CHAPTER 1

OVERVIEW OF PLANT TISSUE CULTURE APPLICATION

Azman Abd Samad and Raihana Ridzuan

1.1 INTRODUCTION TO PLANT TISSUE CULTURE

German scientist Gottlieb Haberlandt made the first discovery of plant tissue culture in 1898. He first proposed the concept of totipotency in 1902, stating that theoretically all plant cells are capable of giving rise to a complete plant. He grew plants using a variety of plant tissues including leaves, pith, epidermis, and epidermal hairs. He suggested that tissue culture may be used to determine the potentialities of individual cells as well as the reciprocal effects of tissues on one another. All the initial experiments were fruitful for several months but did not survive for longer and only in the 1930s were crucial components such as vitamin B and auxin for growing the roots were discovered, which improved the plant tissue culture (Krikorian & Berquam, 1969).

Plant tissue culture has developed into a powerful technique for mass propagation, conservation, cryopreservation, genetic expression and facilitating breeding programmes for abiotic and biotic stress (Capriotti et al., 2023). It is a technique for growing a clone of a plant from an explant in sterile, controlled conditions while employing an artificial nutrition media (Hussain et al., 2012). Controlled conditions offer a favourable setting for the growth and multiplication of the culture. The

culture requires a sufficient supply of nutrients, optimum pH and temperature, and a suitable gaseous and liquid environment.

Different plant tissue culture techniques might be better than conventional propagation methods. Plant tissue culture is utilised to produce high-quality clonal plants. Any vegetative part of a plant, like a shoot tip or a shoot bud, is aseptically removed and cultured onto sterile media under controlled conditions to produce a plantlet that is an exact clone of its donor plant. Plant tissue culture is the only method to obtain clonally large proliferation of commercial species because conventional breeding is challenging. The main benefits of *in vitro* plant propagation include the ability to rapidly disseminate new genotypes on a big scale and the utilisation of small amounts of original material (Bhatia, 2015).

Plant tissue culture offers improved plant multiplication that is both effective and quick to ensure that the planting materials are free of disease. Regeneration of plants with virus-free cells can create virus-free crops all at once, eradicating any infections that might have been passed from parent to offspring and enhancing yield because the crops are of high quality. In plant tissue culture, quality is an important aspect since it affects not only the quantity of plants produced but also their superiority and worth (Neumann et al., 2009).

1.2 DEFINITION OF PLANT TISSUE CULTURE

Plant tissue culture refers to techniques for keeping or growing plant cells, tissues, or organs in sterile circumstances on a known-composition nutrient culture medium. Micropropagation is an extensively used technique to make clones of a plant. Different plant tissue culture techniques may have advantages over traditional propagation methods. For instance, make identical replicas of plants that produce exquisite flowers, fruits, or other desired characteristics, generating mature plants in a short amount of time and grow plants in sterile containers to allow them to be moved with reduced risk of disease transmission.

Plant tissue culture is based on the ability of many plant cells to regenerate an entire plant. When given the necessary nutrients and plant

hormones, single cells, plant cells without cell walls (protoplasts), fragments of leaves, stems, or roots can often be utilised to grow a new plant on culture media. The mechanism of tissue-culture plant regeneration can be classified into somatic embryogenesis and de novo organogenesis. Both mechanisms have their own direct and indirect organogenesis pathways that can occur in the same explant, however the duration of obtaining regenerated shoots differs. The indirect pathway has a longer period to regenerate shoots due to the callus-induction stage and mostly the shoots produced demonstrated somaclonal variation (Long et al., 2022; Zhang et al., 2021).

Plant growth regulators (PGRs) are tiny chemicals that, despite being present at very minute concentrations, can significantly impact a plant's development. In addition to the phytohormones that plants naturally produce, some growers also use synthetic regulators to give their plants an extra boost. Plant growth regulators are crucial to plant tissue culture. Tropism, elongation, and apical dominance are just a few of the growth phases for which these regulators are essential. Cytokinins, auxins, abscisic acid, and gibberellins are some of the various kinds of plant growth regulators. The development of organogenesis in tissue culture plants depends on auxins and cytokinins, particularly the balance between the two.

Plant growth regulators (PGRs) known as cytokinins encourage cytokinesis or cell division, in the roots and shoots of plants. However, they also impact apical dominance, axillary bud formation, and leaf senescence. Their prominent roles are in cell proliferation and differentiation. There are two types of cytokinins: Those of the adenine-type, which include kinetin, zeatin, and 6-benzylaminopurine (BAP), and those of the phenylurea type, which include diphenylurea and thidiazuron (TDZ) (Aina et al., 2012). Most roots produce adenine type cytokinins. Additionally, cytokinins are produced by the cambium and other actively proliferating tissues. Plants have not been discovered to have phenylurea cytokinins. Cytokinins use the exact transport mechanism of purines and nucleosides in both local and long-distance signaling. Usually, the xylem is used to carry cytokinins.