Introduction

1

Abstract

The performance of oil palm plantations is determined from an early stage by the quality of the planting materials. These are mainly seedlings, but ramets (usually produced from tissue culture cloning) are also used. Raising seedlings and ramets is performed in a nursery. The aim of oil palm plantations is to produce high yields, and a basic necessity is the provision of good quality planting materials. This in turn requires good nursery practices. Direct planting of oil palm seed is possible, but it cannot produce uniform materials. Nursery-grown seedlings or ramets provide healthy, strong and uniform planting materials at a suitable stage for field planting, which results in good seedling/ramet establishment and thus a high yield potential. Nursery practices are therefore a critical component of the oil palm plantation industry. In addition to commercial young plant production, seedlings and ramets are also needed for trialling (young plant screening and mature palm field performance testing) to assess progenies and breeding lines for selection and breeding and materials for pest and disease resistance or tolerance to abiotic stresses and responses to, and suitability for, changing agronomic practices and new planting materials.

1.1 History of Oil Palm Nursery Practices

The health of palms coming from the nursery has a huge effect on plant establishment once transplanted into the field. Thus, great attention needs to be paid to nursery techniques at all stages, from sowing seeds or planting ramets to the delivery of field-ready plants in the best condition possible.

Various systems have been developed in oil palm-growing countries around the world. Countries may vary in climate, soils, pest and disease incidence and management. Oil palm seedlings in Africa, for example, have specific challenges due to seasonal climate changes as compared to

Southeast-Asia, which has a more uniform climate. This, in turn, affects the occurrence of nursery diseases, and was a stimulus to initiate nursery research in West Africa (Corley and Tinker, 2015).

Early methods that were set as standards in oil palm nurseries, and which lasted until the 1960s, involved sowing germinated seeds in pre-nursery beds or pots at high density, and then transferring the young plants to a specially prepared nursery for about a year, until the seedlings reached the four- to five-frond stage. In Southeast Asia, large polythene bags were introduced in the mid-1960s to raise seedlings and this became the standard practice. Growing young oil palm plants (seedlings and ramets) in planting bags of various sizes has been tried, tested and developed. Small planting bags proved to be convenient for sowing germinated seeds and planting tissue culture-produced ramets, which are then transferred to larger bags in the main nursery. This is also cheaper than field nursery practices (described briefly below). Growing young palms in bags reduces labour costs and provides a convenient means of transporting plants from the nursery to the field. As with many plant species, this practice also reduces plant stress, as there is minimal disturbance to the plant during transfer (especially over large distances/time) and during field planting. The various stages of planting materials from seed to field-ready plants are illustrated in Table 1.1. Traditional oil palm nurseries have a high demand/use of polybags which raises concerns for the environment. Alternatives such as the use of biodegradable bags and reusable plastic trays are therefore of interest and a welcome development.

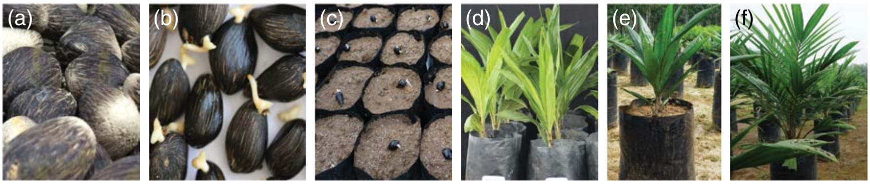

Fig. 1.1. Seed and seedling development in an oil palm nursery. a) Un-germinated seed; b) Germinated seed ready for sowing (0 weeks); c) Sowing seedlings; d) Seedlings in small bags ready for transplanting (12 weeks); e) Transplanted seedling in big bag with spacing (main nursery); f) Palms in big bag ready for field planting (36–48 weeks).

Direct planting of oil palm germinated seed in the field is possible, but there are several problems. First, there is a significant risk of damage from animals (especially insects and rodents). Secondly, the plants generated will not be uniform and abnormal palms cannot be discarded. Thirdly, there is wastage of time in crop production: palms take longer to mature and bear fruit, compared to planting field-ready plants raised in a nursery (Turner and Gillbanks, 2003; Corley and Tinker, 2015). Thus, direct field planting is generally neither practical nor economical and so is not recommended. It is instead recommended that reputable suppliers provide seed, seedlings, and/or ramets for the nursery production of field-ready plants.

Note: seeds extracted from fruits produced in commercial plantations and volunteer palm seedlings in a plantation should never be used as planting materials because commercial oil palm has a Tenera fruit form (thin shelled) which is produced by crossing a Dura (thick shelled fruit) female with a Pisifera (no shell) male. This is achieved by careful and deliberate cross-pollination by seed-producing companies and is not what occurs by random open pollination of commercial Teneras – the trait is not true breeding (see Setiawati *et al*., 2018).

In some circumstances, bare-rooted seedlings (such as those removed from the wild in African jungles) may be transferred to the nursery. Here, sand beds, raised beds, frames and wedge practices may be used as described by Duckett (1999).

There are two commonly used oil palm nursery types: single and double stage. Single stage involves a main nursery only; double stage involves a pre-nursery and a main nursery stage. The various activities of a single- and double-stage nursery are shown in Table 1.1 and a general layout of a nursery is given in Fig. 1.2.

Table 1.1. Activities in single- and double-stage oil palm nurseries.

Activity	Single-stage nursery	Double-stage nursery
Sowing seed	√	√
Use of small bags		√
Use of large bags	√	√
Transplanting		√
Spacing	√	√
Irrigation	√	√
Pest and disease control	√	√
Culling	√	√

The decision as to which nursery system should be used depends on circumstances, which are discussed in the next section.

1.2 Importance of Nursery Best Management Practices

Oil palm is a crop that comes into maturity at about 20–25 months after field planting. The earlier it is in production the earlier the profits can be reaped. Peak yield occurs at 4–5 years after first harvest or 9–18 years after field planting (Alam *et al*., 2015). Good nursery management provides strong and healthy plants (seedlings or ramets), which lead to good field establishment after planting and, in turn, promotes early flowering and fruit production and thus early and high yields. This then leads to a long productive life span of the plantation. Substandard planting materials will have long-term consequences for yield, i.e. throughout the lifetime of the plantation, which may be as long as 25 years (Heriansyah and Tan, 2005).

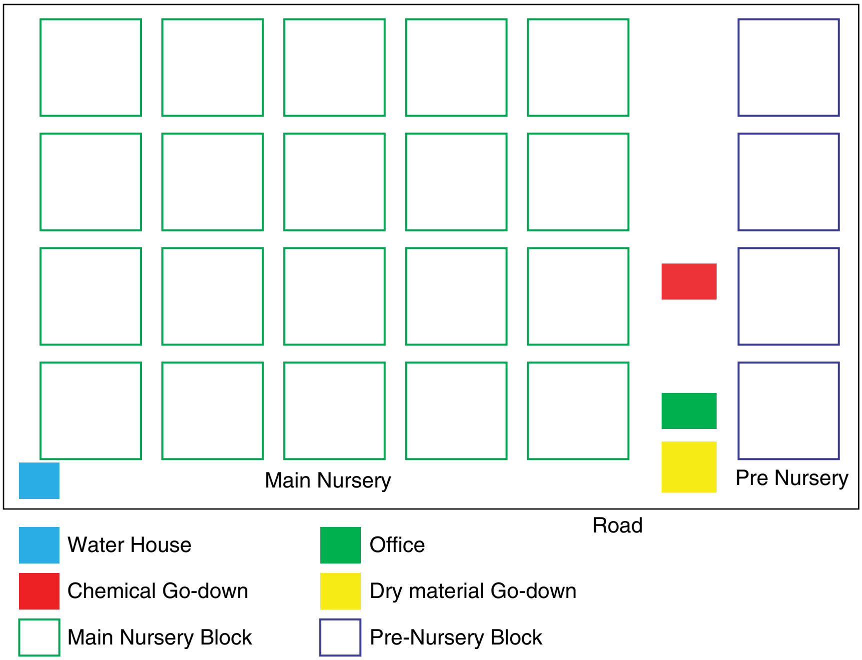

Fig. 1.2. Components of an oil palm nursery layout: blocks in the main nursery and pre-nursery, road access, dry and chemical go-down/store, water house, road construction and office. Other off-site facilities include soil supply, incinerator and offices.

The production of superior oil palm planting material is dependent on all stages and all procedures in the nursery. The procedures of an oil palm nursery need to be followed stringently.

a) **Seedlings.** Area preparation, single-/double-stage nursery, nursery maintenance (manure and fertiliser application, watering, culling and weeding), pest and disease control.
b) **Ramets.** Activities are the same as seedlings, the difference is in shading young ramets and a longer pre-nursery period for acclimatisation from tissue culture conditions.

Oil palm seedlings are developed from germinated seeds arising from controlled pollination (either for commercial production or breeding purposes). Ramets (plantlets) are clones produced from tissue culture. Both are raised using the standard operating procedures (SOPs) of nursery husbandry. Basic requirements are adequate sunshine/shading, potting soil, water, supplementary nutrients and control of pests and diseases (Duckett, 1999). The production of good quality planting materials is the main objective; the end product is field-ready planting material that is uniform, healthy and vigorous. It is possible, if needed, to hold palms in the nursery until the optimal planting time, as determined by the needs of the planter (Heriansyah and Tan, 2005).

As mentioned above, there are two types of oil palm nursery: single stage and double stage. The main advantage of the single-stage nursery is a reduction, by about two months, of the overall time spent in the nursery (Bevan and Gray, 1969; see also Table 1.1). The single-stage nursery gives larger palms for field transplanting at 13 months from germination. However, such operations require high labour and water requirements in the first four months, in turn requiring close supervision, especially at the initial plant growth phase. Such nurseries also require a larger total area (Rankine and Fairhurst, 1998).

Traditional nursery practices use large amounts of polybags. Single-use plastic is now being replaced by more environmentally friendly practices such as the use of biodegradable bags and re-usable plastic trays. Raising oil palm seedlings in a nursery pot tray system was reported by Chee *et al.* as early as 1997. This system can be used repeatedly to raise up to 20 cycles of oil palm seedlings, and the pot trays used can be built from recycled plastic. Mathews *et al.* (2010) reported that this method is being taken up by most oil palm companies. In the pre-nursery stage this method is more efficient: the area needed per seedling is less (up to 169 seedlings/m^2), less planting medium required, ease of transfer and more sustainable.

The large polybags that are currently used traditionally in the Main nursery stage can be replaced by biodegradable bags. Muriuki *et al.* (2013) and Bilck *et al.* (2014) describe benefits of biodegradable bags, a major benefit, aside from sustainability, is that the bag containing the seedling can be direct planted, thus avoiding root disruption. Another sustainable issue in the nursery is the use of topsoil. Small planting bags usually require about 1.2 kg of soil per seedlings, but this can be reduced to a tenth if pot tray systems are used (Mathews, *et al.*, 2010). However, the quantities of topsoil required in the Main nursery is considerably larger, up to 20-25 kg/planting bag (CIRAD, 2008). Alternatives are now being used. Cocopeat, compost, POME (palm oil mill effluent) are materials that may be used to mix with soil. Mohammad *et al.* (2012) reported the effective use of 100% cocopeat, and Lord and Betitis (2007) showed no differences between 100% soil and 100% compost (POME) derived from oil palm empty fruit bunches (a bi-product from oil palm mills). Thus, topsoil usage can be reduced or even eliminated.

Other important and routine aspects in nursery plant care include fertiliser application, watering, monitoring and controlling pests and diseases, as well as culling of off-type plants. It is recommended that fertiliser treatments of young oil palm plants are a combination of organic fertiliser and compost applications. Organic fertilisers are preferred over inorganic fertilisers because they are milder and there is less risk of damage caused by more aggressive inorganic chemicals. In addition, organic fertilisers improve the physical, chemical and biological properties of the soil and can provide carbon compounds that may also improve the physical properties and microbial community of the soil (Ariyanti *et al.*, 2018; see also Chapter 6).

The availability of water is essential to meet the needs of actively growing young plants. Water deficiency has negative effects on plant metabolism, physiology and morphology, as well as disease and pest susceptibility, and can be hugely damaging to young plants. If neglected, plant death can result (Sun *et al.*, 2011; see also Chapter 7).

Young plants are also vulnerable to a range of pests and diseases. These can cause severe losses if not recognised at an early stage and immediate action taken. Thus, prevention and control of pests and diseases is a major concern (Mathews *et al.*, 2010; see also Chapter 10), especially in quarantine nurseries (see Chapter 12).

New practices in the nursery include pre-field planting screening. Screening is traditionally done in the nursery for phenotypic off-types (e.g. slow growth and development, crinkled leaf, wide internode, chimera, etc., see Chapters 5 and 8) which are culled before transfer to the field. Culling is a major nursery activity and is typically done three times at 3, 6 and 9 months. Common culling rates are between 10 – 25%. Lower than 10% is considered risky and greater than 25% indicates problems in the material (either inherent or due to poor nursery practices). Other screening includes seedling screening for response to *Ganoderma*, a major disease of oil palm. Breeders and seed producers are consequently keen to develop materials that exhibit resistance to this disease. Seedling screening provides an early and quick method of assessing disease resistance/susceptibility. A manual on nursery screening of *Ganoderma* response is available in this series (Rahmaningsih *et al.*, 2018).

Genomic selection (use of DNA diagnostics) is now a reality in oil palm breeding and has application in quality control in commercial plant production. In relation to DNA testing, leaf samples can be taken from nursery plants and transferred to the laboratory where DNA is extracted and screened for specific genes/traits, or for the correct genetic background in the case of legitimacy testing and in the case of ramets for somaclonal variation. The primary example of the application of such testing is for fruit type. The shell thickness gene controls fruit type, which is the most commercially important trait in oil palm. Commercial oil palm has the Tenera (*Sh/sh*) thin-shelled phenotype and is produced from crosses between thick-shelled Dura (*Sh/Sh*) females and no-shelled Pisifera (*sh/sh*) males (Setiawati *et al.*, 2018). DNA testing can discriminate between Tenera, Dura and Pisifera genotypes and thus selections can be made in progenies, for example the removal of Dura contaminants among commercial Tenera seedlings (Sambanthamurthi *et al.*, 2009) and the removal of Pisiferas which are sterile. Thus field trialling can focus on relevant fertile Dura or Tenera germplasm (see Sitepu *et al.*, 2019 this series; see also Chapter 11). Fruit colour change, black-red (*Nig*) or green-yellow (*Vir*) is another trait that can be easily determined by DNA analysis. As with shell type, this trait can only be seen at maturity, thus DNA screening in the nursery not only picks out desired types but saves five years in determination.

Other considerations for the nurseryman are checks that seeds are from the right source (legitimate), that there is ample provision of financial capital for buying sprouted seeds or tissue culture-produced ramets, proper handling of germinated seeds/ramets and the application of improved agronomic practices in the management of the nursery (Yusuf *et al*., 2014).

The nursery practices outlined above are based on local or within-country supply of seeds and ramets. Oil palm breeders continuously access materials from other countries, and their entry into the country is regulated by strict import and quarantine controls. For seed, seedling and ramet materials, this requires growing in a specialised quarantine nursery where materials can be sampled and inspected regularly over a prescribed quarantine period by official quarantine officers, before release. These issues are described in detail in Chapter 12.

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