PLANT MITOSIS AND MEIOSIS: CYTOGENETICAL ANALYSIS

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446

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Cytogenetics is a branch of genetics involved in the study of chromosomes and cell division. Fluorescent and non-fluorescent dyes can be used to visualize chromosomes by simultaneously using various banding and molecular cytogenetic techniques. For an organism to grow and reproduce, its cells must divide. Mitosis and meiosis are both the processes of cell division, with very different outcomes. Mitosis (*Figure 1*) produces two daughter cells and, meiosis (*Figure 2*) four. Mitosis and meiosis occur in somatic and reproductive cells, respectively. *Figures 1* and *2* are the schematic presentations and stages of mitosis and meiosis.

OBJECTIVE

Using cytogenetical analysis, mitotic and meiotic cells can be observed for abnormalities in their chromosome, morphology or their processes.

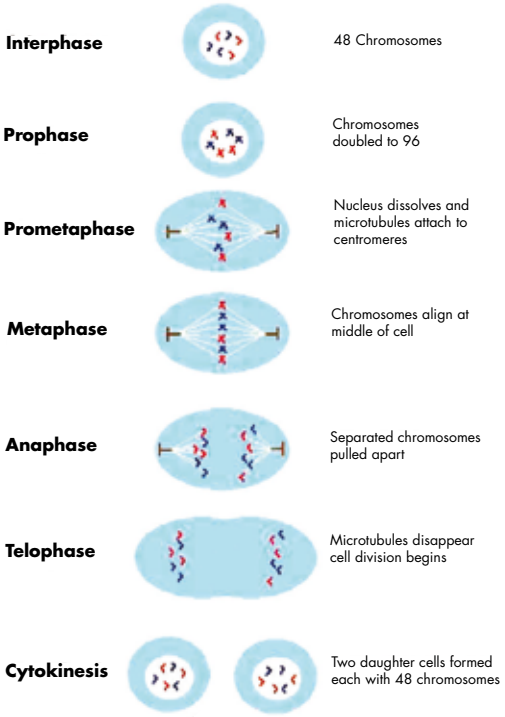

Figure 1. Mitosis.

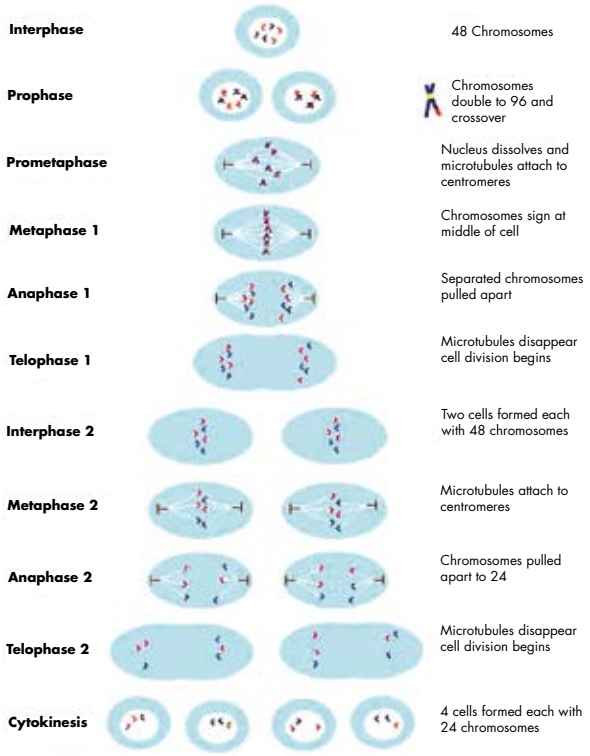

Figure 2. Meiosis.

METHODOLOGY

Plants are one component of the biosphere, and the cell is the basic unit of structure in both plants and animals. In *Elaeis*, the meristematic cells of the root tips and pollen mother cells from the anthers are used for cytogenetic analysis of the mitosis and meiosis processes, respectively.

Materials Used to Observe Mitosis in Oil Palm

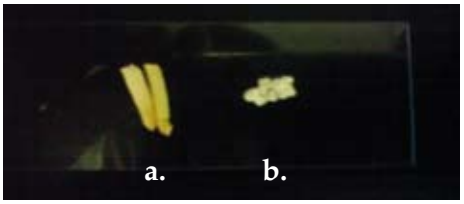

Figure 3. (a) Root tips and (b) callus tissues of oil palm.

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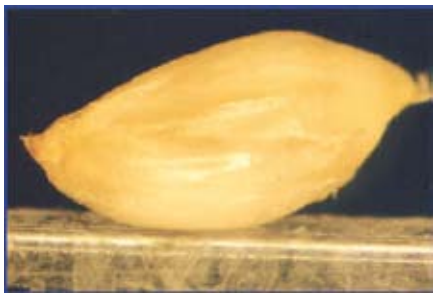
Materials Used to Observe Meiosis in Oil Palm

a.



b.

c.

Figure 4. (a) Oil palm male spikelets containing male flower buds, (b) male flower bud, and (c) the six pairs of anthers from a male flower bud containing pollen mother cells.

Flow Chart of Cytogenetic Analysis

Table 1 is the flow chart for studying mitosis and meiosis in *Elaeis*.

RESULTS

Mitosis in Meristematic Cells (normal)

Cytogenetical analysis of meristematic cells can determine whether the mitotic processes are normal or abnormal. *Figure 5* shows some cells undergoing various mitotic activities without any chromosomal anomalies, such as chromosome bridging (*Figure 6a*) and lagging (*Figure 6b*).

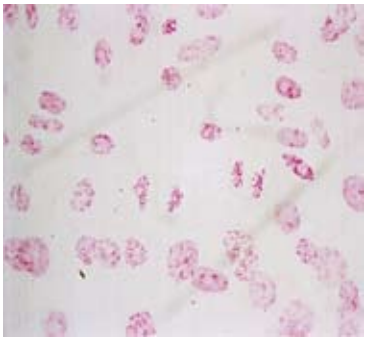
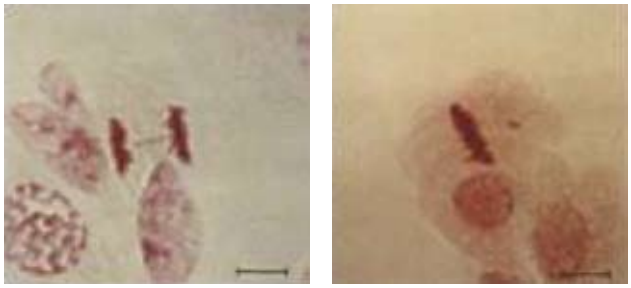


Figure 5. Meristematic cells undergoing various mitotic activities.

Mitosis in Callus Cells (abnormal)



a. **b.**

Figure 6. Chromosomal anomalies such as (a) bridging and (b) lagging in callus tissue.

TABLE 1. FLOW CHARTS FOR CYTOGENETICAL ANALYSIS OF MITOTIC AND MEIOTIC ACTIVITIES

Mitosis in *Elaeis*	Meiosis in *Elaeis*
Root tips or callus tissues ▼ Squashing with stain, *e.g.* aceto orcein (non-fluorescent) or DAPI-diamidinophenylindole (fluorescent) ▼ Microscopy visualization and image analysis	Male flower buds containing anthers ▼ Squashing with stain, *e.g.* aceto orcein (non-fluorescent) or DAPI-diamidinophenylindole (fluorescent) ▼ Microscopy visualization and image analysis

Karyograms of *Elaeis*

Using metaphase chromosome spreads and image analysis measurement software, the karyotypes of plants can be obtained. *Figure 7* shows the karyotypes of *E. guineensis* and *E. oleifera*, the two species of oil palm. Both have 2n=32 chromosomes, divided into Group I (Pair 1), Group II (Pairs 2-9) and Group III (Pairs 10-16).

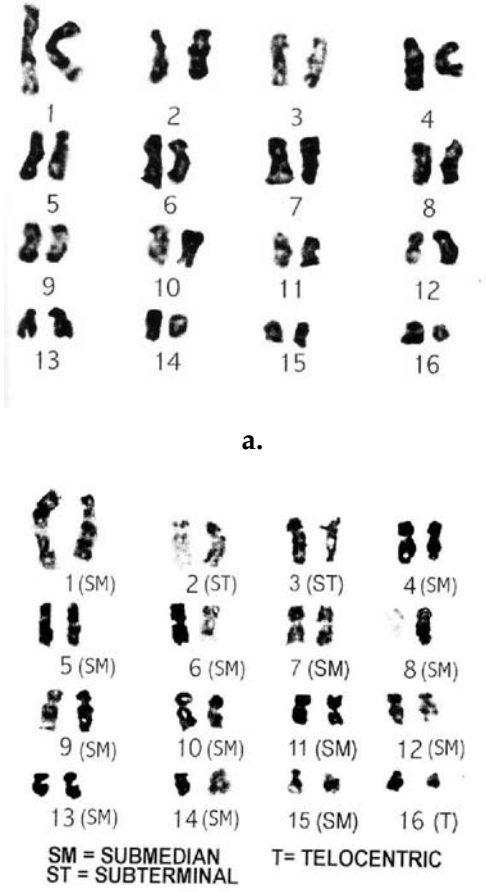


Figure 7. Karyotypes of (a) Elaeis guineensis *and (b)* E. oleifera.

Meiosis in Oil Palm Pollen Mother Cells (normal)

Cytogenetic analysis of the anthers containing pollen mother cells (PMC) can indicate whether the meiosis occurring is normal. *Figure 8* shows a normal meiosis, and *Figure 9* abnormal meiosis in PMC of a normal tissue-cultured palm. The abnormal meiosis can eventually lead to the production of pollen with abnormal amount of DNA.

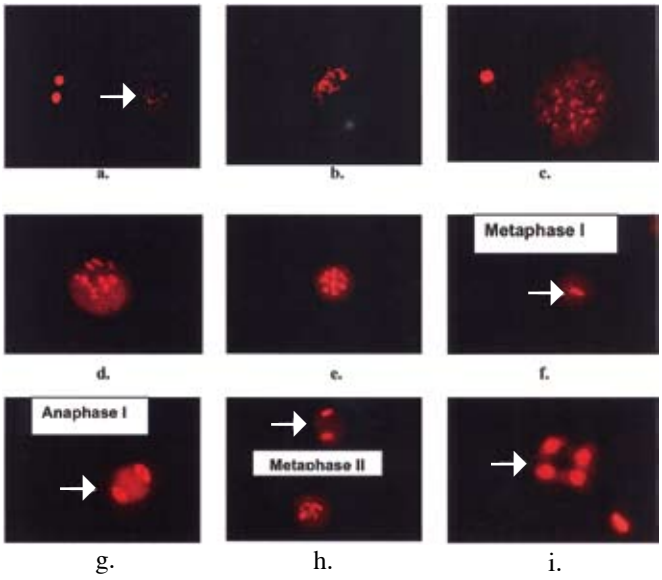


Figure 8. (a) Uninucleate microsporocyte or pollen mother cells (PMC) (arrow) with two tapetum cells on the left, (b) pachytene stage of microsporocyte chromosomes, (c) chromosome bivalents condensing, (d) further condensation of chromosome bivalents, (e) diakinesis (pairing of bivalent chromosomes), (f) bivalent chromosomes at metaphase I stage of meiosis, (g) chromosomes separating at anaphase I stage of meiosis, (h) chromosomes at metaphase II stage of meiosis and (i) tetrad stage of PMC or uninucleate microspore (arrow) prior to release from pollen mother sac.

Meiosis in Oil Palm Pollen Mother Cells (abnormal)

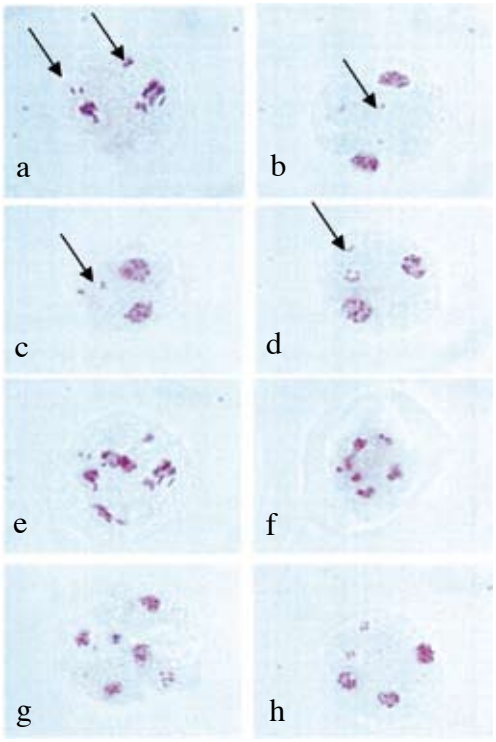


Figure 9. (a - d) Chromosomes lagging (arrows) in a pollen mother cell (PMC), (e - h) abnormal divisions of nuclei as opposed to in Figure 8.

CONCLUSION

As illustrated in the examples, cytogenetical analysis is a powerful classical tool that can be used by itself or in combination with molecular cytogenetics to enable more efficient research at the chromosomal level. These tools provide a holistic view of the genome, cytogenetic mapping for crop improvement, and quality control in tissue culture.

COST

Expertise consultation fee per species is RM 2500. Bench and chemical fee is RM 1000 per species. Limited to 25 cytogenetical sample preparations.

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