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Innovative nursery and propagation technique

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Abstract

Nursery management and propagation techniques are central to producing high-quality planting material in horticulture, forestry, and agriculture. Traditional practices such as cuttings, grafting, and seed propagation are increasingly complemented by advanced methods including micro propagation, aeroponics, and integrated technology systems. These innovations improve propagation rates, genetic fidelity, resource efficiency, and year-round production. This paper reviews contemporary advances, discusses their applications, and highlights future research needs.

Keywords: Nursery management, propagation techniques, vegetative propagation

Introduction

Nursery and propagation techniques play a vital role in the production of healthy, uniform and high quality planting material. Traditional nursery practices often face challenges such as low multiplication rate, disease incidence, poor survival, and non-uniform growth. To overcome these limitations, innovative nursery and propagation techniques have been developed using modern scientific knowledge and improved management practices. This technique aim to enhance propagation efficiency, reduce time and space requirements, ensure disease free planting material, and improve field establishment. Innovations such as tissue culture, mist propagation, root trainers, soilless media, protected nursery structures, and the use of plant growth regulators have revolutionized nursery production, making it more reliable, economical, and sustainable.

Root Trainers

instead of polybag -A new trend in the nursery is to use rigid containers called root trainers. Root trainers are conical shape rigid containers. Root trainers comprise cells in groups of about 16 to 30 formed into a frame of molded plastic sheet. Cells have vertical ribs on inner surface. The lower end of the root trainers is open; the diameter the base is smaller than the top. The lower end allows air pruning of roots. The bottom opening is called drainage hole. Root trainers are kept suspended on a wire frame above ground level. Seedlings possess very fibrous root system. Root coiling is prevented. The vertical ribs on inner surface direct the growth of roots vertically downwards to avoid root coiling. The root trainers are kept suspended on a wire frame at least 10 cm above ground. Growing medium is filled in the root trainers. As roots emerge from the base of the root trainer, they get dried up i.e. air pruned. This results in a very fibrous root system compared with polythene bags. Coiling of roots observed in the polythene bags is prevented in this method (ICFRE, Dehradun). The root trainer as component of a potting mix growing system was able to overcome soil polybag problem with its unique features that encourage the root growth vertically. which occupies larger space in the nursery, less number of seedlings are produced per unit area which makes it necessary to have an alternative growing system that will minimize the cost and increase the seedlings production per unit area (*Nabayi Abba et al.*)^[2]. Root trainers are increasingly being used to avoid root coiling and distortion and lack of wind tolerance after field transplanting, when compared to the conventional polybag planting system. Root tips grew out of root trainer forming an intact root mass and then could be transplanted to the field with high survival rate (*Xin-long Wang et al* 2020)^[1]. root trainers have advantages such as requiring no change of medium, least possibility of transplantation shock,

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advantage of air pruning, prevention of root coiling due to antispiral design and requirement of small area which makes them suitable for mass production of seedlings (Sharma *et al*, 2015) ^[4].

Mist Chamber

Mist chambers are valuable tools for modern agriculture, horticulture, and research. By providing a controlled environment, they enhance the propagation of plants, accelerate germination, and support tissue culture acclimatization. Although they require an initial investment and regular maintenance, their benefits far outweigh the costs. As technology evolves, mist chambers are set to become even more efficient, sustainable, and accessible, revolutionizing plant propagation and research practices. Mist chambers are advanced structures designed to create a highly controlled environment for propagating plants, germinating seeds, and acclimatizing tissue cultured plantlets. They are vital in agricultural, horticultural, and research applications where humidity, temperature, and light conditions play a significant role in plant growth and development (Dr. Malathi *et al*, 2024) ^[5]. Mist events were activated when predicted evaporation reduced stored water in the canopy to below a threshold quantity. Compared to static mist control (5 sec every 10 min) there was a 38% reduction in misting using the evapo-transpiration determined system. Method of control did not effect the number of roots per cutting, but there was an increase in overall root length and production of finer (less diameter) roots in cuttings misted based on the evapo-transpiration model (R, Geneve *et al* 2004) ^[6]. Misting is a technique for minimizing plant moisture loss by controlled periodic wetting of the foliage of cuttings which are being rooted. This technique is helpful for rooting leafy cuttings; however, succulent plants are usually not placed under mist. Constant misting has been successful with a few plants, but results are generally better with intermittent misting. Constant misting wastes water, leaches nutrients from the leaves, and reduces soil temperatures which, consequently, restricts root development. Mist beds can be used in greenhouses year round or during the growing season for nursery stock (Michael A. *et al*, Oklahoma Cooperative Extension Service) ^[7].

Climate control polyhouse

Polyhouse technology plays a pivotal role in mitigating climate risks for floriculture farmers by providing a controlled environment that safeguards crop from various environmental stressors. By regulating factors such as temperature, humidity, and light intensity, polyhouses offer a range of benefits that enhance the resilience and productivity of floriculture operations. The enclosed environment of polyhouses limits pest and disease infestations, allowing for more sustainable and chemical-free pest management practices. Polyhouse technology facilitates efficient water management, minimizing water wastage and ensuring optimal soil moisture levels through techniques like drip irrigation and hydroponics. By promoting sustainable farming practices and minimizing chemical inputs, polyhouses help conserve natural resources and reduce the environmental footprint of floriculture operations. Polyhouse technology (Kumar, M. 2024). This review confirm the significant advantages of polyhouse farming over open-field agriculture in terms of providing a stable and controlled environment for crop growth. Temperature, humidity, light, and CO₂ levels are all crucial factors in determining crop productivity, and the polyhouse offers a clear advantage in maintaining optimal conditions. As sustainable agriculture

continues to evolve, polyhouses represent a promising solution for improving crop yields and resilience, particularly in the face of climate change and environmental variability (Preeti, *et al*, 2025) ^[26].

Biostimulants

Biostimulants are substances or microorganisms that, when applied to plants or the rhizosphere, enhance natural plant processes to improve nutrient uptake, growth, quality, stress tolerance, and overall performance — without supplying nutrients directly like fertilizers do. A positive impact on crop quality and performance, no negative or harmful impact on people, animals, or the environment, increased biodiversity of beneficial microorganisms, and improvement of soil properties are the main advantages of biostimulants (Magdalena Drobek *et al*, 2019) ^[9]. Biostimulants can improve tolerance to abiotic stresses like drought and salinity by enhancing antioxidant systems and stress-responsive metabolism (Kasinathan Rakkammal, *et al*, 2022) ^[10]. Positive effects of biostimulants on growth and biomass accumulation Chlorophyll content and plant quality, Stress resistance during production and shipping periods (Yiyun Lin and Michelle L. Jones, 2021) ^[11]. Seaweed extract-based studied by Danilo Loconsole *et al*, 2023 ^[13] reported that seaweed extracts improve rooting and overall quality of ornamental cuttings, impacting nursery propagation protocols. results reported herein highlighted that, Megafol® (AaB) was more efficient than Mc Extra ® (SwB), increasing the quality performance of Abelia and Lantana transplants compared to those produced without biostimulants. Both biostimulants, McExtra® and Megafol®, in a low fertilization input, improved the NUE of young cuttings.

Grafting Innovations

Grafting is the combination of two living parts from two different plants acting as a single plant. This new plant, known as a grafted plant, is used to increase plant output by giving plants better growth, vigour, and pleading against abiotic and biotic stresses Grafting is suitable effectively in solanaceous and cucurbitaceous vegetables. The aim of current review focus on the impact of grafting on yield, quality, disease resistance, and stress tolerance of fruiting vegetables. Fruiting vegetables are often grafted using the tongue, cleft, tube and splice methods. Studies on tomato, eggplant, pepper, cucumber, watermelon, and melon indicated that grafting significantly improved production, quality, and the ability to withstand soil-borne and environmental stress (Ahmed S. Mohamed *et al*, 2024) ^[14]. Grafting is a useful technology that can be used in addition to agricultural production that is more environmentally friendly techniques, such as reduced rates and overall use of soil fumigants. For the development of resistant cultivars, grafted vegetables to help them choose the best scion and rootstock cultivars. With the growth of the grafted vegetable sector in Egypt, this alternative can be used to generate foreign currency. (Sanat Kumar Prajapati *et al* 2023) ^[15]. Proper selection of scion and rootstock is the key factor for higher fruit yield and quality. Under changing climate, this technique could play significant role to improve vegetable productivity. Thus, there is a need to identify more resistant sources by exploiting wild and elite germplasm (Hira Singh, 2016) ^[16]. Grafting of fruit vegetables represents an effective tool not only for overcoming the salinity problem but also for enhancing fruit quality. Moreover, it may reduce or eliminate the use of certain pesticides (especially soil fumigants) because the rootstocks will provide tolerance to many soil insect and disease pests (Hassen Yassin & Seid Husse,

2015) ^[17].

Micro and mini cutting

Vegetative propagation in horticulture allows production of true-to-type plants with desirable horticultural traits. Conventional cutting techniques often suffer from low propagation rates, seasonal effects, and poor rooting responses in mature or recalcitrant genotypes. To overcome these limitations, mini-cutting and micro-cutting techniques have been developed to increase propagation efficiency while maintaining clonal fidelity (Assistech LTDA, 2011) ^[18]. benefits of this system included a more robust root system, faster growth and improved plant quality of mini-cuttings, which are favourable traits to reduce transplant stress when planted in-field (D. Naidu, N. Jones, 2016) ^[19]. The mini-cutting technique has been applied to increase the production of sweet potato cuttings (*Ipomoea batatas*) by enhancing cutting supply and robustness, integrating nutrient management for improved quality (Ni Kadek Ema Sustia *et al*, 2020) ^[20].

Aeroponics

Aeroponics is one of the most advanced forms of soilless cultivation, distinct from hydroponics and traditional propagation systems because plant roots grow suspended in air and receive nutrients via a fine mist. It allows maximum oxygen availability at the root interface and enables very rapid plant responses in growth and rooting. Aeroponic propagation has been used historically as a research tool to understand root physiology and is now widely applied in horticultural propagation, commercial production, and vertical farming systems. Aeroponic systems have proven superior in enhancing horticultural plant growth while simultaneously conserving water. These findings support aeroponics as a sustainable, efficient, and relevant alternative modern agricultural technology for application in areas with limited land and water resources (Syahriana TN *et al* 2025) ^[21]. aeroponics can increase plant output by up to 45-75% over conventional systems due to efficient propagation and higher survival rates (Lingdi Tang *et al* 2024) ^[22]. Nutrient use efficiency also improves because misting delivers nutrients directly to roots, decreasing waste and increasing uptake efficiency (Abhishkar Regmi *et al*, 2024) ^[23].

Hydroponics

As global agriculture faces limits of land resources, water scarcity, and climate pressures, hydroponics offers an efficient alternative to conventional soil farming. In hydroponic systems, plant roots receive a continuously circulating nutrient solution, allowing for intensive crop production with reduced water and nutrient use. Hydroponics supports sustainable food production, especially in urban agriculture, greenhouses, and vertical farming system (Richa Sharma *et al*, 2024) ^[24]. The crop quality also improved under the deep water culture system, which was reflected by the higher values of quality parameters like chlorophyll, total soluble solids, protein, and crude fiber content. Both the hydroponic systems produced significantly higher yield, and nutritionally superior produce in lesser time than the soil-based system ($p < 0.05$). However, there was a significant reduction in the dry matter content under hydroponic conditions (Maliqa Majid *et al*, 2021) ^[25].

Soil less cocopeat based

The implementation of cocopeat substrate bags increased vegetative growth and fruit yield by enhancing the number of fruits per tree or the mean fruit weight, therefore, favoring early

production in a young persimmon orchard. This was the results of an improvement in the tree water and nutrients status ((M. Parra *et al* 2022) ^[27]. These soilless systems mostly utilize porous soilless substrates to maintain an optimal balance of air and water, and retain mineral nutrients needed for crop production. Unlike in field production, where roots have the opportunity to explore the vast soil profile, 100% of the container-grown rhizosphere is restricted to the container volume. However, plant root health and quality can have direct influences on crop development, growth, and overall plant performance (K.S. Criscione, J.S. Fields, 2024) ^[28]. (M. Parra *et al* 2022) ^[27]. Open field soil-less system using coco-peat substrate bags improves tree performance in a young Mediterranean persimmon orchard Scientia Horticulturae.

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