production costs, processable bunch yields, the extraction rate, and oil quality (acidity).

harvesting and pruning practices

- At the start of harvesting (up to the end of the 5th year after planting), there should be as little pruning as possible, only removing dry fronds. The bunch is harvested leaving in place all the remaining green fronds.
- From the start of the 6th year after planting (corresponding to almost complete closure of the canopy) and up to year 15, two fronds should be left under the lowest (ripening) bunch. The ripe bunch should be harvested by first cutting the subtending frond. At least 40 fronds should be left in the crown.
- From year 16 onwards, pruning should be carried out leaving a single frond under the last bunch, which will then be cut on harvesting.

These practices need to be adapted to the planting material and growing conditions. Harvesting is carried out with a chisel up to the fifth year, then with a hooked knife or “Malayan knife” until the palms reach a height of between 12 and 16 metres. Beyond that height, it becomes too difficult to use and replanting must be considered.

- After cutting the bunch, use a V cut to shorten the peduncle, which is a source of reduced extraction rate.
- Collect ripe fruits fallen to the ground, as they contain 50% oil.
- Move bunches and collected loose fruits as quickly as possible to the edge of the field in a maintained collection area, grouping them in lines and in a single layer to avoid damaging them and prevent oil acidification, with the peduncle upwards to facilitate counting (covered if the collection area is in full sunlight, or if the wait is long).

pollination

- Pollination is of paramount importance for obtaining good oil yield, which is directly linked to the number of well-pollinated flowers, irrespective of the planting material chosen.
- Pollination efficiency depends on several interacting factors: insects, wind, pollen quantity (number of male flowers in anthesis), pollen quality, the number of female flowers in anthesis, the aggressiveness of pollinators, the interaction between male and female flowers in anthesis, the duration of female flower anthesis, the temperature and rainfall, application of chemicals, human interventions.

Unripe harvested bunch

Ripe bunches in the collection area

It is generally considered necessary to have between 3 and 6 male inflorescences in anthesis per hectare at all times, to ensure adequate pollination; otherwise (usually under exceptionally favourable agro-climatic conditions), assisted pollination is needed: collection and release of pollinating insects, dispersion of male inflorescences in anthesis in deficient zones, hand pollination.

- For OxG interspecific hybrids, hand pollination is needed throughout the year in the productive phase, whatever the origin of the planting material.

replanting

The working life of an oil palm plantation usually varies between 20 and 35 years.
A general rule for deciding to replant is to replant a plot when the percentage of living palms falls below 70% (around 90 palms per ha), or when harvesting with the longest poles is no longer possible.
Palms can be felled manually with a chisel or with a chainsaw, or with a light caterpillar tractor equipped with a jib in the dry season, so as not to compact the soil. Whole palms, or 2 to 3-metre sections of stem, are then arranged into the windrow; they can be cut into thin slices. Such cutting into chips a dozen centimetres thick leads to faster decomposition, which prevents *Oryctes, Rhynchophorus or Strategus* from completing its cycle and, for the same reason, slows down *Ganoderma* development (see "Pests & Diseases" section).
Removing stems is not recommended (unless the palms display *Ganoderma* symptoms), as it would reduce the return of nutrients to the soil and organic matter turnover in the plot.
Windrowing is usually carried out every other interrow perpendicularly to the slope, which limits erosion, without pushing the stems so as to avoid also pushing the topsoil into the windrow.

By replacing a plantation that is old or low-yielding, it is possible to benefit from more modern planting material that incorporates the latest genetic advances in terms of disease resistance and yield gains.


Male inflorescence in anthesis


Female inflorescence in anthesis


Pollinating insects on a male inflorescence


Assisted pollination

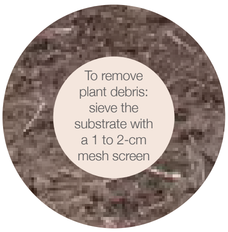
Soil

prenursery

Forest topsoil quality affects the emergence rate of germinated seeds.

Forest mould

Choose forest topsoil that is as close as possible to loamy sand, taken from the top 10 to 15 cm of soil, preferably light, humus-rich and healthy (avoid areas contaminated with *Ganoderma* or vascular wilt), mix it, or not, with compost (2/3 forest topsoil + 1/3 compost).



Substrate quality

Good quality substrate is mandatory for a good start and can potentially nourish the plant for the entire stay in the prenursery. Sieve the topsoil at the sampling site with a 1 to 2-cm mesh screen, to remove plant debris, stones etc... If storing, cover the topsoil with a plastic sheet to protect from rain.

Transferring to polybags

Use of polybags is still the usual procedure, but some plantations use plastic trays with wells filled with a substrate (topsoil or peat).

In conventional prenurseries, depending on the polybag size, 1.5 kg of topsoil will be needed to fill it properly. Fill the bags to the top, in 3 to 4 well-tamped layers, because settling occurs when setting in place and with successive watering. Top up the level of the topsoil in the polybag if it drops more than 2 to 3 cm from the top. Polybags are prepared a few days in advance so that the soil has time to settle and extra substrate added prior to planting.

Poorly filled polybags can lead to problems when watering, as the top of the polybag may slightly fold inwards, preventing the irrigation water from flowing into the bag, being of no benefit to the seedling.

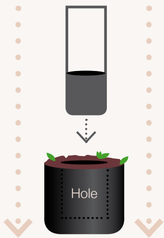
Mulching the surface of the polybags (coconut fibre, oil palm fruit shells, etc.) helps to slow down evapotranspiration, limit weed development and lessen soil erosion in the event of aggressive watering.

Substrate preparation at Mbongo in Cameroon

Agronomists inspecting substrate at Mbongo in Cameroon

Transferring to the nursery

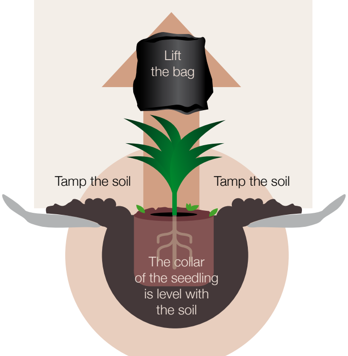
1. Dig a hole in the middle of the bag



2. Tear the bag

3. Remove the bag

4. Tamp the soil



nursery

- **Fill polybags with a substrate** from a site near the nursery, with a sandy texture, sieved (2-cm mesh) at the sampling site, mixed or not with compost and a basal dressing.

- **Make sure the quality of the substrate enables a good start in the nursery.** Then, regularly apply maintenance fertilization. For the right amounts, do not hesitate to contact specialized agronomists.

- **As in the prenursery, mulch the surface of the polybags.**

Filling nursery bags

Holing in the nursery

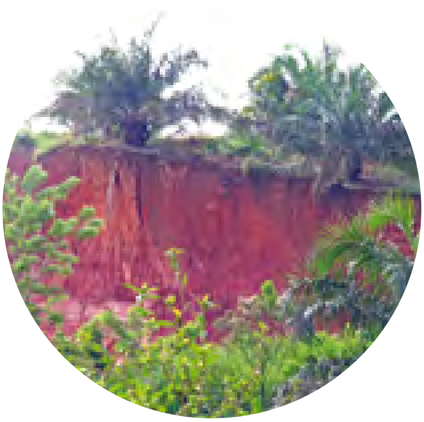

Healthy nursery plant

plantation

Ideally, the soil should be deep and mellow: a depth of at least 1 m, the optimum being between 2 and 3 m. Oil palm can adapt to numerous soil textures, from light loamy sand to clay, but care should be taken with extreme textures. Pure sand must be ruled out (totally leached), avoid excessively clayey soils (clay content over 80%), avoid compact horizons less than 80 cm down. Coarse elements (> 2 mm) are generally not really suitable (coarse sands < 80%).

Table 1:
Agricultural value of soils for oil palm growing
(J.-C. Jacquemard, Le palmier à huile)

Geomorphological formation	Regions	Value
Quaternary marine sands	Coastal sands	Unsuitable.
Tertiary sediments	West Africa, Amazon basin	Physical aptitude recognized, generalized potassium deficiency, frequent magnesium deficiency, phosphorus deficiency, and possibly copper in the Amazon basin.
Ancient bedrock	Africa, Southeast Asia (Borneo), Oceania	Frequent gravelly horizon at a shallow depth, potassium, magnesium and phosphorus deficiencies of highly variable severity.
Ancient alluvial terraces	Valleys of large rivers	Often suitable, but sometimes a hydromorphic horizon, or even an impermeable horizon at depth; quality depends on the internal drainage capacity, which is variable.
Recent alluvial deposits	Edge of the cordillera of the Andes, coastal zones of Malaysia and the Indonesian archipelago, African delta plains	Often suitable, depends on drainage possibilities in the rainy season and maintaining the water table at 80 cm below the surface in the dry season. Warning: frequent existence of sensitive high conservation value zones, planting not recommended (RSPO).
Volcanic sediments	Ecuador (slopes of the Andes), Indonesia (North Sumatra, Papua), Oceania	Great chemical richness, mineral deficiencies with possible imbalances: in a suitable climate, these soils give the best yields in the world.
Organic formations	Malaysia, Indonesia, small deposits in Africa	Good aptitude, but substantial technical ability and heavy land development needed. Plantations on peat are not compatible with the new RSPO criteria (criterion 7.7).



Soil profile under oil palms at Sushufindi in Ecuador

Soil acidity is not a problem for oil palm growing, except under the extreme conditions found in acid sulphate soils. Such soils are often near the coastline. In general, the accepted threshold is a pH of 4.

The oil palm does not tolerate saline soils, or the presence of brackish water in the first 50 centimetres of soil.

In soils formed from ultrabasic rocks, nickel or chrome has a toxic effect that is very difficult to correct.

Table 2:
Indicative level of soils suitable for oil palm growing
(J.-C. Jacquemard, Le palmier à huile)

Element	Indicative level
pH	Over 4.0 to neutral
Organic matter	1-2%
Carbon	1%
Mineral nitrogen	0.1%
C/N	10
Total phosphorus	300 to 400 ppm
Exchangeable potassium	0.2 meq / 100 g
Exchangeable calcium	Over 0.05 meq/100g
Exchangeable magnesium	0.4 meq / 100 g
Manganese	200 ppm
Copper	10 ppm
Available boron	0.3 ppm
Iron	1%
Molybdenum	0.5 ppm
Zinc	0.8 ppm
CEC	Over 10 meq/100g

planting

- **When preparing the land,** preserve the soil structure, or even improve it with appropriate cultural practices.
- **Replanting,** when windrowing, make sure not to disturb or drag the topsoil into the windrow, otherwise there will be a substantial loss of fertility that is highly prejudicial to young oil palms as they start out.

Where needed, soil tillage, subsoiling and disking may help to eliminate weeds and prepare a soil propitious to good development of the cover crop.

Disking

Planting out


Soil preparation prior to planting

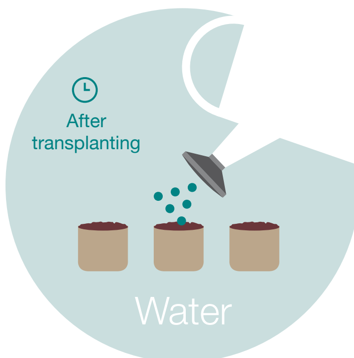

Young plantation and land preparation at Aek Loba in Indonesia

Water

The water resource is essential for the successful development of any oil palm plantation. This resource must be assessed in terms of quantity, but quality must not be neglected, as water from polluted rivers is often the source of major prenursery and nursery problems.

seed

If seeds have to be stored for more than three days before transfer to the prenursery, open the bags for rapid aeration and mist very slightly with a hand sprayer (if the bag walls are dry), then carefully close them again.



prenursery

Incorrect, excessive or irregular watering may prevent germinated seeds from emerging.
Seedlings require around 2 mm of water per day if the prenursery is shaded, and possibly more without shade.

- Water before and after transferring to polybags.
- In the absence of rain, provide 4 mm of irrigation water every other day, preferably early in the morning or at the end of the day. Use a jet that is gentle enough not to unearth the seeds or seedlings.
- If there is more than 5 mm of rainfall, postpone watering for a maximum of 2 days.
- When moving seedlings to the nursery, water slightly before transporting them.

Fertiliser burns may show on the leaves if there is insufficient watering after fertilizer application. Excess water or poor drainage can cause leaf yellowing. Excessive ambient humidity can cause diseases to develop (*Pestalotiopsis* leaf spot anthracnose, etc.): this can be avoided with good ventilation.

Prenursery irrigation equipment in Sierra Leone

Prenursery in Cameroon

nursery

Care must be taken to fulfil seedling water requirements throughout the nursery phase and watering must be considered as a supplement to natural rainfall.

The nursery must be located near a water point (water course, reserve, hill dam, borehole) able to supply 100 m^3 of water per hectare per day. One hectare of nursery can hold an average of 18,000 seedlings with spacing of 70 cm considering 25% of the space is already occupied by roads and paths. The well-draining soil should have a gentle slope for easier drain-off of excess irrigation water.

- Water after transfer to facilitate striking
- Make sure the water requirements of the plants are perfectly satisfied throughout the nursery stage:

B (n) = B (n-1) + R – ET

- B (n) = Balance on day D
- B (n-1) = Water balance the previous day
- R = Rainfall and irrigation on days (n) and (n-1)
- ET = Plant evapotranspiration (or consumption)

Seedlings are highly susceptible to drought as soil dries faster when in polybags: it is estimated that the easily usable water reserve in a polybag is between 30 and 35 mm. However, overwatering can be just as harmful as a lack of water: destructuring of the soil, nutrient leaching and plant asphyxia. Additional drainage therefore sometimes needs to be considered.

Mulch can be placed in each bag (2 to 3 cm thick) to prevent evaporation and maintain moisture inside the polybags. The mulch can be composed of oil palm fibres and nuts, coconut fibres, rice bran, cocoa parchment, etc.

Depending on the tree species, sawdust may cause a degree of phytotoxicity, so it must be tested beforehand. Rice bran may still contain a few grains, so any young shoots must be quickly and systematically removed, as rice is a grass that harbours the vector insect of Blast disease (see "Pests & Diseases" section).

The watering system must ensure regular and uniform water distribution. Several systems exist, which need to be adapted to the environment: fine sprinkler, spraylines (polyethylene pipes with regularly spaced holes) drip irrigation. It should be chosen with care depending on the nursery programmes and the planned location. It must be adaptable to slightly different units without any major modifications (longer watering times, spacing between sprinklers).
To make sure you choose the right system, we recommend you consult a specialist.

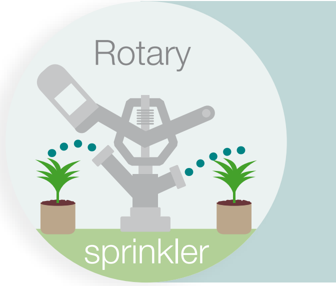


Table 1:
Water requirements (consumption) in mm per day

Plant age since transfer (months)	Unshaded nursery mm/day	Shaded nursery mm/day
0 – 2	4.0	2,0
2 – 4	5.0	2,5
4 – 6	7.0	3,5
6 - 8	10.0	5,0

Table 2:
Water per round, in mm
Cycle of 2 days, i.e.
3 rounds per week, 1 day of rest

Seedling age since transfer (months)	Unshaded nursery mm/round	Shaded nursery mm/round
0 - 2	9.0	4,5
2 - 4	11.0	5,5
4 - 6	16.0	8,0
6 - 8	23.0	11,5

(Source: Sprinkling of oil palm polybag nurseries, Oléagineux, IRHO Advice Notes 314).


Oil palm nut mulch on a nursery plant


Nursery irrigation system at Thitawan in Thailand

plantation

Bunch production reaches its maximum right from 1,800 mm of well distributed rainfall throughout the year: ideally 5 mm per day (150 mm/month), i.e. 350 litres per palm/day, or around 50 m^3 per hectare/day. Under these suitable conditions, with good soil and good crop management, PalmElit-CIRAD® planting material can produce up to 32 tonnes of fresh fruit bunches (FFB) and 9.5 tonnes of oil (CPO+KPO).

A linear relation has been established under dry conditions between irrigation and yields, although irrigation is not always cost-effective: **20 to 30 kg of FFB/ha/year** gained per mm of irrigation in zones with a **water deficit of 200 to 600 mm** *(L.S. Woittiez et al. 2017).*

The useful water reserve of the soil is the maximum amount of water that the soil can contain and supply to the roots. It depends on the physical and chemical qualities of the soil, along with the volume of soil explored by the roots. It is considered that the easily usable reserve without any reduction in photosynthesis is around 200 mm, but it also depends on many other factors, such as soil type, water table depth, etc.
Oil palm can tolerate temporary flooding, but submerged roots cannot breathe normally, which reduces water and nutrient uptake and reduces sugar availability: photosynthetic activity is reduced 3 to 4-fold.
In the rainy season, a reduction in pollination levels may be seen, which is due to a drop in pollen quality in the event of heavy rainfall, and reduced pollinating insect activity.

A drainage network inside the plantation block may sometimes be essential. It must be carefully designed to avoid any waterlogged zones that would be highly detrimental to development. It must be connected to the general drainage network and must be isolatable in dry periods.

Drainage network in a plantation in Ecuador


Asphyxia symptoms due to poor drainage

Moderate to severe water stress has a major impact on yield: the fronds do not wilt, but the opening of new fronds is delayed, with up to 5 or 6 unopened fronds (spears). An air relative humidity under 65% at 30°C (or equivalent) causes stomata to close, leading to reduced photosynthesis.

A prolonged water deficit leads to:

- A drop in the average bunch weight, or even bunch abortion, or a halt to lipogenesis.
- Abortion of inflorescences (male and/or female) in the axil of unopened fronds, or a reduction in the number of bunches or male flowers 8 to 10 months later. Inflorescence abortion rates of 25 to 40% were recorded on young mature oil palms after a prolonged dry season in Nigeria, with that rate decreasing to between 5 and 10% on 15-year-old palms *(Broekmans, 1957 quoted by L.S. Woittiez et al. 2017)*.
- Male sexualisation causing a reduction in bunch number 24 to 30 months later.

A severe water deficit, as occurs in the dry season in West Africa, can reduce the sex-ratio (number of female inflorescences out of the total number of inflorescences) to 0.1 - 0.2 *(Broekmans, 1957; Bredas and Scuvie, 1960; Corley, 1976a quoted by L.S. Woittiez et al. 2017).*

An exceptional water deficit immediately affects vegetative organs (bent or broken green fronds, early desiccation of fronds, toppling of the cabbage, palm death) and reproductive organs (partial or total abortion of inflorescences on spathe opening or flowering, suspended fruit growth, halt to lipogenesis, late abortion of unripe bunches). Lipogenesis has been seen to stop in periods of 3 to 4 weeks without rain in suitable ecologies.

Supplementary irrigation in relatively dry conditions improves:

- Earlier yielding.
- The bunch number and average bunch weight.
- Mesocarp oil content.

Drip irrigation

Drought symptoms in a plantation in Thailand

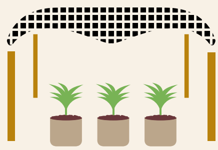
☼ Light

When compared to annual oil crops, an advantage of the oil palm, a perennial plant, is that it is perfectly adapted to the humid tropics and has leaves capable of intercepting light at all times.

prenursery

Shade is recommended for prenurseries, though some farmers in certain regions, such as West Africa, do not use it.

Protect from:
- sunlight
- insects



Shade protects seedlings from:

- Over-exposure to sunlight. Indeed the hypodermis of leaflets at this stage comprises just a single layer of cells and the cuticle is still very thin.

- An insect of the family *Cicadellidae, Recillia mica,* which is a sucking insect that transmits a phytoplasma responsible for so-called "blast" disease. Only the installation of shade and strict elimination of grasses provides effective protection against that insect (see the "Pests & Diseases" section).

The shade can be constructed:

- With fronds, which must be healthy and laid perpendicularly to the cross-supports at a rate of 3 or 4 per running metre. They must be treated against noctuid caterpillars every fortnight for the first three months, taking care to wet all the fronds well. They must be replaced as and when they dry out, treating any new fronds against noctuid caterpillars. In order to acclimatize seedlings gradually to sunlight, remove every third frond 3 weeks before the seedlings leave the prenursery then, a week later, remove every other frond and, lastly, remove the entire shade a week after. If the fronds have been laid in several layers, half should be removed.
- With polypropylene shade nets. Moreover, the nets will provide better protection if also installed vertically all around the prenursery. Three weeks before seedlings are transferred to the nursery, remove the net every other day for an increasingly long time (an hour per day, then two hours, then three hours, etc.), up to final removal.

Shaded prenursery at La Cabaña in Colombia

Shaded nursery in Cameroon

nursery

If the nursery is sown directly without a prenursery phase, it is usually managed without shade, but occasionally some growers install temporary shade for the first 2 months, to facilitate striking, and they group together the polybags of 4 or 6 rows side by side. The shade is gradually removed the following month.

A two-stage nursery, with seedlings transferred from a prenursery, is not shaded.

plantation

15 MJ/m^2/day of total solar radiation (equivalent to around 7.5 MJ/m^2/day of photosynthetically active radiation, or 5.5 hours of sunshine per day) is optimum for oil palm growth and yields.

Annual sunshine of 1,800 hours is considered optimum; this figure is exceeded in some countries such as Guatemala (around 2,400 hours), with highly beneficial results for yields.

1,800 h/year

An average of 15 to 23 MJ/m^2/day of total solar radiation is received in all oil palm growing regions. A lack of light means a loss of yield and the shortfall is estimated at around 2.1 t/ha/year of FFB for each MJ/m^2/day lost. In Africa, and in some regions of America, less than 10 MJ/m^2/day is received in the rainy season.
Solar radiation is limited by cloud cover.
In Africa, dust carried from the Sahara by the Harmattan wind causes occasional reductions in solar radiation.

In oil palm growing regions, 5.3 to 6.9 hours of sunshine are observed in Asia; 2.2 to 7.7 in America and 3.6 to 6.3 in Africa.

A gain of 15 to 20 kg of bunch dry matter is obtained per palm per year for each additional hour of daily sunshine compared to cloudy conditions, according to a study carried out at a density of 110 palms per hectare (the ideal planting density for PalmElit-CIRAD® *E. guineensis* material is 143 palms/ha, or even 160 for #C material). Yield potential in regions with 8 hours of sunshine per day could be more than 60% higher than in regions with 3 hours of sunshine per day *(Kraalingen, D.W.G.v., Breure, C.J., Spitters, C.J.T., 1989 quoted by L.S. Woittiez et al. 2017)*.

Oil palm yellowing caused by a lack of light in Ecuador

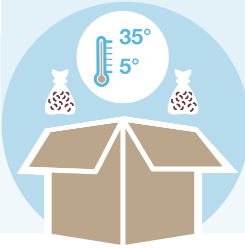
Campbell sunshine recorder in a plantation weather station in Nigeria

Temperature

seed

Despite all the care taken in preparation and packaging quality, seeds may get damaged in transit, especially if they have been exposed to low temperatures contrary to the strict instructions given to shipping agents.

Transport and storage minima/maxima



Check the temperature recorder always placed in package No. 1.

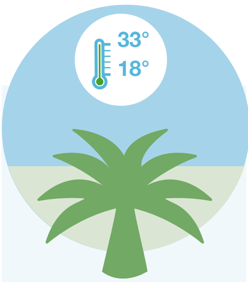
If the temperature has fluctuated below 5°C or over 35°C, report it immediately and send a copy of the temperature recording to PalmElit by e-mail.

In principle, seeds must be transferred to the prenursery on arrival. However, if they cannot be transferred immediately, they must remain in their original packing cases and be kept in an air-conditioned room at 25°C without temperature variations, particularly exposure to heat (sunlight or poorly ventilated store) or cold (strong air conditioning, refrigerated storerooms).

plantation

In order to develop well, oil palm requires relatively high temperatures, the optimum seeming to be between 24 and 28°C and the maximum temperatures between 28°C and 33°C. Temperatures of 33°C to 38°C can only be withstood if the relative humidity of the air is sufficient.

Monthly minima/maxima



Oil palm is susceptible to cold. It is generally considered that the monthly minimum temperatures must be over 18°C. Low temperatures result in slow growth, bunch abortions and delayed maturity. If temperatures frequently fall below 18°C, they could be fatal. In relatively cool zones, such as Bahia (Brazil) and Tela (Honduras), a large reduction in yield occurs in the second half of the cold season and the start of the warm season. In Sumatra, low temperatures at high elevation lengthen the immature period by a year *(Hartley,C.W.S., 1988 quoted by L.S. Woittiez et al. 2017)*.

There is a temperature recorder
in one box of each shipment

Healthy seeds

Cold damage on germinated seeds

Avoid planting in zones with frequent cyclonic depressions or high winds.

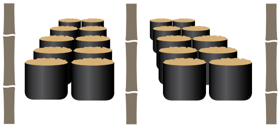
High winds cause:

- frond twisting and breakage
- toppling of the leaf cabbage
- breakage of the central cabbage
- uprooting when the soil is mellow or waterlogged.

⊕ Site Improvements

prenursery

It is preferable to install the prenursery near the nursery, or near the manager's home, bearing in mind the continual monitoring and frequent watering required. The land chosen should enable appropriate and rapid drainage of water in the event of heavy rain: permeable, non-hydromorphic soils that drain well and are gently sloping.



Mark out the beds

- Create slightly domed beds to prevent water accumulation.
- Edge the beds with strips of wood, bamboo or small bricks, supported by stakes. For example: 20 m long and 1.50 m wide for 5,000 seedlings (250 rows of 20 polybags 10 cm in diameter), with a 0.80 m alley between the beds (for wheelbarrow access), slightly sunken to allow better drainage.
- If needed, install shade (see "Light" section) and a drainage network (see "Water" section).
- Where necessary, surround the prenursery with a 1-m high fine-mesh wire fence to keep animals out.

A 1,000 m^2 prenursery can hold 80,000 seedlings divided into 16 beds surrounded by a 5-m wide track to facilitate truck and tractor access.

nursery

The nursery site depends on:

- The ability to connect it to a water point (see "Water" section).
- The possibility of setting up a drainage network if needed (see "Water" section).
- Its proximity to the plantation site.
- The possibility of totally clearing and levelling the land (by way of a cover crop for example).

As bags are laid out in 70 cm equilateral triangles (rows 60 cm apart), a 5-m wide space should be kept for the main tracks, and paths should be established by removing a row or column of polybags to enable easy movement within the nursery and to separate the beds.

A 1 ha nursery can hold 18,000 seedlings once the paths and roads have been created (amounting to around 25% of the area).

Lining in a nursery

Polybag layout in a Peruvian nursery

plantation

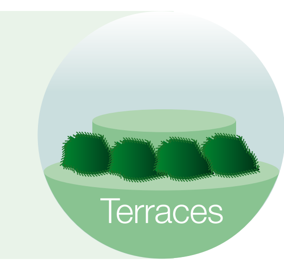
site improvement

Site improvements influence the profitability of the plantation and, along with cultural practices (windrowing, cover crop sowing, etc.), help to control erosion and maintain soil fertility.

The road structure must be studied before planting takes place. Always take the land characteristics effectively into account so that the track network is practicable throughout the year.

Table 1:
Land characteristics and improvements for oil palm growing
(J.-C Jacquemard, Le palmier à huile)

Landscape type	Characteristics	Improvement required
Slope	Between 0 and 10%	Not necessary, maybe a few bunds
	From 10 to 15%	Bunds, infiltration ditches
	From 15 to 30%	Individual terraces, continuous terraces along contour lines, or not
	Over 30%	Not recommended for planting
Bottomland and floodable areas	River deltas and backwaters	Protective dykes
		Efficient water management system (drainage and water table management)
		Floating roads



Individual terraces are circular platforms around 3 m in diameter in the middle of which the future oil palm will be planted. They are created manually and, ideally, should have a counter-slope of around 10%.

Continuous terraces are strips of mechanically flattened land around 2 to 3 m wide, installed along contour lines, also with a counter-slope of 10%, if possible.

The crests of the terraces should be consolidated by planting beneficial plants (e.g. Indian lemongrass, *Cymbopogon sp.*).

Bunds are ribbons of land from 50 to 90 cm high raised manually or with a ridging plough, always along a contour line. They are useful in helping to block future erosion on slopes of less than 10%.

Terrace cultivation

Planting platforms are essential in all small hydromorphic or floodable areas. They are around 3 m in diameter, and from 40 to 50 cm high, centred on the position of the future palm. They help young plantings, which would otherwise risk asphyxia, to get off to a good start.

A drainage network inside the block may sometimes prove essential. It must be carefully designed to prevent any waterlogged zones that would be highly detrimental to oil palm development. It must be connected to a wider network and be isolatable in the dry season.

Timing

seed

After controlled pollination of chosen parents, it takes 12 months to obtain germinated seeds: 8 months for dry seeds, a further 3 months to convert them into preheated seeds, and one more month to obtain germinated seeds (usual marketing stage). These times have an impact on seed production programming.

Month after controlled pollination	+ 8	+ 11	+ 12
Seed type	dry	preheated	germinated

For orders of tens of thousands, delivery usually takes place 40 days after payment.
For orders of hundreds of thousands, delivery takes place 120 days after payment.
For orders of millions, the order must be placed long enough in advance for the best delivery schedule to be drawn up in agreement with **PalmElit's sales department.**

prenursery

Transfer seeds to the prenursery as soon as possible after their arrival. Seedlings are usually ready to be transferred to the nursery between three and four months later (see the "Planting Material" section).

Month	+ 3 to + 4
Prenursery duration	20 to 25-cm tall seedling

Prenursery plants ready for transfer to the nursery

Prenursery – Work for a 1000 m^2 (80,000 seedlings)

Source: CIRAD® germinated oil palm seeds.
Recommendations for prenursery and nursery management.

Task	Date or frequency	Contract (man-days)	Number of man-days	Number of tractor hours	Requirements
Land preparation	D-45		x	y	Choice of phytosanitary products *
Beds, fencing, ditch	D-30		15		Wire netting (160 m), bamboo poles, stakes
Shade	D-25		20	5	Fronds (1,200), wire, tacks
Substrate					
Excavation, sieving	D-25	0.5m^3	130		Soil (65 m^3)
Transport	D-20	2	32	20	
Bag filling, installation	D-20	500	160		Polybags (80,000)
Disinfection	D-15		1		Choice of phytosanitary products *
Transfer	D	2,500	32		
Herbicide treatments	D+10		1		Choice of phytosanitary products *
Fungicide treatments	15 days		6		Choice of phytosanitary products *
Insecticide treatments					Choice of phytosanitary products *
Watering	2 days		15		Water (4 m^3/application)
Manual weeding	5 beds		90		Choice of phytosanitary products *
Fertilization	D+75		3		Urea (2kg)
Shade removal (3 stages)	D+98, +105, +112		6		
Culling, seedling dispatch	D+115	1,250	64		Transport cases

* For the choice of phytosanitary products, please contact your nearest input distributor.

Month	+ 8 to +10
Nursery duration	0.6 to 1-m tall palms

nursery

After spending eight to ten months in the nursery, seedlings are usually ready to be planted out.

Direct sowing in large polybags saves 1 to 1.5 months (see the "Planting Material" section).

For commercial nurseries, it is often advisable to market seedlings 10 months after seeds are received, rather than 12 (need for working capital, time available – 2 months – between two seasons to clean and maintain the installation).

Work required for a 1 ha nursery (20,000 seedlings, duration 8 months)

Source: CIRAD® germinated oil palm seeds.

Recommendations for prenursery and nursery management.

Task	Date or frequency	Contract (man-days)	Number of man-days	Number of tractor hours
Land preparation	D-90		x	y
Substrate				
- Collection	D-30	2,000 kg	180	110
- Bag filling	D-25	150 polybags	120	
- Bag installation	D-15	250 polybags	80	
Stake cutting and lining	D-20	1,000 + 400	85	
Transfer	D	250 polybags	80	
Bag weeding + hoeing between bags	Monthly	3,600 +600	300	
Watering	Constant	1/2 ha	250	
Fertilization	Monthly	1,800 polybags	90	
Insecticide (6 rounds)	Monthly	1,500 polybags	80	
Fungicides	Weekly	4,000 polybags	175	
Monitoring	Constant		240	
Culling	D + 200	4,000 seedlings	5	

Nursery plant around 12 months old

plantation

immature phase

The immature phase lasts approximately 2 years under the most suitable conditions, 4 years under less suitable conditions.

It is possible in the first year to replace dead palms, or palms with unwanted traits not detected during prenursery and nursery culling.

productive phase

Yields rise, reaching a maximum after 7 years under the most suitable conditions, 9 years under less suitable conditions.

Inflorescence initiation occurs a few weeks after leaf initiation. The leaf opens two years after initiation.

The sex determination of inflorescences, depending on the experiments conducted and the planting material used, has been estimated at between 20 months before harvest *(Breure and Menendez, 1990, quoted by L.S. Woittiez et al. 2017)* and 29 to 30 months *(Broekmans, 1957, quoted by L.S. Woittiez et al. 2017)*.

The mean sex ratio (number of female inflorescences to the total number of inflorescences), in the absence of a severe water stress, is from 0.9 to 1.0 in the first four years after planting *(Henson and Dolmat, 2004, quoted by L.S. Woittiez et al. 2017)*, from 0.6 to 0.9 until the 12 years after planting *(Jones, 1997; Henson and Dolmat, 2004, quoted by L.S. Woittiez et al. 2017)*, and then regularly decreases *(Corley and Gray, 1976, quoted by L.S. Woittiez et al. 2017)*.

Abortion may occur from 4 to 6 months before anthesis (or around 10 months before harvest), when developing inflorescences are most susceptible. This coincides with the start of floral organ development and elongation *(Broekmans, 1957, quoted by L.S. Woittiez et al. 2017)*.

Bunches are harvested around 3 years after flower initiation. This long period can be affected by various factors linked to the bioclimate, nutrition, crop management, availability of pollinating insects, pollen quantity and quality, pests and diseases. All these factors affect frond development, inflorescence sexualisation, sometimes inflorescence abortion and, in the most serious cases, bunch abortion.

Consequently, in production terms, a plantation does not respond immediately when suitable conditions resume, but it does take optimum advantage of an environment that is constantly suitable, where agronomic management is an integral part.

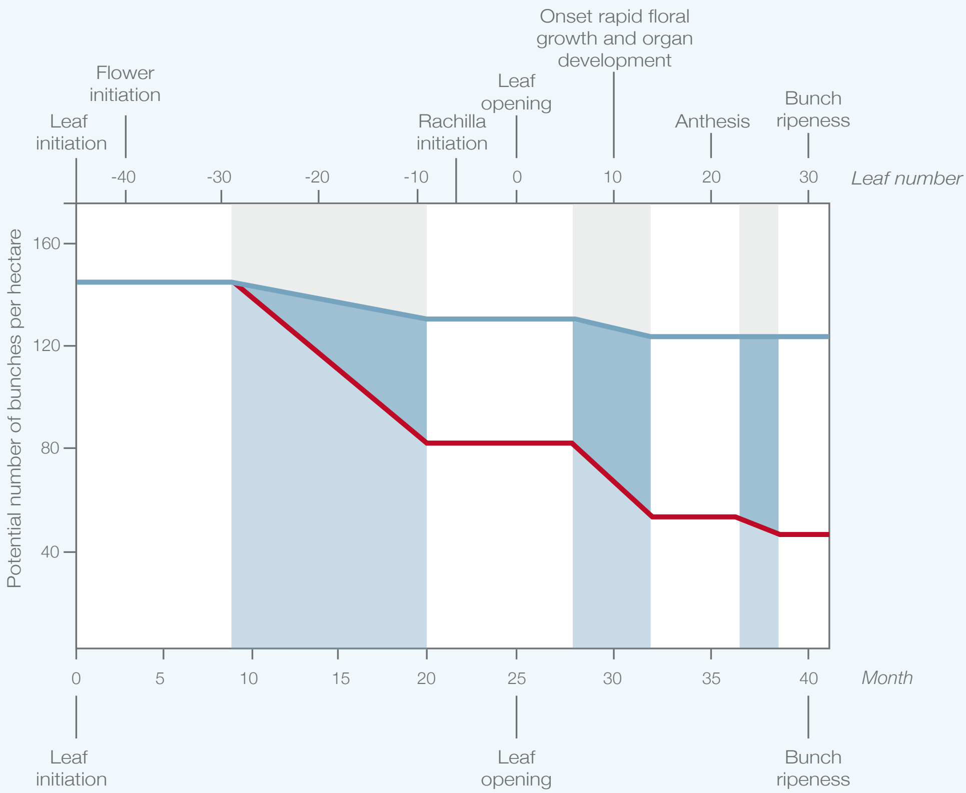
Young palm starting to bear

Harvesting

Diagrammatic representation of inflorescence and bunch development

Key developmental stages and effects of stress on the potential bunch number

(L.S. Woittiez et al. 2017, according to Uexküll and Fairhurst, 1991; Corley et al., 1995; Adam et al., 2005)



The timetable begins with leaf initiation (point zero) and progresses up to bunch ripening. It is indicated in months (bottom axis) and in leaf number (top axis). The Y-axis gives the potential bunch number per hectare. The two curves show the potential progression of two batches of bunches subjected to different agro-climatic conditions (density: 142 palms per hectare). As time goes by, the potential bunch number decreases as the batches pass through several critical phases. Severe stress (bottom curve) leads to a greater reduction in bunch number than slight stress (top curve). The vertical bars represent the stress periods: sex determination (left), inflorescence abortion (middle) and bunch abortion (right).

Bunch collection and alignment

Bunches lined up in the collection area

replanting

The working life of an oil palm plantation usually varies between 20 and 35 years (see "Planting Material" section).

The stem grows in two phases:

- **Horizontal** growth up to 2.5 to 4 years old.
- **Very slow vertical** growth at the young age, speeding up from 6 - 7 years old to 15 years old, and then slowing down again.

Vertical growth (cm/year) between 6 & 9 years for **PalmElit-CIRAD®** planting material:

Material	PalmElit-CIRAD® product	Vertical growth in cm per year	
		Suitable conditions	Less suitable conditions
Elaeis guineensis	#S DExLM #C DExLM	46-50	42-46
	DExLM	46-56	42-52
	DExYA	54-60	Not recommended for growing under less suitable conditions (water deficit)
Elaeis oleifera x Elaeis guineensis	$\#PC_{OxG}$ #HO COxLM $\#PC_{OxG}$ #HO MMxLM	20-25	Not determined
	$\#PC_{OxG}$ COxYA	25-30	Not determined

Height measurement

Timetable for land preparation and track laying
(J.-C. Jacquemard, Le palmier à huile)

	Operations	Number of days (per ha planted)	Number of tractor hours (per ha planted)	Equipment
Extension	Manual or mechanical felling	30-40		Chainsaw
	Planting row clearance	6-10		Chainsaw
	Manual windrowing	45		Chainsaw
	Mechanical windrowing	2	3-4	Medium caterpillar tractor [1]
	Track opening	0.2	1	Caterpillar tractor [2]
	Track profiling	0.2	1	Leveller
Replanting	Manual felling	40-50		Chisel
	Simple mechanical felling and windrowing	0.75	1	Medium caterpillar tractor or dedicated excavator
	Mechanical felling and stem shredding	0.75	11	Dedicated excavator

[1] Fleco, Rome KG or excavator blade
[2] Rome KG blade

Felling with a chainsaw

Timetable – Planting operations
(J.-C. Jacquemard, Le palmier à huile)

Operations		Number of days (per ha planted)	Number of tractor hours (per ha planted)	Requirements
Lining	Stake cutting	1		
	Lining, head of rows	2		Surveyor's chain, 20 m tape measure
	Lining, oil palms	8		
Cover crop sowing		2-3		Sowing density depending on plant used
Seedling transport		1-3	0.5-1.5	Agricultural tractor, light trucks
Manual holing, planting		4-10		
Mechanical holing			1.5	Auger on agricultural tractor
Pest protection		As required		


Holing auger

Timetable for special improvements
(J.-C. Jacquemard, Le palmier à huile)

Operations	Number of days (per ha planted)	Number of tractor hours (per ha planted)	Requirements
Bunds	25	1	Agricultural tractor + ridger
Manual individual terraces	70		Hoe
Mechanical continuous terraces	2	4-6	Caterpillar tractor + tilt blade
Subsoiling	2	1-2	Heavy caterpillar tractor + subsoiler
Cleaning of natural drains and small water courses	1	2-3	Excavator
Manual or mechanical drainage	8-10	2-3	Excavator
Ploughing		2-3 per round	Agricultural tractor + disc plough


Drainage in Colombia

Density

seed

PalmElit-CIRAD® germinated seeds are packed in bags of 210 seeds (200 seeds + 5% safety batch).
Each packing case contains 16 bags (3,200 seeds + the 5% safety batch).

prenursery

The beds are often 20 m long by 1.50 m wide. With this width, all the bags are easily accessible when the operator wishes to start sowing. The length of 20 m, which is mostly used, can take 5,000 seedlings. It can be reduced to 10 m to take only 2,500 seedlings if the land area used is smaller and a smaller number of seeds is to be sown.

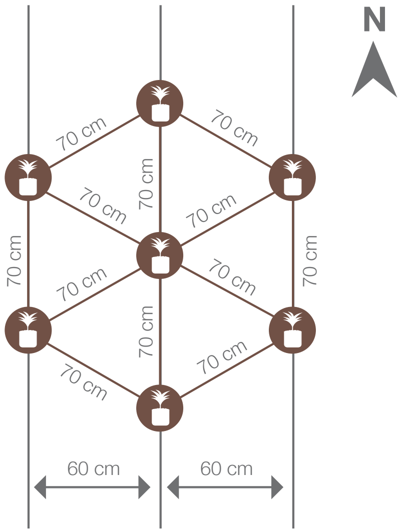
The paths must be 0.80 m wide for wheelbarrow access.
The tracks are 5 m wide for easy truck or tractor access.

It should be noted that, nowadays, many plantations use hard plastic trays with compartments, on tables 1 m in height, the main advantages being easier sowing, easier handling, especially during transport, and space saving (with 24.5 cm x 31.5 cm trays containing 24 compartments, around 350 m2 can hold 100,000 seedlings, i.e. over 480 hectares of plantings, while it takes more than 600 m2 in a conventional polybag prenursery).
A tray can be reused up to 6 times, thereby avoiding used bags being abandoned in the wild.

nursery

One hectare of nursery can hold 18,000 seedlings, i.e. slightly over 100 ha of ultimate plantation (bearing in mind a planting density of 143 palms per hectare, plant culling and any replacements in the field). Polybags are usually laid out in a 70 cm equilateral triangle arrangement (60 cm between rows), and 25% of that area must be reserved for paths and roads. If the nursery time needs to be extended, the spacing of 70 cm between seedlings could be increased to 80 or 90 cm, to prevent plants from becoming etiolated through lack of light.

Nursery layout

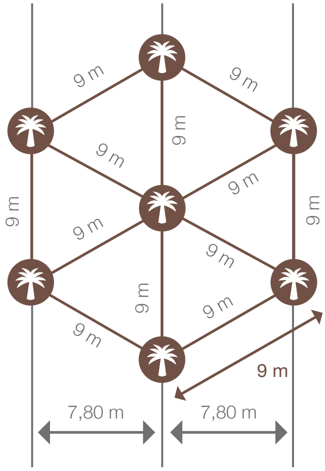


Field layout for conventional

PalmElit-CIRAD® material

E. guineensis

Recommended planting density: 143 palms/ha



Nursery layout

plantation

planting density

Planting density is an important factor in determining yield potential.

The optimum density is a balance between seeking the quickest possible closure of the canopy in the immature phase, to reduce the cost of maintaining the ground cover, land productivity at the young age, and limiting competition between palms in the mature phase, which is detrimental to yield.
Oil palm is planted in an equilateral triangle layout at densities that vary with the planting material.

Planting density recommended for PalmElit-CIRAD® planting material :

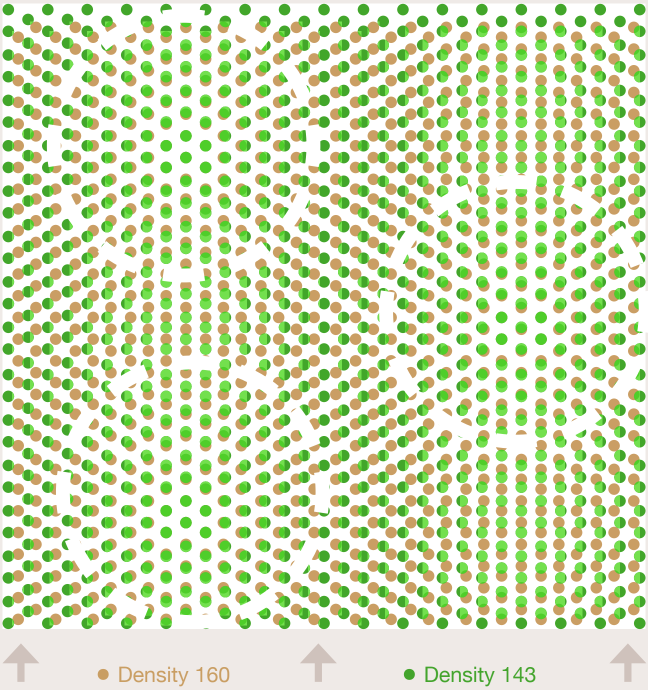
Material	PalmElit-CIRAD® Product	Frond length (m)	Distance between palms (m) in the planting row	Distance between rows (m)	Number of palms per ha
Elaeis guineensis	All Deli x La Mé (except #C DExLM)	6.30	9.0	7.80	143
	#C DExLM	6.00	8.5	7.35	160
	DExYA	6.50	9.0	7.80	143
Elaeis oleifera x Elaeis guineensis	#PC_{OxG} #HO COxLM	7.00	9.5	8.20	128
	#PC_{OxG} #HO MMxLM	nd	9.5	8.20	128
	#PC_{OxG} COxYA	7.10	9.5	8.20	128

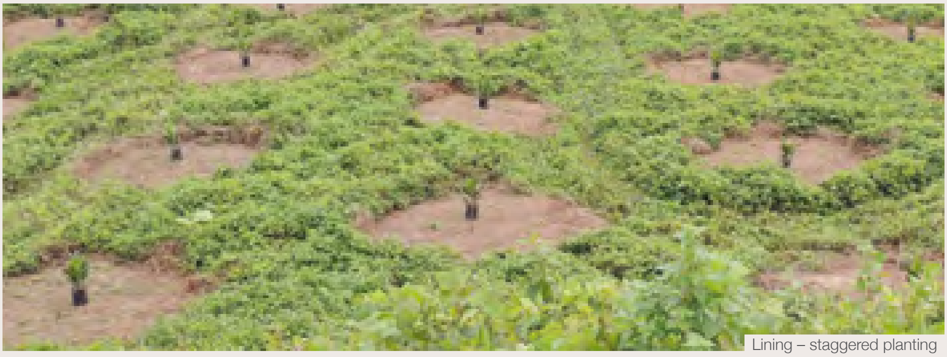
When replanting, if diseases were found to exist in the previous generation of oil palms (vascular wilt or *Ganoderma*), new palms should be planted as far as possible from the old planting positions, so it is necessary to keep the same density as before to avoid having zones where the palms are very close to, or even in the same positions as the previous palms.

Replanting in plot infected by *Fusarium* or *Ganoderma*

It is essential to plant at the same density
as the former plantation.

Plot replanted at a density of 160 palms/ha, different from previously (143 palms/ha): in places, the new palms are planted exactly in the same potentially infested old positions.





Lining – staggered planting

Other plants

prenursery

- Weed the bags and the paths over an area larger than the final installation (extend well beyond the area earmarked for the prenursery).
- Eliminate grasses from the site itself, and beyond for at least 10 m wide all around the site. These weeds are host plants that promote the development of insects that are disease vectors (Blast, dry bud rot, ring spot).

nursery

- Take care to set up the nursery site far from any food crops and plots containing grasses, to prevent the propagation of insects.
- Establish a cover crop (*Pueraria, Calopogonium, Mucuna bracteata* etc.) in a radius of 50 m around the chosen site.
- Weed the site or plant an *Arachis pintoi* cover. This legume cover crop will prevent erosion and drastically reduce grass elimination costs.
- Manually weed the inside of the polybags twice a month (take advantage of this to straighten up the bags and consolidate the stability of the seedlings).
- Weed between the polybags (e.g. with a hoe or a hand weeder). Chemical weeding is not recommended, but if it must be done as a last resort, take care to use herbicide shields to avoid touching the seedlings.

beneficial or service plants

Nectar-bearing plants are useful in controlling certain insect pets, such as *Turnera subulata*.

These plants are usually sown around and inside nurseries and plantations (see the "Pests & Diseases" section).

Turnera subulata nectar-bearing plant

Turnera subulata flower

oil palms

planting after savannah

PalmElit advises against planting oil palms on previous forest cover unless highly degraded secondary forest is involved.

The vegetation is felled and manually or mechanically cleared depending on the possibilities. After drying, it is preferable to start marking out blocks and rows directly, windrowing the plant mass. Windrowing is usually carried out in the direction of the planting rows, every other interrow. The operator must take care not to disturb the topsoil or push it into the windrow, otherwise there will be a substantial loss of fertility detrimental to the start out of young palms. If windrowing is manual, the positions of the future palms must be cleared and levelled over a diameter of at least 2 m, as should the central path every other interrow for access to each palm.

legume cover crops

The shock of denuding large areas, be it after highly degraded secondary forest, fallow or replanting, is such on weed species that, very often, it is invasive plants that take over and cause upkeep problems in the juvenile phase.

Planting a legume cover crop offers many advantages: it helps control invasive plants, including some grasses that are hosts for insects that vector diseases (see "Pest & Diseases" section). It also helps to control soil erosion and compaction, and to reconstitute the humus layer of the soil more rapidly through its decomposition.

Pueraria

Mucuna

Up to the end of the 1990s, *Pueraria phaseolides* was the most commonly used cover crop. It can be combined with an annual legume such as *Mucuna cochinchinensis*, which becomes established very quickly and prepares the land well for *Pueraria*.

Some other legumes have also been used, alone or in mixtures: *Centrosema pubescens, Calopogonium mucunoides, Calopogonium caeruleum, Desmodium ovalifolium*. Since the beginning of the 2000s, *Mucuna bracteata* has also been used, but it is a species that is sometimes too voluble and expansive, climbing into the young oil palms.

Sun-loving cover crops tend to disappear quickly once interrows become totally shaded by palm fronds. In that case, a specific, wild shade-loving vegetation like ferns becomes established. In some cases, oil palm shade is too great, which is often the result of choosing an inappropriate spacing for the planting material: bulky material planted too close together. The soil becomes bare and appropriate steps have to be taken to intensify erosion control.

Pueraria phaseolides cover crop in a Nigerian plantation

Fern development in a mature plantation

immature oil palm plantation

- **Around the palms:**
  In the first year, 6 to 10 upkeep rounds should be scheduled for the weeded circles, cleaning a radius of 1.50 m around the palms. Thereafter, the diameter of the weeded circle will depend on young palm development. Take care to maintain the inspection paths in the plots, in order to monitor the status of the plots (weed cover, deaths due to large rodents such as grass cutters, nitrogen and magnesium deficiencies), and check on the work done.
- **Cover crop control:**
  It is essential to control its development effectively within the immediate vicinity of the weeded circles, to prevent it from invading the young palm crowns.
- **Elimination of invasive weeds:**
  These weeds increase upkeep costs in the juvenile phase: *Eupatorium odoratum* and *Imperata cylindrica* are considered particularly detrimental to oil palm growing, due to their rapid development. The best way to eliminate these weeds is to do so carefully during land preparation. Good establishment of the cover crop also helps to control them.

mature oil palm plantation

- **Around the palms:**
  it is very important to maintain a clean weeded circle around the foot of harvested oil palms. It is essential for this circle to be clean to detect loose fruits, which are indicators of good bunch ripeness, and facilitate their collection. The useful radius of this circle varies depending on palm age. It is around 1.50 m from the third year after planting. On average, 6 upkeep rounds will be organized under highly favourable conditions and 3 under less favourable conditions.

- **Biodiversity:**
  slashing is carried out to control the development of obstructive weeds that are sometimes shrubby or bushy. It is very important to preserve good biodiversity in the interrows, to help balance the useful fauna and microfauna. It is not necessary to maintain close-cropped vegetation in the cleared interrows. The existence of a properly maintained inspection path is enough for operations to be carried out in the plots (harvest, phytosanitary surveillance, etc.).

Clean weeded circle around a bearing oil palm

Clean weeded circle around an immature palm

intercrops

These are food, annual or biennial crops grown between young planted palms.

- **Maintain a 3-m diameter zone without crops** around young palms in the first two years after planting.
- **Never cut the fronds of young oil palms** to make room for food crops.
- **Make sure that all food crops are stopped** once harvesting begins on the palms.

Some repeated crops exhaust the soil, such as cassava, others are bulky and hinder young palms when they are too close (e.g. plantain banana, maize) due to competition for water and light resources. Some intercropped food crops attract numerous pests, including rodents. In all cases, phytosanitary surveillance of the palms must be stepped up.

The longer the growing cycle of food crops, the further they must be planted from the oil palms. This also applies if the soil has to be dug up to harvest them (tubers). Their fertilization must be considered separately, and be added to that of the palms.

permanent agroforest

In Africa, oil palms cohabit with other trees in orchards, and in plots with annual crop and fallow rotations (usually very tall palms, at a density of a few dozen individuals per hectare). These palms are often derived from unselected seeds and do not usually benefit from much upkeep, and under such conditions they produce very little oil. Systems that are more intensive are currently being studied. It is still tricky making any reliable recommendations on this subject.

Pineapple intercrop in a young oil palm plantation

"Granadilla" (passion fruit) intercrop in Ecuador

Organic matter

For each tonne of oil extracted, an industrial oil mill processes 1 tonne of solid organic residues (empty fruit bunches - EFB) and 2.5 tonnes of liquid waste (effluents). Their recycling as organic fertilizers has a highly beneficial effect on oil palm development and yields. They improve the physico-chemical quality of soils, thereby increasing their water-holding capacity, which limits losses of mineral nutrients through leaching (substantial in sandy soils) and supplements mineral fertilization.

prenursery

See also the "Soil" section.

- Choose a topsoil that is as close as possible to loamy sand, taken from the first 10 to 15 centimetres of soil, preferably light, humus-bearing and healthy (avoid zones contaminated by *Ganoderma* or vascular wilt), enriched or not with compost (2/3 topsoil + 1/3 compost).
- Sieve the forest soil at the sampling site with a 1 to 2 cm mesh screen, removing plant debris.
- If storing, protect the topsoil from rainfall by covering with a plastic sheet.

1. Choose topsoil

2. Sieve it

nursery

See also the "Soil" section.

Fill the polybags with a substrate from a site near the nursery with a sandy texture, and sieved (2 cm mesh) at the sampling site, enriched or not with compost. Using the substrate existing at a former nursery site is a good practice if empty bunches had been spread (this helps keep the bags upright and, by decomposing, provides substrate for the following year).

Empty bunch storage

Empty bunch spreading in the nursery

Empty bunches spread in a mature plantation

Compost application

plantation

Soils suitable for oil palm growing contain 1 to 2% organic matter. The humus-bearing horizon, which is the most fertile of the soil, is found in the first decimetres of soil, or even the first centimetres. Apart from its essential role in regulating the physical, biological and chemical properties of the soil, this humus is essential for making clayey or loamy soils permeable or, conversely, improving the water-holding capacity of sandy soils. Under hot conditions and on acid soils, it tends to degrade rapidly.

Nevertheless, under both oil palms and forest, soil nitrogen and organic matter contents evolve little and are in a state approaching equilibrium.
Organic matter is renewed exclusively by litter from the natural vegetation, or from the cover crop that remains in the plantation, by fronds pruned during harvesting and by the recycling of fresh EFB.

It is in this mass of organic matter that most of the oil palm's absorbent roots are found. Erosion control is one of the techniques to be implemented, as it is this humus-bearing layer that will be eroded first.

- Avoid using herbicides over large areas, which might denude this humus-bearing horizon, facilitating rapid degradation of the humus and its washing away by rainwater.
- Avoid intentional or unintentional exports of organic matter, such as petioles or whole fronds.

windrowing

The plant mass existing before planting is a valuable reservoir of organic matter made use of by windrowing every other interrow, with constant recycling.

- Burning should be absolutely forbidden. It completes the disturbance of macro and microbiological diversity, mineralizes a very important plant mass within a few hours and contributes to destroying organic matter in the topsoil.

- When replanting, felled stems of old palms must be prevented from becoming hosts for pests, such as *Rhynchophorus, Oryctes*, or fungi such as *Ganoderma*. The technique of shredding stems into chips is a good solution as this speeds up decomposition, which prevents the development of these pests. Then, sowing a cover crop such as *Mucuna* will have further favourable effects.

Chipping of oil palm stems

Burning, a technique to be forbidden

fronds

- **Cut dry fronds, prune senescent fronds after 4 or 5 years leaving two fronds under the ripe bunch, then a single frond after 15 years:** the aim is to reduce assimilate loss via senescent fronds, without reducing light interception, and facilitate ripe bunch detection and harvesting.

- **Carefully lay out fronds in a "U" shape beyond the weeded circle:** around two thirds of pruned fronds are placed along the row either side of each palm, positioning the spiny petioles towards the windrow, and the final third of fronds are placed in the windrow, thereby distributing organic matter over a larger area. If the plot is on a slope, even a gentle one, lay fronds perpendicularly to the slope to prevent erosion risks.

Empty Fruit Bunches (EFB)

EFB are the highly fibrous support of the bunch. They are recovered after stripping and account for 20 to 25% of the bunch weight entering the oil mill. They contain 60 to 70% water. They offer interesting organic fertilization potential.

They can be spread inside plantations when transportation costs are not prohibitive. In addition to providing nutrients such as potassium, like any organic matter they have a positive effect on the soil structure and on development of the absorbent root system.

After grinding and drying, EFB can be composted using some new techniques carried out under shelter, making it possible also to absorb a fair amount of the liquid and solid effluents arising from mill operations.

This compost can then be used as fertilizer in the plantation, or mixed with topsoil to prepare the nursery substrate. Such composting is usually partial, as it is carried out over 4 to 5 weeks. Nevertheless, it helps to reduce the volume of matter returned to the field by 30 to 40%. The energy arising from compost fermentation is enough to evaporate off surplus water.
The mineral nutrient contents of EFB, or their compost, are closely linked to the nutritional balance of the palms and of their fertilization. EFB composition needs to be checked before estimating their worth as a substitute for mineral fertilization.

Windrowing in a "U"

Empty bunches leaving the mill

Nutrients

prenursery

The reserves in the seed, and in the substrate if it is of good quality and rich in organic matter, are usually enough to provide the seedling's nutritional requirements for the 2 to 3 months spent in the prenursery.

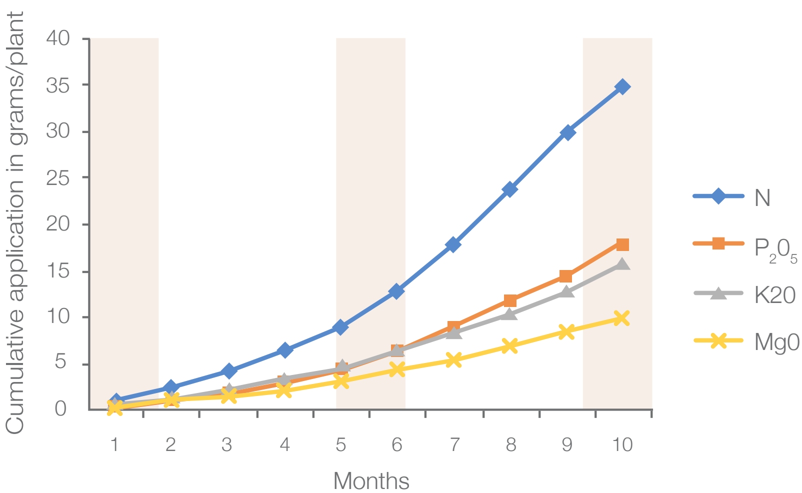
At the end of the cycle, extra nitrogen can be applied if necessary (e.g. for 1,000 seedlings: 25 g of urea in 10 l of water followed by light watering to prevent burns on the foliage).

nursery

The substrate, which should preferably be sandy and rich in organic matter, must ensure quick drainage of excess water. Nutrients should be provided at regular intervals throughout the time spent in the nursery, as the reserves in the substrate are not enough.

Using a controlled-release fertilizer is a very good option for reducing the number of applications.

The following graph gives an indication of the cumulative quantities of nutrients to be provided depending on the time spent in the nursery under standard conditions.




Well-developed root system on prenursery plants


Fertilizer burn on a young prenursery plant

Fertilization in oil palm plantations

Oil palm fertilization helps prevent any deficiencies from occurring as they could limit potential yields, which is determined by other factors such as the climate, soils and uncontrolled pests. Once a satisfactory nutritional status has been reached, the production of the palm no longer responds to additional fertilizer applications: it is therefore pointless and very expensive to apply surplus fertilizers.

Leaf analysis is the most commonly used (and also the most practical) tool for recommending fertilizers. It consists in analysing leaflet samples each year. The nutrient contents are compared to reference values indicating a satisfactory nutritional status. The diagnosis is based on differences from the optimum, along with their changes over time.
In order for analysis results to be comparable from one sampling operation to the next, and *in fine* be interpretable, the leaf analysis process must respect some strict standards, such as the representativeness of the sample, the leaf rank, the position of the leaflets and the time of year the samples are taken. These considerations provide a precise picture of the status of each plot or group of plots sampled, so that a fertilization programme can be designed that helps to maintain productivity at its maximum level.

Many results are available for *E. guineensis* oil palm nutrition that are the basis for different ways of recommending fertilization. Firstly, for each situation it is necessary to determine the reference contents for the major nutrients essential for the crop. Then, a strategy is drawn up to achieve those optimum contents throughout the plantation. This process also has to be applied to *E.oleifera* x *E.guineensis* (OxG) interspecific hybrids, which are now used for oil production on an industrial scale in South America. Studies on interspecific hybrids began later, but some fundamental differences from *E. guineensis* have been found as regards nutrition.

A description is given below of the most important practical aspects of *E.guineensis* oil palm nutrition, along with the broad outline of what is known today for the nutrition of the OxG hybrid.

1. Essential nutrients and content variability as a percentage of dry matter in leaflets

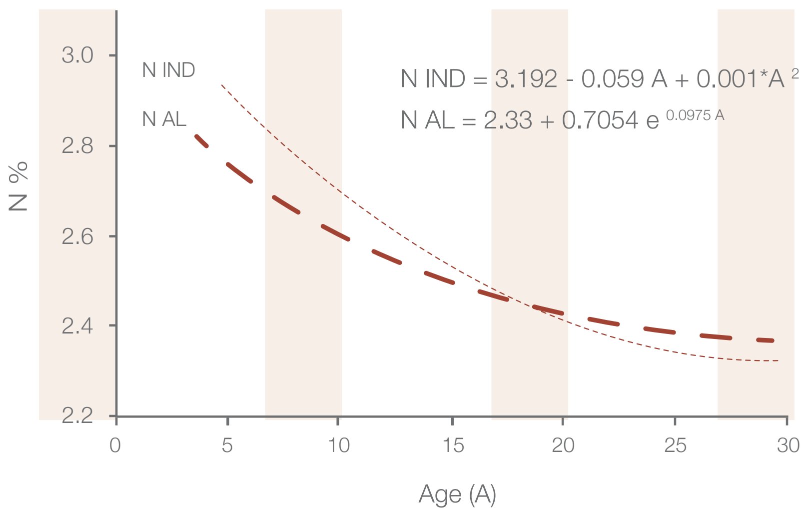
1.1. *E. guineensis*

The size of the frond as a whole, and especially that of the leaflets, continues to increase up to the age of 10 to 12 years. This results in an increase in leaf biomass, which probably explains why leaf contents decrease with age for certain nutrients, such as N, K and Mg.

1.1.1. Nitrogen

Nitrogen is a fundamental element for photosynthesis, hence for producing the sugars needed for vegetative growth and the production of fresh fruit bunches (FFB). At the young age, a severe N deficiency leads to a generalized pale green colour. In mature crops, nutrition may be inadequate without any symptoms showing. It is therefore necessary to refer to leaf contents, which vary between 2% and 3%, or even more. The variability depends on the age of the crop and each leaf content must be compared to an age-related reference value (A), using one of the models shown in the following graph:

Graph 1: Variation in optimum N content depending on crop age. The Indonesian model was described by Tampubolon et al. (1990). The exponential model, N AL, has been successfully used in South America. For this model, a content of 2.5% is deficient (90% of the optimum) at the age of 5 years, and excessive (105% of the optimum) at 25 years.

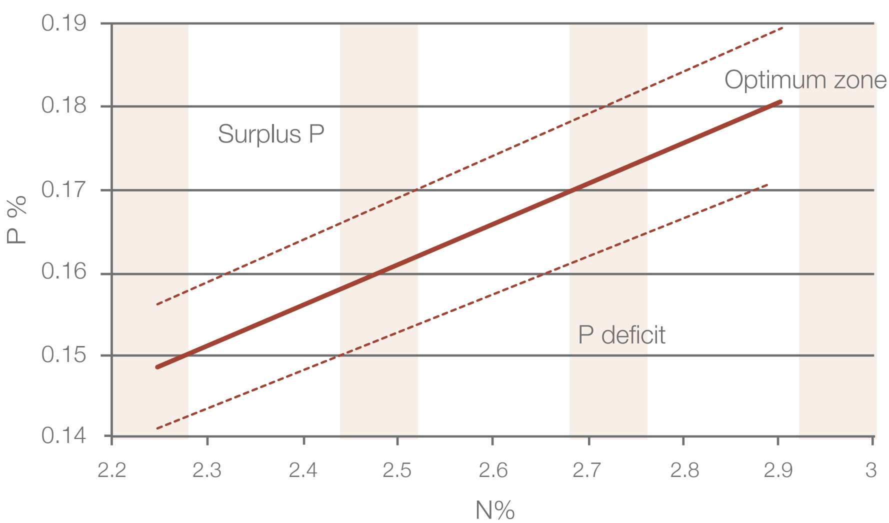


In some circumstances promoted by a good legume cover crop and good organic matter management, nitrogen nutrition can be "naturally" satisfactory, in which case no outside application is necessary. When nutrition is deficient, applications of 0.5 to 1 kg of N per palm per year (i.e. for example 1.1 to 2.2 kg of urea) is enough to reach the optimum content.
It should always be borne in mind that excess nitrogen fertilizer entails risks for the environment, due to nitrate leaching and greenhouse gas emissions.

1.1.2. Phosphorus

P Phosphorus plays a very important role in the composition of nucleic acids and energy transfers. However, a P deficiency is very difficult to detect visually, as it leads to a reduction in the stem and frond size that requires precise observations. Leaf P contents vary from 0.12% up to almost 0.20%. This variation is in very close relation to nitrogen, probably because of the composition of leaf tissue.
Using the results from several field trials conducted at different locations, it has been possible to show that the equation P = 0.0487 N + 0.039 effectively reflects the optimum balance between P and N. In this way, it is possible to assess the nutritional status of plantations by plotting the contents of samples on a graph like the one below.

Graph 2: Balance relation between leaflet P and N contents. Depending on the N content, P contents are considered satisfactory when they are between 95% and 105% of the theoretical values that delimit the optimum zone.
Annual applications of 0.5 to 1 kg **of** P_2O_5 per palm are enough to maintain or improve leaf contents in the event of a marked deficit.



1.1.3. Potassium

Potassium is an essential nutrient for FFB production, as it is involved in several physiological processes (notably stomatal opening and carbohydrate conveyance).

The effect of a deficiency on yields begins before the most typical symptom of yellowing is visible, which is another reason why an optimum leaf content needs to be referred to. That optimum value greatly depends on soil and climate conditions, and sometimes the planting material. A the young age, between 3 and 5 years, there is usually no difficulty in maintaining leaf contents between 1% and 1.3%. Thereafter, they decrease rapidly and, as a rule, a content of between 0.9% and 1% is considered optimum. However, for some soils, or with certain planting materials, some major difficulties have been encountered in reaching that range, and contents remained around 0.8%.

The fertilizer most commonly used to maintain or improve K contents is KCl (60% $K^{2}O$); application rates of 0.6 to 1.2 kg of $K^{2}O$ per palm per year are considered "normal". However, repeated applications of more than 2 kg per palm without any positive effect would mean that the optimum levels need to be questioned, along with the objectives of the fertilizer schedules; the economic cost-effectiveness of fertilization needs to be reassessed and a specialist should be consulted.

Potassium deficiency (OxG)

1.1.4. Calcium

Usually, Ca determination is included in standard laboratory services. However, it has never been possible to establish an optimum content for this nutrient, and deficiency symptoms remain unknown.

In mature crops, contents over 0.5% are generally found and can reach 1% in the event of synergy with chlorine. When that occurs, fertilizing with KCl induces an increase in calcium contents and a decrease in potassium contents, which makes diagnosing potassium nutrition very difficult.

1.1.5. Magnesium

It is generally accepted that Mg contents of between 0.22 and 0.24% are satisfactory. Some authors considered that planting material origin has a pronounced effect on the Mg content and that the Deli x Avros origin is more demanding than Deli x La Mé material. The first deficiency symptoms appear when concentrations are below 0.22%, particularly on palms along tracks and most exposed to sunlight; however, a true deficiency (one that has a negative effect on yields) is at a much lower level, around 0.16%. We can therefore conclude that the visible appearance is usually more alarming than analyses actually indicate.

Moderate application rates of up to 0.15 kg of MgO per palm per year are enough to maintain adequate contents. In some plantations, patches of palms have been found displaying severe deficiencies and Mg levels not exceeding 0.10%. In such cases, localized applications at high levels are recommended; organic amendment is also recommended to improve soil properties, which are usually a source of uptake problems (sandy or stony soils, among others).
Using a sulphate as a source of Mg makes it possible to provide periodically a little sulphur to crops and is a good precaution.

1.1.6. Chlorine

Unlike some other nutrients, such as N and K, Cl content increases rapidly with crop age, reaching and exceeding 0.50-0.60%, a range that is considered optimum. This threshold can easily be maintained by applying 1 kg of KCl per palm, so using that fertilizer for potassium fertilization also makes it possible to manage chlorine nutrition easily.
There are no visible deficiency symptoms for this nutrient.

Magnesium deficiency (OxG): yellowing is more intense on the leaflet tips of the lower fronds due to the effect of light and recycling to the youngest fronds

Severe magnesium deficiency in a mature crop (OxG): the lower fronds dry out early

1.1.7. Boron

Boron is the trace element most susceptible to deficiencies, which are mainly reflected in a reduced leaf area, following shortening of the rachis of new fronds. Observation of the shape of the palm is therefore a good indicator, notably from 2 to 5 years old, which is the most susceptible period. When the leaf crown displays a flat top, rapid intervention is required with applications of 7 to 15 grams of B per palm (25 to 50 grams of $B2O3$), where needed, they can be repeated a few months later if the soil remains moist enough.
The occasional observation of some other symptoms (hook leaf, crinkle leaf, among others) is not enough to conclude on a B deficiency.

It has not been possible to examine any experimental results strictly confirming that an optimum content is 12 ppm or more in frond 17. Given its limited mobility in leaf tissues, an analysis of B in that frond only provides an indication of B availability at the time that leaf opened. There is therefore a difference of 6 to 8 months compared to the analysis date *(Rajaratnam, 1972)*.

1.2. OxG hybrid

Some crosses of OxG hybrids may display specific nutritional characteristics, especially for magnesium and potassium. However, fertilization trials conducted on the Coari origins have helped to determine the overall optimum average contents in Colombia and Ecuador.

For N, K and Mg, the age effect on leaf contents is also very marked. Interspecific hybrids display high leaf biomass; it therefore seems logical that the optimum N and K contents are lower than those for *E. guineensis*.
Based on experimental results, it has been possible to define a model for N that takes crop age into account and can be used to make sure that leaf contents are satisfactory. This model ($N\ AL = 2 + 0.7054\ e^{0.0975\ A}$) is similar to the one used for *E. guineensis*.

For K, a content of 0.7% is considered sufficient for crops over 6 years old.
For phosphorus, no marked difference has been found compared to *E. guineensis*. In particular, the same relation between N and P ($P = 0.0487\ N + 0.039$) can be used, along with the same standards to assess leaf levels (the P concentration must be kept between 95% and 105% of the optimum).

Leaf contents of between 0.50% and 0.60% for chlorine and between 0.22% and 0.24% for magnesium are considered satisfactory in interspecific hybrids.

Boron deficiency (E.g.): palm A has a normal growth habit, unlike palms B starting to display a flat top


Boron deficiency (OxG) on alluvial soils in Ecuador: yellow or pale stripes and the central fronds starting to shorten. The silhouette of the palms is beginning to change.

Even at the young age, boron deficiencies are very rare in interspecific hybrids. In general, this material has low susceptibility to this deficiency, but it can still occur under certain soil conditions, particularly on alluvial soils and peats. As for *E. guineensis*, defining an optimum B level in frond 17 does not seem to make any sense, as it would not reflect B availability at the sampling time. However, any large drop in the leaf area of the latest fronds emitted must be taken seriously, especially on young palms.

2. Strategies for implementing a fertilization plan

As already mentioned, it is extremely important to define reference contents for each plantation. Above all, special care must be taken to determine the N and K contents that will be optimum, as these two nutrients determine the greatest share of the fertilizers that will be recommended.

Depending on soil and climate conditions, optimum N, P and K contents can be locally very different from the generally accepted levels, for several reasons:

- Natural abundance of nutrients (e.g. N).
- Fixation of nutrients in the soil in unavailable forms (P, K).
- Antagonism between nutrients, especially between Ca and K, or Ca and Mg.

Each plantation needs to determine the optimum contents for the major nutrients, taking into account the fertilization cost/benefit ratio. This means conducting fertilization trials to test the main nutrients. This process is only worthwhile for large plantations.

For small oil palm plantations, it should be checked periodically that the fertilization schedules designed to reach optimum contents actually work. If it turns out that optimum contents cannot be achieved, the objectives of the fertilizer schedules must be revised.

In addition, to optimize crop nutrition and reduce costs, it is always important to foster nutrient recycling and/or seek to reduce fertilizer losses. Choosing the best application periods, taking rainfall into account, along with the position chosen for the application of each fertilizer depending on crop age, are all decisive aspects for making the most of each nutrient provided.

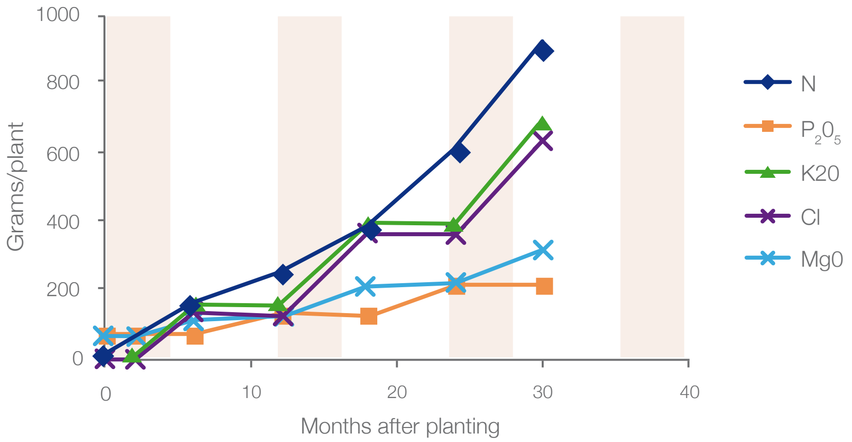
On the other hand, sowing a cover crop, managing shrubby regrowth, spreading empty fruit bunches or oil mill effluents, where possible, not only help to provide an abundance of nutrients, but also improve the nutrient holding capacity of the topsoil. Such recycling of organic matter also promotes biological life in soils (earthworms, insects, fungi, etc.), and its positive effect on their physical properties.

Leaf analysis is a useful tool as soon as healthy rank 17 fronds are available, i.e. around 3 years old. Before that age, a fixed schedule is used for young crops, a standard version of which is given below. This specimen schedule for the first 30 months is suitable for *E. guineensis* and for interspecific hybrids. As soon as the first leaf analysis results are known, the schedule can be revised if necessary.

Table 1: General fertilizer schedule (grams per plant) for *E. guineensis* or interspecific hybrids in the first 30 months after planting.

Age (months)	N	P_2O_5	K2O	Cl	MgO	B
0 (planting hole)		**70**			**60**	
2	70					2.25
6	90		150	135	50	3.00
12	90	55				3.75
18	135		240	220	100	3.75
24	225	90				3.75
30	300		300	275	100	3.75

Graph 3: Fertilization – nutrient applications cumulated over the first 30 months after planting.



Tools - Equipments Containers

At all stages of the crop, it is important to ensure that staff have the right tools and are properly trained to use them. Take particular care to provide adequate protective gear when staff are in contact with treatment products (respirator masks, goggles, protective clothing, gloves, boots, etc.).

prenursery

The main requirements for a conventional prenursery are:

- Fencing (fine-mesh wire fence, or netting), to surround the prenursery site and keep out undesirable animals.
- Black gusseted polybags with a volume of 1 litre (thickness: 0.05 mm; dimensions when flat: 5 x 23 cm, bottom perforated with 5 mm holes). It takes around 205 polybags for one hectare of plantation using conventional PalmElit-CIRAD® material. Plastic trays with compartments (see the prenursery in the "Density" section).
- A mixture of topsoil and compost, all sieved (see the "Soil" section).
- Mulch for the polybags (shells, fibres, etc.).
- Water tank.
- Irrigation equipment (spray lines, sprinklers, drip irrigation, etc.).
- Bamboo poles to edge the beds in which the polybags will be positioned. A bed generally holds 10 polybags widthwise and a path at least 0.80 m wide must be left between beds for wheelbarrow access.
- Small, 20 cm long stakes to support the bamboo poles.
- Metal signs on which the details of the material are written (bed number, quantity of bags, type of material, transfer date).
- Shovels, spades, machetes, rakes, backpack sprayers, watering cans, wheelbarrows.
- Crates for transporting the polybags to the nursery.
- A ventilated room, lockable, to store phytosanitary products (herbicides, fungicides, insecticides).
- Shade materials – nets or fronds (see "Light" section).
- Prenursery logbook (all operations carried out must be entered with the date).

Dibber for transplanting seedlings in the nursery

Backpack sprayer

Prenursery in Liberia

Prenursery shade made with fronds

nursery

The main requirements for a conventional nursery are:

- Black polybags without gussets, with a volume of 20 kg (thickness: 0.15 to 0.2 mm; dimensions when flat: 40 x 40 cm, bottom perforated with three parallel rows of 5 mm holes). It takes around 175 polybags for one hectare of plantation using conventional PalmElit-CIRAD® planting material.
- Mixture of topsoil and compost, all sieved.
- If possible, mulch for the bags (shells, fibres, etc.) and empty fruit bunches (to keep the bags upright).
- Water tank.
- Irrigation equipment (spray lines, sprinklers, drip irrigation, etc.).
- Metal signs on which the details of the material are written (bed number, number of bags, type of material, transfer date).
- Shovels, spades, machetes, dibbers, backpack sprayers, rakes, wheelbarrows.
- Fine-mesh wire fence to protect the site if needed, and to protect the palm collars just before planting out (0.50 m x 0.35 m strips).
- A ventilated room, lockable, to store treatment products (herbicides, insecticides).
- Nursery logbook (all operations carried out must be entered with the date).

At the end of the nursery stage, transportation to the plantation may be by tractor and trailer or by truck. Seedlings must be handled with care; if they are too large, they can be pruned by cutting the fronds at a height of 1.50 to 1.75 m.

plantation

Depending on the size of the project and the preparatory studies, setting in place and maintaining the infrastructures may call for powerful and advanced equipment, not described here.

land preparation

- Land clearance is mechanical, or manual. Trees are felled with a chainsaw. When replanting, old palms are felled with a chisel by cutting the roots around the root mat, or using a light caterpillar tractor equipped with a jib.
- Windrowing is preferably done with an excavator, otherwise manually.
- Where needed, soil tillage, subsoiling and disk ploughing help to eliminate weeds and prepare a seedbed suitable for good development of the cover crop.
- A drainage network can be constructed if necessary. A hydraulic shovel is the equipment generally used for such work.


Seedling protected with a wire guard


Drip irrigation


Nursery in Ecuador


Insecticide application using a granule microdoser

lining

For large projects, the basic equipment comprises a theodolite, an optical square, a compass and a tape measure; for small projects, a right-angle gauge.

holing

This may be manual or mechanized, using a tractor-mounted auger.
Hole depth is checked with a gauge.

seedling transportation

Must be mechanized: agricultural tractor and trailer, or truck.

immature phase

Manual upkeep around the palms, elimination of weeds: machete.

productive phase

- Manual upkeep around the palms, slashing, weed elimination: machete
- Assisted pollination (see also the "Planting Material" section): mixture of pollen/talc in a proportion of 1:10 and an appropriate tool comprising a pole, puffer and pollen container.
- Pruning: chisel up to the 5th year, hooked knife after that, and a machete or axe to chop up fronds.
- FFB harvesting: narrow chisel up to the end of the 5th year, wider-bladed chisel thereafter, a hooked knife (also called a "Malayan knife") once the palm is more than 2 m tall, with a pole length of up to 8 m to which an extension can be attached.
- FFB removal: manual, assisted (wheelbarrow, pack animal, small ox-drawn trailer), or mechanized.

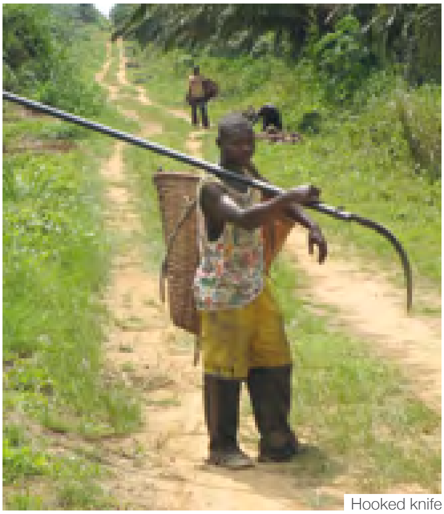
Circle upkeep with a machete

Bunch collection by wheelbarrow

Holing auger

Transportation of palms

Chisel



Hooked knife

Pests & diseases

From the arrival of the seed in the nursery to the replacement of the plantation after 25-30 years of working life, an oil palm is confronted by pests and diseases that often have a major effect on yields, or even on the life span of the plantation.

Prior to planting out, the first stage of disease control, and to a lesser extent of pest control, lies in the choice of planting material proposed by seed merchants.
Diseases such as *Fusarium wilt* in Africa, *Ganoderma* in Asia and Africa, and Bud Rot in Latin America are very difficult to control, and only genetic protection is effective. Such protection is provided by the planting material itself after many years of selection and testing.
The choice of planting material is guided by a good assessment of the health risks existing at the planting site.

Selecting high-yielding *E. guineensis* varieties with resistance to the main three diseases (*Fusarium* wilt, *Ganoderma,* Bud Rot) is the No.1 priority of the breeding work undertaken by PalmElit and its partners.

In terms of pests, although differences in performance within the guineensis species are still not well known, it can be said that the *E. oleifera* x *E. guineensis* interspecific hybrids, grown almost exclusively in Latin America, offer some satisfactory responses to attacks by a majority of leaf-eating insects, such as *Limacodidae*.

The origin of seeds or seedlings is paramount.
By purchasing certified seeds from an acknowledged breeder, or buying seedlings from an approved nursery, you will be launching your project with perfectly healthy, tested planting material adapted to local conditions.

Once the planting material has been chosen, the second stage consists in ensuring good cultural practices from the outset of the prenursery and/or nursery and throughout the working life of the plantation. Land preparation, creating a drainage system if needed, weeding, sowing a cover crop, fertilization, pruning and harvesting, constant and regular phytosanitary surveillance by a team of skilled staff, quick action against infection foci, are all aspects that must not be neglected if the status of the plantation is to remain optimum.

Maintaining good health
must be the grower's No. 1 priority.

Fusarium wilt test reading in Benin

***Fusarium* wilt, which is lethal and endemic in Africa, can lead to more than 60% mortality in a plantation.**

Our selection work enables growers to cultivate varieties with vascular wilt resistance.

Plantation devastated by *Fusarium* wilt in Liberia

Susceptible and resistant seedlings undergoing early screening in the prenursery

Vascular wilt test in Benin

With staff training, knowledge of the plantation's environment and of the main diseases and pests existing in the zone, the most effective control methods can be anticipated. Where possible, sharing the experience of close neighbours is a bonus.

Many growers are gaining an increasingly better command of integrated pest management (IPM) or integrated disease management (IDM), with some very satisfactory results. These methods take into account genetic control (planting material), biological control, physical control (cultural practices) and chemical control.

Chemical control, which was widely used in the past, remains an essential fall-back when all other methods have failed, or when insect outbreaks have not been detected or rapidly treated.

However, it does entail risks: for the health of the workers applying it, for the environment through the imbalances and pollution it causes, for consumers, and financially for the plantation too.

Chemical control must therefore be used in a supervised way.

In this chapter, we only consider the pests and diseases most often encountered, and which are known to have a serious economic incidence.

As the commercial specialities and active ingredients of phytosanitary products can evolve very quickly and as legislation regarding their use can be different from one country to another, each grower must be vigilant and seek information from the relevant authorities.

You should contact the input distribution point nearest to your plantation, to seek its advice on the choice of products and how to use them.

Integrated pest and disease management

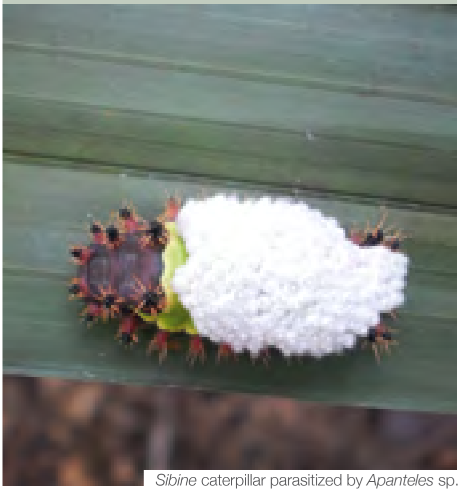
Genetic control:
Choice of planting material

Fusarium wilt-resistant palm

Physical control:
Cultural practices

Removing soil from a plantation infected by *Ganoderma*

Biological control:
Pheromones, predators, etc.



Sibine caterpillar parasitized by *Apanteles* sp.

Chemical control:

Weeding team

prenursery and nursery

The prenursery and nursery are two stages when pest and disease control is crucial. A healthy plant at the outset considerably increases project profitability.

Regular surveillance is extremely important throughout the plant rearing stage, to detect any problems as soon as possible and act promptly.

Make sure that:

- The prenursery or nursery site is located on well-drained and gently sloping land.
- Access to the prenursery and nursery sites is reserved exclusively for staff trained in carrying out the necessary work.
- The personnel involved are properly kitted out to ensure their protection during treatments.
- The sites are always very clean. Avoid leaving waste lying around.
- Equipment, tools and work clothes are always clean and treatment apparatus properly rinsed.
- The forest soil used to fill polybags is free of pathogens and pests, and check that the place from which it is taken does not entail any risk of diseases, such as *Ganoderma* or *Fusarium* (see the "Soil" chapter).
- The sites, pre-nursery bags and nursery bags contain no weeds before transferring seeds or seedlings (see "Other Plants" chapter).
- Irrigation water is of good quality (avoid using reserves of stagnant water, which may contain pathogenic germs).
- Shade is installed over the prenursery and that a strip of at least 25 metres wide is cleaned all around the prenursery and nursery, to limit the development of insects that vector certain pathologies such as blast in Africa, chlorotic ring and dry bud rot in Latin America (see "Light" chapter).
- The prenursery and nursery site is surrounded by a 1.50 m high wire fence buried 20 cm deep to keep out harmful animals.
- A wire guard is installed around the collar of young palms just before planting out to protect from rodents.

Seedling protected with a wire guard prior to planting

In Asia, it is quite common **to sow nectar-bearing plants** such as *Turnera subulata, Antigonon leptopus* or *Cassia cobanensis* around nurseries, and around or even inside plantations. Their flowers are reputed to attract certain useful insects that are predators or parasitoids (small wasps) of leaf-eating caterpillars.

Blast: 1st symptoms and advanced symptoms (see p.114 and 116)

Dry bud rot in the nursery (see p.116)

Chlorotic ring (see p. 116)

Main pests encountered in the prenursery and nursery

Insects	Leaves	Hemiptera	*Recilia mica*	Africa	This leafhopper is considered to be the vector of Blast, a particularly serious disease in Africa. The insect measures 2.9 to 3.3 mm and is pale grey. It is very frequent on young palms and in nurseries from November to January. It can kill up to 50% of plants in a nursery.
			Cerataphis variabilis *Rhopalosiphum rufiabdominales* *Myzus persicae*	Asia	By sucking young emerging fronds, these aphids can cause spear distortion. Myzus persicae might transmit chlorotic spot, a viral disease.
			Planococcus citri	All continents	This scale insect colonizes the underside of leaves, but also the collar and roots. It is often brought by ants.
			Sogatella kolophon *Sogatella cubana*	Pacific Africa Latin America	Insect vectors of dry bud rot disease.
		Lepidoptera	*Metisa plana* *Spodoptera litura* *Spodoptera littoralis*	Asia	Lepidoptera that can cause severe damage in prenurseries and nurseries and also in plantations under 10 years old. Their larvae strip the epidermis of the leaf.
		Orthoptera	Grasshoppers *Zonocerus variegatus*	West Africa	Defoliation.
		Hymenoptera	Ants *Atta cephalotes*	Latin America	Defoliation.
	Collar Roots	Orthoptera	Crickets	All continents	Can cause severe damage in prenurseries and nurseries, by cutting the collar of young seedlings.
		Hemiptera	*Planococcus citri*	All continents	This scale insect colonizes the underside of leaves, but also the collar and roots. Often brought by ants.
		Coleoptera	*Temnoschoita quadripustulata*	Africa Latin America	Small weevil parasitizing wounds. White grubs in the root bulbs and petiole bases of nursery plants.
			Strategus aloeus	Latin America	Adults mine a gallery 10 or 20 cm from the foot of the young palm, then attack the root mat and destroy young tissues.
Mites	Leaves	Red spiders	*Tetranychus piercei*	Asia	Reddish brown mites whose adults measure less than a millimetre. At all stages, the mite sucks the plant continually, causing the leaves to turn a bronze or even yellow colour. Development of the young palm is considerably slowed down.
			Tetranychus mexicanus	Latin America	
			Eutetranychus enodes	Africa	
Gastropods	Leaves	Snails Slugs	*Achatina fulica*	All continents	Can sometimes cause serious damage if not controlled, especially in Asia.
Birds	Seeds	Parrots Parakeets		Asia	Surveillance needed.
Mammals	Collar Roots	Rats, field mice		All continents	Rodents cut young palms at the collar, which often kills them.

Crickets in the nursery

Atta ant damage in Colombia

Main diseases and abnormalities encountered in the prenursery and nursery

Diseases	Roots	Damping off	*Pithyum* *Rhizoctonia*	Africa	When these two fungi are present in the substrate, they can cause root rot and would appear to be implicated in Blast disease. The leaves of the young palm become discoloured, then necrotic and the palm ultimately dies.
	Leaves	*Cercospora* leaf spot	*Cercospora elaeidis*	Africa	A fungus causing orangey-brown freckles on old leaves, followed by necrosis.
		Curvularia leaf spot	*Curvularia oryzae*	Asia	A fungus causing round to oval necrotic yellow spots on the leaves.
		Pestalotiopsis leaf spot	*Pestalotiopsis sp.* *Pestalotia sp.*	Latin America	Small purplish brown spots that increase in size. The centre becomes ash grey with black specks.
		Anthracnose	*Botryodiplodia* *Colletotrichum sp.* *Melanconium*	Africa Asia	Fungi responsible for anthracnose. Small, round brown spots, which elongate with a yellow or dark brown halo.
		Chlorotic ring	Potyvirus	Latin America	Mottling on all the leaves, though not leading to the death of the plant. The disease would seem to be caused by a potyvirus. The disease might be transmitted by the aphid *Myzus persicae*.
		Orange spotting	*Cadang Cadang Coconut Viroid (CCCVd)*	Asia Pacific	Orange spots, especially on old leaves. Deterioration of the root system and palm death. Assumed to be transmitted by insects and contaminated tools.
	Leaves Cabbage	*Dry bud rot*	Causal agent unknown	Africa Latin America	The disease is spread by two insects, *Sogatella cubana* and *Sogatella kolophon*, which develop on grasses. Yellow and white patches on the spear or first leaf, then spear necrosis. The symptoms especially appear in unshaded nurseries, and also in the first years after planting out. In plantations, yellowing, followed by desiccation from the youngest fronds to the oldest. Purplish-wine coloured patches in the stem.
		Ring spot	African Oil Palm Ring Spot Virus (AOPRV)	Latin America	Affects nursery plants and plantations up to 3-4 years old. Yellowing of the youngest fronds, sometimes with scattered spots on the leaflets and base of the rachis. Meristem necrosis kills the palm. The disease might be transmitted by the aphid *Myzus persicae*.
	Leaves Spear Roots	Blast	Causal agent unknown Mycoplasmas suspected	Africa	Disease transmitted by the leafhopper *Recilia mica*. Blackish-brown wet rot at the base of the spear and basal yellowing of young fronds. Brown discolouration of lower fronds. Wet rot of the root cortex. Rapid death of the palm through frond desiccation. The development of this disease can be limited by providing shade and eliminating grasses.
Genetic abnormalities	Leaves	Crown disease		All continents	Appears on particular crosses in the nursery and is characterised by slightly wet rot of the central leaflets of the spear. In plantations, the symptoms take the form of more or less severe bending of the rachis of certain fronds, which disappears over time.
		Chlorophyll deficiency		All continents	This abnormality may appear on certain E. guineensis x E.oleifera interspecific hybrid crosses. A multitude of small brown spots edged with yellow, causing leaflets to dry out. Desiccation is ascendant and the symptoms are not very visible on young leaves. Generally lethal abnormality.

Ring spot

Pestalotiopsis on a hybrid in Colombia

Seedling affected by *Curvularia* in Thailand

Cercospora leaf spot in a Nigerian nursery plantation

An oil palm plantation is an environment where the biodiversity of both plants and animals naturally increases with the age of the plantation. A balance becomes established between populations of pest insects and those of parasitoids or predators. That balance is sometimes broken and outbreaks of certain species can suddenly occur. Such outbreaks can be facilitated by cultural practices, if they are not properly mastered.

Prevention is always preferable, as chemical treatments are not selective and destroy both harmful and beneficial insects. Once broken, the balance takes several months to recover.

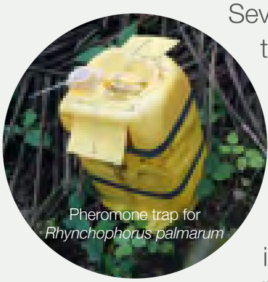
Constant surveillance of the plantation is essential for that reason. Care should therefore be taken to organize inspection rounds by properly trained teams. Alert thresholds that trigger curative control operations have been established for pests whose economic damage is known to be severe. Larva, caterpillar and imago counts on leaves must be carried out before reaching a decision.

This is essential for detecting the first developments of diseases or insect attacks, and treating them before they spread.

The inspection teams can be specialized in diseases and in pests. The inspection round frequency is once a month and a detailed record is kept. Nowadays, drones fitted with a camera can help these teams detect infestation foci, but they will never replace a careful human examination on the ground.

For biological control, several techniques and specialities are offered to growers:

- Traps using attractants, which trap certain insects and can prove useful for monitoring population levels, warning and taking action before they become economically damaging for the plantation. They can also be used actually to control those populations.


Pheromone trap for *Rhynchophorus palmarum*

Several attractants are available. Pheromones can be used, but in the case of *Rhynchophorus palmarum* (a very common beetle in Latin America and a vector of red ring disease), their use is greatly disputed: the traps must only be installed around the outside of a plantation, to avoid attracting *Rhynchophorus* into it and worsening the problem rather than solving it.

Sugarcane molasses or pieces of crushed sugarcane are used inside the traps. The same type of fermented attractant, but with a different trap, is used for *Opsiphanes*. Trapping *Stomoxis calcitrans* (stable fly) using blue, sticky plastic panels is used to monitor population sizes and determine when to act. This bloodsucking fly is not a direct pest on oil palms, but it multiplies in all organic matter, including empty bunches, which raises serious problems for livestock farmers in Amazonia and the Colombian Llanos region.

- Spraying solutions containing:
  - entomopathogenic viruses has given some positive results on nettle caterpillars, such as *Sethothosea asigna* and *Setora nitens* in Indonesia, and on *Sibine fusca* in Colombia;
  - a fungus such as *Cordiceps militaris* is used to control *Setora nitens* in Asia;
  - a bacterium such as *Bacillus thuringiensis* has been tested in Asia to control *Metisa plana*.
- Several strains of the fungus *Trichoderma* are also used to control *Ganoderma*, but their effectiveness remains to be proved.
- The introduction of barn owls and the installation of nesting boxes in plantations helps to control populations of rats, which can cause serious yield losses.

Many cultural techniques also help to prevent pests and diseases from developing. Care should be taken to:

- Only plant healthy and vigorous seedlings. Before planting, it is essential to cull palms in the nursery to optimize yields in the plantation (see the "Planting material" section).
- Protect young palms from rodents by surrounding the collar with a wire guard before planting.
- Eradicate all diseased palms before replanting. In a plot infected by *Ganoderma* or *Fusarium*, care should be taken to replant at the same density as the one used previously (see the "Density" chapter).
- Carry out shredding of felled oil palm stems when replanting, which can be worthwhile as decomposition is faster, thereby preventing *Oryctes* from completing its cycle. For the same reason, this practice would offer the advantage of slowing down *Ganoderma* development.
- Sow a cover crop, such as *Mucuna* or *Pueraria*, to prevent weeds from developing and limit *Oryctes* damage in young plantations, by forming a physical barrier against that beetle.
- Spread empty bunches in the plantation and windrow pruned fronds. This helps to improve the physical and chemical quality of the soil by providing organic matter and recycling mostly potassium (for empty bunches), and potassium and nitrogen (for leaves). In Latin America, spreading EFB in the weeded circle around young palms also limits damage by *Sagalassa* in the first year after planting (physical barrier).
- Install a good drainage network if necessary. In Latin America, drainage would appear to slow down Bud Rot development.

Fertilization could play a role in disease control. For instance, KCl, tricalcium phosphate or potash applications can slow down or reduce the development of *Fusarium oxysporum* F.sp. *elaeidis*. Potash also plays a role in controlling *Ganoderma*.

Main pests encountered in plantations

Insects	Leaves	Hemiptera	*Haplaxius crudus*	Latin America	This leafhopper is considered to be the vector of lethal wilt (marchitez letal).
			Leptopharsa gibbicarina	Latin America	The larvae and adults suck the underside of leaflets. The severest damage results from the development of the fungus of the genus *Pestalotiopsis*.
			Lincus spp	Latin America	This bug is considered to be the vector of sudden wilt disease (marchitez sorpresiva).
			Sogatella kolophon *Sogatella cubana*	Pacific Africa Latin America	Insect vectors of dry bud rot disease.
		Lepidoptera	*Metisa Plana* *Mahasena corbetti*	Asia	Formidable pests in Indonesia and Malaysia, causing severe defoliation. The caterpillars and female adults live in a bag consisting of plant debris agglomerated by a network of silk threads secreted by the caterpillar.
			Setora nitens *Setothosea asigna* *Thosea spp.*	Asia	Severe defoliation in young and old plantations.
			Latoia pallida *Latoia viridissima*	West Africa	Usually defoliation on palms more than 4 years old.
			Stenoma cecropia	Latin America	Stripping of leaf epidermis, causing desiccation. The wounds provide access to Pestalotiopsis.
			Sibine fusca, *Sibine spp*		Stripping of leaf epidermis, then complete defoliation.
			Euprosterna eleasa *Euprosterna copula*		Defoliation. The damage can sometimes encourage *Pestalotiopsis*.
			Euclea Diversa		Defoliation. The damage can sometimes encourage *Pestalotiopsis*.
			Brassolis sophorae		Nests can contain up to 1,000 individuals and defoliation can be total.
			Opsiphanes cassina		The caterpillar is green with yellow strips and can be up to 9 cm long.
		Coleoptera	*Coelaenomenodera lameensis* *Coelaenomenodera minuta*	West Africa Central Africa	Eggs are inserted into the underside of the leaf. Mining of small furrows in the leaf. Very large populations.
			Spaethiella tristis	Latin America	The larvae strip the underside of leaves and the adults mine small furrows.
			Metamasius hemipterus	Latin America	The entire cycle of this beetle takes place in the petiole bases of leaves and in the rachis of pruned fronds. It is considered by some to be another vector of red ring disease by disseminating the nematode *Rhadinaphelenchus cocophilus*, the causal agent of the disease.
		Orthoptera	Grasshoppers *Zonocerus variegatus*	West Africa	Defoliation.
		Hymenoptera	*Atta cephalotes*	Latin America	Leaf cutting.

Opsiphanes cassina caterpillar and adult

Setora nitens in Indonesia

Coelaenomenodera lameensis larva

Lincus spp.

Marchitez sorpresiva and its vector

Main pests encountered in plantations

Insects	Spear Cabbage	Blattoptera	*Coptotermes curvignathus*	Asia	These termites invade young oil palm spears causing damage to the apical meristem, which can even lead to palm death.
		Lepidoptera	*Tiquadra spp.*	Ecuador Colombia	The larva can attack the spear and cause "whip-like" defoliation, which can be confused with Bud Rot.
		Coleoptera	*Alurnus humeralis*	Ecuador Colombia	Eggs are laid near the oil palm cabbage. The young larvae feed off the cabbage, and then move to the basal section of young frond petioles.
			Oryctes rhinoceros	Asia	The adult mines galleries in the base of young oil palm spears. The attacks can be lethal.
			Oryctes monoceros	Africa	
			Scapanes australis	Asia	
	Stipe	Lepidoptera	*Cyparissius daedalus*	Latin America	The caterpillar can be up to 13 cm long and mines galleries in bunches and stems.
		Coleoptera	*Strategus aloeus*	Latin America	The adults mine galleries at the foot of palms and move up to the meristem.
			Rhynchophorus phoenicis	Africa	The adults lay eggs in wounds on palms. The larvae, which can reach 4 to 5 cm, mine galleries in the fresh tissues, which can kill the palm. *Rynchophorus palmarum* is the vector of red ring disease by disseminating the nematode *Bursaphelenchus cocophilus*, the causal agent of the disease.
			Rhynchophorus palmarum	Latin America	
			Rhynchophorus vulneratus	Asia	
			Rhynchophorus ferrugineus	Asia Oceania	
	Collar Roots	Lepidoptera	*Sufetula sunidesalis*	Asia	The larva attacks root tips in which it mines a gallery, leading to the emission of new roots. In peat soils, attacks can be very substantial, with a severe drop in yields.
			Sufetula diminutalis	Latin America	
			Sufetula nigrescens	Africa	
			Sagalassa valida	Latin America	The larva mostly causes damage in young plantations bordering on forests. It destroys the root system by mining galleries.
	Bunches Fruits	Hemiptera	*Dysmicoccus spp.*	All continents	These scale insects suck sap from the mesocarp of the fruits.
		Lepidoptera	*Cyparissius daedalus*	Latin America	The caterpillar, which can reach up to 13 cm, mines galleries in bunches and stems.
			Elaeidiphilos adustalis	West Africa	The larva feeds off the stylus and stigmata of female flowers, and then encases itself in a silken cocoon. Sometimes, all the female flowers are wrapped in silk threads preventing their fertilization.
			Tiquadra spp.	Colombia Ecuador	The larva eats away the mesocarp of fruits and causes the bunch to rot.
			Tirabatha rufivena	Asia	The larva attacks male and female flowers, and young fruits.
		Coleoptera	*Protoestus sculptilis*	West Africa	The larva mines a downward gallery around the gynoecium. The female flower can be cut in two.
			Imatidium neivai	Latin America	The larva eats away the surface of the fruit, which turns grey, and ripening can no longer be detected.

Cyparissius daedalus : cocoon-caterpillars-chrysalises and adult

Oryctes rhinoceros larva

Rhynchophorus ferrugineus

Rhynchophorus palmarum

Main pests encountered in plantations

Mites	Leaves		*Retracus elaeis*	Latin America	Development in the dry season. Sucking leads to the formation of brownish oily spots, which turn orange. The oil palms can become completely orange.
Gastropods		Snails Slugs	*Achatina fulica*	All continents	Damage to leaves and meristem.
Nematodes			*Bursaphelenchus cocophilus*		This nematode is carried by the weevil *Rhynchophorus palmarum*, with infested females depositing it at the same time as their eggs in leaf axils. The nematodes enter egg-laying wounds, where they develop then gradually invade all the tissues of the plant, generally killing it between 2 and 4 months after infection.
Birds	Leaves Fruits	Weaverbirds Parrots	*Ploceidae* *Psittacidae*	Africa Asia	Damage to leaves. Damage to fruits.
Mammals	Whole plant	Cattle		All continents	Cattle trample young palms and may eat leaves.
		Rats Field Mice Porcupines		All continents	Rodents cut young palms at the collar, which often kills them.
		Capibaras		Latin America	

Weaverbird damage

Tiquadra Spp. (see p.122)

Dysmicoccus spp. on fruits (see p.122)

Temnoschoita quadripustulata larvae (see p.114)

Sufetula sunidesalis (see p.122)

Mahasena corbetti bag and caterpillars (see p.120)

Main diseases encountered in plantations

Diseases	Roots Stem	*Fusarium* wilt	*Fusarium oxysporum F. sp. elaeidis*	Africa	This fungus is located in the woody vessels of the roots and stem. There are two forms of the disease. The chronic form resulting in a stunted palm, which does not usually die, and the acute form, which usually kills the palm rapidly within 5 months after symptoms appear. The fronds dry out and collapse, forming a skirt around the stem.
		Ganoderma	*Ganoderma boninense*	Asia Africa Not common in Latin America	Chlorosis of the leaf crown, then wilting of old fronds, which collapse forming a skirt around the stem. The first symptoms can resemble those of drought. Presence of fruiting bodies on the stem. Decomposition of internal tissues at the base of the stem, often leading to the appearance of a crack and the collapse of the palm.
	Cabbage	Bud Rot complex (P.C.)	*Phytophthora palmivora ?*	Latin America	The symptoms can be very variable depending on the geographical zone. They usually begin with young leaf chlorosis. More or less wet rot then develops under the leaflets of the spear leaves. There is deliquescence of the tissues at the base of those leaves, which then spreads to the meristem.
		Sudden wilt (Marchitez Sorpresiva)	*Phytomonas sp.*	Latin America	This disease is transmitted by a bug, Lincus sp. or Ochlerus. Rapid rotting of all developing bunches, drying out of the leaves from the oldest fronds to the youngest. Death of the palm within 4 to 6 weeks.
		Lethal wilt (Marchitez letal)	Agent unknown	Latin America	Symptoms quite similar to those of sudden wilt (Marchitez Sorpresiva). The disease would seem to be transmitted by the leafhopper Haplaxius crudus.
		Ring Spot	African Oil Palm Ring Spot Virus (AOPRV)	Latin America	Affects nursery plants and plantations up to 3-4 years old. Yellowing of the youngest fronds, sometimes with scattered spots on the leaflets and base of the rachis. Meristem necrosis kills the palm. The disease might be transmitted by the aphid *Myzus persicae*.
		Dry Bud Rot	Agent unknown	Africa Latin America	The disease is spread by two insects, *Sogatella cubana* and *Sogatella kolophon*, which develop on grasses. Yellow and white patches on the spear or first leaf, then spear necrosis. The symptoms especially appear in unshaded nurseries, and also in the first years after planting out. In plantations, yellowing, followed by desiccation from the youngest fronds to the oldest. Purplish-wine coloured patches in the stem.
	Leaves Stem	Red ring	*Bursaphelenchus cocophilus*	Latin America	Shortening of the leaves in the crown and grouping of young fronds in a compact mass. Older fronds collapse and hang down the stem. Radial cutting of the lower part of the stem reveals a brown ring a few centimetres from the edge. *Rhynchophorus palmarum* is considered to be the main vector of the disease by disseminating the nematode *Bursaphelenchus cocophilus*, the causal agent of the disease. Attacks usually occur on palms more than 5 years old and death can occur between 2 and 4 months after infection.

Diseases	Leaves	Basal petiole rot	*Agent unknown*	Latin America	Slight shortening of the central fronds and spear, with intermediate fronds sometimes breaking. Bunch rot before ripening. Petiole bases display rot, which can reach the peripheral section of the stem.
		Pestalotiopsis leaf spot	*Pestalotiopsis sp.* *Pestalotia sp.*	Latin America	Small purplish brown spots that increase in size. The centre becomes ash grey with black specks.
		Chlorotic ring	*Potyvirus*	Latin America	Mottling on all the leaves, though not leading to the death of the plant. The disease would seem to be caused by a potyvirus. The disease might be transmitted by the aphid *Myzus persicae*.
		Orange spotting	*Cadang Cadang Coconut Viroid (CCCVd)*	Asia Pacific	Orange spots, especially on old leaves. Deterioration of the root system and palm death. Assumed to be transmitted by insects and contaminated tools.tools.
Genetic abnormalities	Leaves	Crown disease		All continents	Appears on particular crosses in the nursery and is characterised by slightly wet rot of the central leaflets of the spear. In plantations, the symptoms take the form of more or less severe bending of the rachis of certain fronds, which disappears over time.
		Chlorophyll deficiency		All continents	This abnormality may appear on certain *E. guineensis* x *E.oleifera* interspecific hybrid crosses. A multitude of small brown spots edged with yellow, causing leaflets to dry out. Desiccation is ascendant and the symptoms are not very visible on young leaves. Generally lethal abnormality.

Crown disease

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PalmElit is a simplified joint stock company owned by CIRAD and Sofiprotéol. Its head office is near Montpellier, in France.

Following on from IRHO (1941) then CIRAD (1984), PalmElit has been conducting the genetic improvement and marketing programmes for CIRAD® oil palm seeds since its creation in 2009. Its breeding programmes involve 64 PalmElit and CIRAD researchers, engineers, Ph.D. students and technicians.

PalmElit also benefits from the support of 8 partners including a public institute and 7 private firms for the selection, production and marketing of CIRAD® oil palm seeds. This network, located in Africa, America and Asia includes 1,600 hectares of field trials and 8 seed gardens.

PalmElit proposes seeds intended to guarantee regular incomes for family farms and agroindustries.

Seeds are improved to meet the expectations of the main stakeholders in the supply chain:

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Intermediate to high resistance to the Bud Rot complex

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#L Low Lipase
Reduced oil acidity

#S Short
For better plantation sustainability

#C Compact
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Supermachos
Palms for pollen production

RSPO Sustainability at the heart of our values

RSPO is a not-for-profit organization that unites stakeholders from seven sectors of the palm oil industry: oil palm producers, processors, or traders, consumer goods manufacturers, retailers, banks/investors, and environmental and social non-governmental organisations (NGOs).

RSPO has developed a set of "Principles and Criteria" designed to protect the environment and communities in palm oil producing countries.

7 principles for RSPO certified production

1. Behave ethically and transparently
2. Operate legally and respect rights
3. Optimise productivity, efficiency, positive impacts and resilience
4. Respect community and human rights and deliver benefits
5. Support smallholder inclusion
6. Respect workers' rights and conditions
7. Protect, conserve and enhance ecosystems and the environment.

Thanks to the RSPO, the oil palm supply chain has developed and made available on its website some very useful tools for preparing a sustainable oil palm project, including small-scale projects. These tools also help to make the project certifiable from the outset.

As an affiliate member of the RSPO, PalmElit strongly recommends that project initiators procure and use these tools.

www.rspo.org

Bibliography

Jean-Charles Jacquemard, Le palmier à huile. Editions Quæ, Cta, Presses agronomiques de Gembloux 2011.

Oriane Plédran, Sylvain Rafflegeau et Patrice Levang, "L'adaptation du contexte institutionnel : condition sine qua non du développement durable des palmeraies camerounaises", VertigO la revue électronique en sciences de l'environnement [En ligne], Volume 16 numéro 2 | septembre 2016, mis en ligne le 09 septembre 2016, consulté le 21 novembre 2016. URL : https://journals.openedition.org/vertigo/17757 ; DOI : 10.4000/vertigo.17757.

Brandão F and Schoneveld G. (2015). The state of oil palm development in the Brazilian Amazon. Working Paper 198. Bogor, Indonesia: CIFOR.

Jean-Charles Jacquemard (1992). Choix des plantules de palmier à huile en pré-pépinière...
Oléagineux, Vol. 47, n°1 – janvier 1992 – Conseils de l'IRHO – 325.

Willy Wuidart et Dominique Boutin (1976). Palmier à huile. Choix des plants de pépinière. Oléagineux, Vol. 31, n°s 8 -9 août – septembre 1976 – Conseils de l'IRHO – 164.

Pierre Quencez (1990). Arrosage par aspersion des pépinières de palmiers à huile en sacs plastiques, Oléagineux, Vol. 45, n°12 - Décembre 1990 – Conseils de l'IRHO – 314.

Fedepalma (2012). Guía de prácticas agrícolas en el cultivo de palma de aceite ya establecido.

Woittiez, Lotte & Van Wijk, Mark & Slingerland, Maja & Van Noordwijk, Meine & Giller, Ken (2017). Yield gaps in oil palm: A quantitative review of contributing factors. European Journal of Agronomy. 83. 57-77. 10.1016/j.eja.2016.11.002.

Jean-Charles Jacquemard et Dominique Boutin (CIRAD, 2008). Semences germées de palmier à huile CIRAD® Recommandations pour la conduite de la pré-pépinière et de la pépinière.

Irina Comte, François Colin, Olivier Grünberger, Stéphane Follain, Joann K. Whalen, Jean-Pierre Caliman (2013), Landscape-scale assessment of soil response to long-term organic and mineral fertilizer application in an industrial oil palm plantation,Indonesia. Agriculture, Ecosystems & Environment Volume 169, 1 April 2013, Pages 58-68.

Tampubolon, F. C., Daniel, C., & Ochs, R. (1989). Oil palm responses to nitrogen and phosphate fertilizer in Sumatra (pp. 419–428).
Presented at the 1989 PORIM International Palm Oil Development Conference, Kuala Lumpur.

Rajaratnam, J. A. (1972). The distribution and mobility of boron within the oil palm, *Elaeis guineensis* L. II:
The fate of applied boron. Annals of Botany, (36), 299–306.

De Franqueville H., Diabaté S. (1995). La fusariose du palmier à huile en Afrique de l'Ouest. Plantations, recherche, développement - Juillet - Août 1995.

Fuad Nurdiansyah, (2016). Local and Landscape Management of Biological Pest Control in Oil Palm Plantations.
Dissertation for the award of the degree "Doctor of Philosophy" of the Georg-August-Universität Göttingen, Faculty of Crop Sciences.

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Dominique Mariau, (CIRAD, 2000). Les ravageurs du palmier à huile et du cocotier.

Dominique Mariau (2000). Problèmes entomologiques en replantation des palmeraies et des cocoteraies. Oléagineux, Corps Gras, Lipides. Volume 7, Numéro 2, 203-6, Mars - Avril 2000.

Aude Verwilghen (2015). Rodent pest management and predator communities in oil palm plantations in Indonesia: a comparison of two contrasting systems. Ecosystems. Univ. de Franche-Comté, 2015. English.

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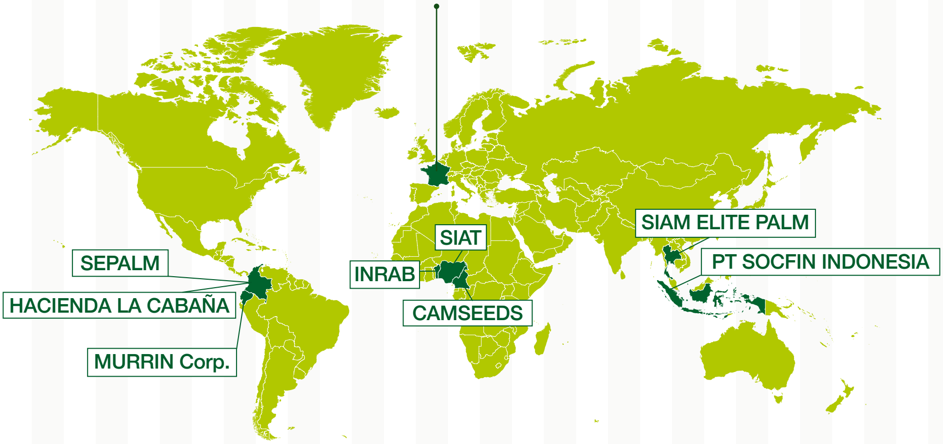
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Notes

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