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Oil Palm Plants Production: Its Importance in Agriculture

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The African oil palm (*Elaeis guineensis* Jacq.) is a tropical plantation crop cultivated for its production of two types of vegetable oil: palm oil and palm kernel oil. It is a monocotyledonous species belonging to the family of *Arecaceae*, which includes more than 2,000 palm species. The genus Elaeis contains two species: *E. guineensis* or African oil palm and *E. oleifera* or American oil palm. The African oil palm is native to West Africa, but nowadays 84% of palm oil production takes place in Indonesia and Malaysia. Because of its low oil yield, the American oil palm is not cultivated on commercial plantations.

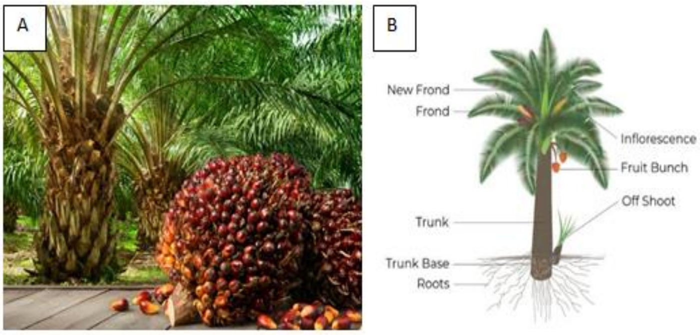

Fig. 1: Oil palm tree and structure of oil palm tree

The oil palm has a single vegetative shoot meristem, giving rise to an unbranched stem topped by 40–50 leaves (**Figure 1**). Each new leaf is accompanied by an inflorescence meristem in its axil that under appropriate conditions develops into a fruit bunch, containing up to 2,000 fruits. Palm oil is extracted from the outer mesocarp of these fruits, while palm kernel oil is extracted from the inner kernel. Palm oil is naturally reddish in colour because of high beta-carotene content. Palm oil has a large range of applications. About 90% is used in food industry, e.g., to produce margarine, shortenings, biscuits, ice-cream, salad dressings, mayonnaise etc. The remaining 10% is used for soap and oleochemical manufacturing. Palm oil currently is the most important vegetable oil worldwide, accounting for 36% of the total vegetable oil production. The increased demand for vegetable oils in the last two decades has encouraged governments of developing countries to promote oil palm cultivation.

The cultivation of the oil palm has expanded tremendously in recent years such that it is now second only to soybean as a major source of the world supply of oils and fats. Over the last 20 years, the production of palm oil has increased almost fourfold, accompanied with an increase of area. Presently, Southeast Asia is the dominant region of production with Malaysia being the leading producer and exporter of palm oil.

Oil palm plantations mainly consist of hybrid *tenera* trees, which are produced by crossing a "Dura" mother plant and a *"pisifera"* father plant. The *dura*, *pisifera*, and *tenera* varieties differ in shell thickness and oil yield. While fruits of the *dura* variety have a relatively thick shell and thin mesocarp, *pisifera* fruits are thin-shelled and have a thick mesocarp, rich in palm oil. However, *pisifera* palms are usually female-sterile, hampering oil production. *Tenera* fruits have an intermediate shell and mesocarp thickness, yielding 30% more than *dura* fruits and are thus the preferred variety for oil production.

Oil Palm propagation

In oil palm, the conventional propagation is only through seed, whereas long-term storage of seed is also impossible by its intermediate storage behaviour. In natural conditions, oil palm seed germination is a very slow process, requiring several years, and germination rates are very low. Procedures, mainly consisting of heat pre-treatments, have been developed to speed up the germination process, but several months are still required to obtain germination and lots of non-germinated seeds are lost. Moreover, genetic improvement by seed propagation is cumbersome. Selection cycles last for around 10 years and high heterogeneity is observed among hybrids. Some palms of a certain cross yield 60% more than the average progeny of that cross.

The oil palm does not produce axillary shoots, making vegetative propagation impossible. Around 98% of oil palm planting material therefore consists of hybrid seeds. Tissue culture technique is an alternative technology that can be applied in the propagation of oil palm seeds. Tissue culture derived plantlets makeup the remaining 2% of planting material. Although its limited implementation, tissue culture provides some benefits over traditional seed propagation. This technique has ability to regenerate large amount of uniform plants in a relatively short time. In contrast, a yield increase of at least 20% could be obtained by cloning high-yielding trees by tissue culture. Oil palm tissue culture is employed both as a means for producing good *tenera* palms for commercial planting and to multiply good parents (both *dura* and *pisifera*) for seed production. Moreover, tissue culture can accelerate the multiplication of trees with interesting characteristics related to disease resistance, growth pattern or oil composition. Also biotechnical approaches along with tissue culture of oil palm could yield novel genetic variants in the future.

Traditional tissue culture methods, such as node or meristem cultures, cannot be used for oil palm micropropagation. In these methods a piece of plant tissue containing a pre-existing meristem, namely an axillary bud or shoot apical meristem, is isolated and grown on a culture medium to provide a new shoot. Because the oil palm only has one meristem, it must be propagated in vitro by indirect somatic embryogenesis (SE). Different stages of somatic embryogenesis from zygotic embryo as explant are represented in Figure 2. In this process somatic cells of a plant tissue of choice differentiate, via an intermediate callus phase, into bipolar structures resembling zygotic embryos (i.e., bipolar structures without any vascular connection with the parental tissue) through an orderly series of characteristic embryological stages without fusion of gametes. This morphogenetic route is influenced by several factors imposed by *in vitro* conditions. The process of somatic embryogenesis is dependent on such factors as explant sources and plant growth regulators employed in culture medium, sources and developmental stage of explant are key factors that can change cellular competence, media components etc. The resulting somatic embryos can then germinate into plantlets.

Oil palm tissue culture is not widely implemented because of several difficulties associated with it. These include limited availability of explants, a low overall efficiency, caused by low somatic embryo initiation and regeneration rates, and a high risk for somaclonal variation as well as mantled abnormality caused by inappropriate practice of tissue culture procedures. The embryogenic structures are extensively propagated to increase the somatic embryogenic efficiency, thereby increasing the frequency of somaclonal variation.

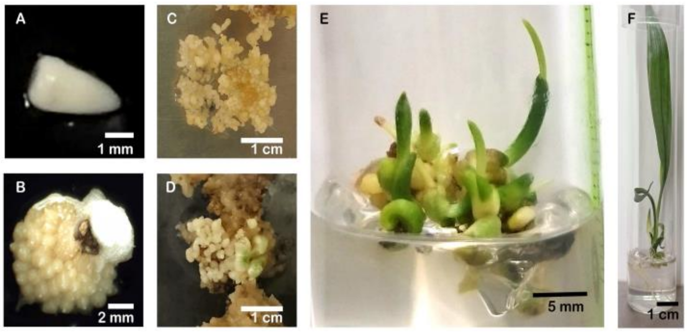

Fig. 2: Different steps of indirect somatic embryogenesis development from oil palm zygotic embryos. (A) Immature zygotic embryos. (B) After 8 weeks, the formation of primary, nodular callus. (C) Nodular calli have developed into embryogenic callus. (D) Initiation of the formation of somatic embryos. (E) Germination of somatic embryos. (F) Plantlets having a well-developed shoot and root system.

Despite that worldwide many researchers are working on the establishment and optimization of protocols for commercial micropropagation of oil palm, no general protocol is available. A large amount of papers focuses on the use of mature and immature zygotic embryos as explants, which are not suitable for commercial purposes. Moreover, much of the research has been carried out by companies with commercial interests, often reporting insufficient details for replication of the protocol. Also, responses depend on the genotype, the age of the parent tree and the type of explant used, requiring adaptation of the protocol to the actual conditions.

To date, the large-scale production of oil palm plantlets by tissue culture is limited because of several difficulties associated with the propagation procedure, which is based on indirect somatic embryogenesis starting from immature leaf explants. To allow mass propagation of oil palm by tissue culture, most likely a combination of several different adaptations to the protocol will be needed, indicating the importance of the investigation of several of the proposed research topics instead of focusing on one technique. For example, an increase in somatic embryogenesis induction and/or regeneration efficiency alone could increase the number of plantlets produced from a single isolation of immature leaves and could thus reduce the need for a proliferation phase but it will never allow the elimination of callus or embryoid proliferation completely. Somaclonal variation will thus still be present to a certain amount. On the other hand, if an increase in somatic embryogenesis induction and/or regeneration efficiency could be combined with a performant new detection technique, mass propagation of reliable oil palm tissue culture plantlets could be achieved. Tissue culture planting material provides many advantages over hybrid seeds in increasing oil yield on the current cultivated area. Since the demand for sustainable palm oil keeps growing, it is important to keep investing in the optimization of oil palm tissue culture procedures.

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