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### Plant tissue culture progress across the Globe

<sup>1</sup> Nikita Negi, <sup>2</sup> Suman Rawte, <sup>3</sup> Zenu Jha

<sup>1</sup> Department of Agricultural Entomology, IGKV, Raipur, Chhattisgarh, India

<sup>2,3</sup> Department of Plant Molecular Biology and Biotechnology, IGKV, Raipur, Chhattisgarh, India

Corresponding Author: **Zenu Jha**

#### Abstract

Growing plant tissue, organs, or entire plants in an *in vitro* environment is known as plant tissue culture. Since PTC has gained significant industrial importance in the fields of plant propagation, disease eradication and plant conservation, in addition to the previously mentioned key areas, plant tissue culture is now gaining importance in the production of biopharmaceuticals and bio-energy. This makes plant tissue culture an essential tool in the modernization of agriculture.

Various market analyses indicate that North America now retains the top spot in the PTC industry, followed by Europe and the Asia-Pacific region. Asia Pacific emerging as a strong rival due to growing infrastructure and biopharmaceutical outsourcing. India is currently the nation with the world's fastest growing tissue culture market, more particularly, the fastest growing tissue culture market, despite.

**Keywords:** Tissue culture, Plant propagation, Conservation, Growth

#### Introduction

Plant tissue culture has been used for more than 30 years (isaaa.org.in). A single explant can be multiplied into several thousand plants in a short amount of time and space when grown in controlled circumstances, regardless of the time of year or the weather (Idowu *et al.*, 2009) <sup>[7]</sup>. A simple method that many poor nations have already mastered is plant tissue culture. Its implementation just needs a clean work environment, a nursery, a greenhouse, and skilled labor. Oil palm, pine, banana, date palm, eggplant, jojoba, pineapple, rubber tree, cassava, yam, sweet potato and tomato are some important plants that have been cultivated through tissue culture on large scale (isaa.org.in). The size of the global plant tissue culture market, which was anticipated to be worth \$382.305 million in 2020, is expected to increase by 8.5% between 2021 and 2030 to reach \$895.006 million. The market for plant tissue culture will continue to grow and present substantial potential prospects through the year 2030 because to the quick advancements in plant tissue culture techniques and the high demand for disease-free plants, hybrid plants, and others (Rosslee, 2021) <sup>[14]</sup>. Tissue engineering is becoming more and more popular worldwide, especially in research and development and it is permeating practically every market area due to the broad range of applications that tissue culture may be utilized for. Tissue culture is quickly emerging as one of the scientific fields where North America is a global leader. According to experts, North America is indeed the industry's top supplier of tissue culture products since the United States represents the region's largest supply market, followed closely by Canada. The North American region is seeing an increase in research and development in the field of tissue culture, which explains why they are dominating the market supply for tissue culture. However, Asia is currently a hot challenger because to the fact that it will have the most biopharmaceutical outsourcing over the next five years, exceeding prior projections. The ongoing development of the infrastructure that supports the tissue culture market is another factor contributing to Asia's rising growth rates in this industry. India currently has the world's fastest-growing tissue culture market, or more specifically, the fastest-growing tissue culture supply market, according to several market analyses (Rosslee, 2021) <sup>[14]</sup>.

Plant tissue culture was first established in the US in the 1970s with orchid micropropagation. Since then, the industry has received enormous support and expanded globally. From 1985 to the present, both the number of production units and factories has grown. Agribusiness accounts for 50–60% of the estimated \$150 billion global biotechnology market, which increases the demand for tissue culture goods by 10% annually (Patil *et al.*, 2021) <sup>[11]</sup>. The market is analyzed by region across North America, where the primary producers are the United States, Canada, and Mexico. Germany, France, the UK, Italy, Spain and Russia hold a majority of the market share in Europe. Key players in the Asia-Pacific region include Brazil, South Africa, Saudi Arabia, Turkey and Japan, China, India, Australia and New Zealand (Apoorva & Onkar 2021) <sup>[4]</sup>. Whereas, on the basis of crop type, the floriculture plants segment contributed the largest revenue in 2020 and is anticipated to maintain its

dominance over the forecast period of 2030, as shown in figure 1.

About 156 ornamental genera are propagated through tissue culture in different commercial laboratories worldwide. Major ornamental tissue culture plants such as Begonia, Ficus, Anthurium, Chrysanthemum, Rosa, Saintpaulia, and Spathiphyllum are being produced in the developed countries out of 212.5 million tissue cultured plants 157 million ornamental plants which amounts for 78% of the total production. These include major ornamental tissue culture plants including Begonia, Ficus, Anthurium, Chrysanthemum, Rosa, Saintpaulia, and Spathiphyllum. The Netherlands (33%), Japan (24%), Italy (11%), the United States (12%), Thailand (10%), and other countries (14%), make up the majority of producers. The Netherlands (59%), Colombia (10%), Italy (16%), Israel (4%), Spain (2%), Kenya (1%), and others (18%) are the top exporting nations. Around 80% of the global export market is made up of the top four countries i.e., Israel, Colombia, Italy, and Netherlands. Less than 20% of developing nations including those in Africa, Asia, and Latin America are represented in the floriculture category (Twaij., 2020) <sup>[17]</sup>. According to Stratagem Market insight, 2022 market analysis the leading companies in the global plant tissue culture market are Alpha Laboratories, Phytoclon Inc, 3 Rivers Biotech, AgriForest Bio-Technologies, Caisson Laboratories, Inc, AgriStarts, Dark Heart Nursery, DP-Deroose Plants, Himedia Laboratories, IribovSBW, Labland Biotech Private Limited, Lifesible, Knight Hollow Nursery, Merck KGaA (Sigma-Aldrich).

### PTC in western Europe

With 37 units producing more than a million plants annually, Western Europe has the capacity to generate 212 million plants. Whereas Netherlands manufactures 67 commercial units and around 62 million reengineered plants annually. Production in Germany increases to 8 million units with 21 working ones (Bhatia., 2015) <sup>[5]</sup>. The export of ornamental plants, including potted plants like Begonia, Ficus, Cyclamen, Philodendron, Saintpaulia, Spathiphyllum, and Rhododendron, is dominated by the Netherlands (Patil *et al.*, 2021) <sup>[11]</sup>.

### PTC in Africa

As many parts of the tropical and subtropical developing world, banana is a highly important food crop. In the last 20 years however, there was a rapid decline in banana production due to widespread soil degradation and the infestation of banana orchards with pests and diseases is reported in Africa (ISAAA). These problems were further aggravated by the common practice of propagating banana plants using infected suckers. The situation was threatening food security, employment and incomes in banana-producing areas. Tissue culture technology was considered an appropriate option to provide sufficient quality and quantity of such materials. With proper management and field hygiene, yield losses caused by pests and diseases at farm level have been reduced substantially. Tissue culture technology has made it possible for farmers to have access to the following:

- large quantities of early maturing superior clean planting materials (12-16 months compared to the conventional banana of 2-3 years).

- 30-45 kg bunch weights compared to the 10-15 kg from conventional material)
- Higher annual yield per unit of land (40-60 tons per hectare against 15-20 tons).

Similarly, in case of rice, scientists tried of combining the ruggedness of the African rice species (*Oryza glaberrima*) with the productivity of the Asian species (*Oryza sativa*). However, the two are very dissimilar. Attempts to cross them failed since the resulting offsprings were all sterile. Advances in agricultural research helped scientists cross these two species. After cross-fertilization of the two species, embryos were removed and grown on artificial media using a process known as “embryo-rescue and backcrossed with sativa. The fertility of the progeny was improved (often after several cycles of back-crossing) Further anther cultivation was utilised to double the gene complement of the male sex cells (anthers), improving the progeny's fertility (typically after multiple cycles of back-crossing), producing true-breeding plants known as NERICA (West Africa Rice Development Association, or WARDA).

### Plant tissue culture in Asia

#### a. Thailand

Plant tissue culture is used to assist grow cut flowers and decorative plants in Thailand, Singapore, and Malaysia. Thailand is the industry leader, in terms of tissue culture of ornamental plant production and export. Orchids, Sansevieria, Musa, Drasena, Bougainvillea, Ixora, Euphorbia, Plumeria, Hoya, and Adenium are some of the tissue culture plants that are exclusively grown in Thailand. Among all of these plants, orchids have the best potential for growth. It contributed 61.5% of the total export value in 2016 (Singh, 2021) <sup>[15]</sup>.

#### b. China

China primarily engages in the production of medicinal and horticultural plants. The tissue-cultured crop plants in China include *Oryza sativa* (Rice), *Triticum aestivum* (wheat), *Zea mays* (maize), *Sorghum vulgare* (boom corn), *Medicago denticulata* (alfalfa), *Hevea brasiliensis* (rubber tree), *Capsicum annum* L.(pepper), *Brassica chinensis* (Chinese cabbage), *Beta vulgare* (sugar beet), *Citrus microcarpa* (sweet orange), and *Linum usitatissimum* (flax). China has more than 11000 medicinal plant species which act as major source of supporting the primary health system of country and over five million of land is dedicated to cultivating these plants. Some of the medicinal plants grown in china by tissue culture include *Aconitum carmichaeli*, *Agave americana*, *Allium cepa*, *Allium mongolicum*, *Brassica pekinensis*, *Scutellaria baicalensis*, *Rhododendron hybridum*, *Ginkgo biloba*, etc (Singh, 2021) <sup>[15]</sup>.

#### c. Indonesia

In Indonesia, farmers focus primarily on increasing crop productivity. To boost the plants' overall productivity, a number of tissue culture labs have been developed in research organizations. Rice, cassava, coconuts, maize, sweet potatoes, soybeans, copra, rubber, palm kernels, coffee, tea, and spices are a few of the common tissue culture plants farmed in Indonesia. Following the formation of numerous commercial laboratories, more than 15 million tissue grown plants are generated annually. The tissue

culture business is booming in the country with the advancement of tissue culture tools. With climate change and increasing population, it's become an effective and essential tool to fulfill the growing agricultural and medicinal demands of people (Singh, 2021) <sup>[15]</sup>.

#### d. India

The National Certification System for Tissue Culture Raised Plants (NCS-TCP) was first established in the nation around 2016. After recognizing how plant tissue culture could revolutionize the expansion of agriculture, it was carried out. The department's goal was to grow disease-free, superior tissue culture plants. Around 532 million tissue culture plants were certified by the system, which mentored 85 businesses who entered the tissue culture sector. India currently produces more than 500 million plantlets annually (Singh, 2021) <sup>[15]</sup>. In India, tissue culture plants such as bananas, sugarcane, potatoes, strawberries, anthuriums, orchids, lilies, date palms, and teak are some of the most widely produced crops. According to [www.business-standard.com/article](http://www.business-standard.com/article), the Indian market for plant tissue is worth more than Rs. 500 crores.

#### Use of PTC around the globe with reference to moth orchid propagation: *Phalaenopsis* spp.

Due to their distinctive uses as cut flowers and pot plants, orchids are among the most widely farmed ornamental crop species on earth. However, because of their delayed blossoming and unequal flower qualities, tissue culture is mostly used to grow orchids. In many nations, including Germany, the Netherlands, the United States, China, Japan, and Taiwan, *phalaenopsis* provides solely 75% of all orchids sold. Production of *Phalaenopsis* young plants may now exceed 300 million annually throughout the world. Taiwan leads the globe in terms of output. In Taiwan, *Phalaenopsis* production generated between \$27.5 million and \$35.4 million. 2020 (Khatun, 2020) <sup>[8]</sup>.

#### Use of PTC in conservation with reference to African cherry

One of the most well-liked and critically endangered medicinal plants is the African Cherry (*Prunus africana*). The bark of trees is an economically valuable component, and overuse of this component has forced many trees into the list of endangered species. Unfortunately, due to its lengthy flowering cycle, seed propagation is difficult, hence novel propagation techniques are urgently needed to boost its numbers. The plants that were grown with a survival percentage of 98.0% by following tissue culture of stem nodal segments Komakech *et al.* (2017).

#### Use of PTC in bio crude production with reference to industrial hemp

Bio crude production from industrial hemp using this plant tissue culture method offers the opportunity to integrate advanced plant agriculture and bioenergy to create a circular economy. Genetic manipulation of callus enabled to engineer the lignin content of hemp which provided the lignin free biofuel which is perfectly safer to environment. (Norouzi, 2022)

#### Is India - potential global supplier country?

India is endowed with expertise, biotech professionals with extensive experience in tissue culture, as well as a cheap

labor force to assist in the production of high-quality planting material geared toward export. All of these elements make India a potential global provider of a wide variety of high-quality plants for the global market. Anthurium, apple, bamboo, banana, date palm, gerbera, lily, orchids, pineapple, potato, pomegranate, strawberry, sugarcane, and teak are some of the plants that are commercially produced in India by tissue culture (Department of Biotechnology, India). India exported 17.17 million USD worth of tissue culture plants in 2020–2021. (Pib.gov.in). The Netherlands, the United States, Italy, Australia, Canada, Japan, Kenya, Senegal, Ethiopia, and Nepal are the top ten countries importing tissue culture plants from India. India exported tissue culture plants worth US\$17.17 million in 2020–2021, with the Netherlands receiving about half of the exports.

#### What are the Issues Faced by Tissue Culture Exporters in India?

Increasing power costs, increased cost of transportation of micro-propagated planting material. Low efficiency levels of the skilled workforce in the laboratories, contamination issues in the laboratories. Lack of harmonization in the Harmonized System (HS) code of Indian planting material with other nations are the major issues faced by India.

#### Why India missed the bus in tissue culture?

India missed the bus in tissue culture because Indian research is restricted to the laboratory while the other industrialized countries focused on application-based research.

#### Conclusion

Plant tissue culture has made considerable advances recently and is now a crucial method for the development of agricultural sciences and modern agriculture. When utilized to produce metabolites and phytoconstituents—which are frequently difficult to regenerate and protect the species, saving them from extinction—plant tissue culture has emerged as the most valuable technique. Several specific procedures have been created for the commercial cultivation of a wide range of plants as a result of advancements in current technology. PTC has undoubtedly altered the course of contemporary agriculture, food production, and the pharmaceutical business. It has also ushered in a new era of bioenergy and biopharmaceutical manufacturing.

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