P. ISSN: 0971-8184 II E. ISSN: 0976-1926
DOI: 10.61949/0976-1926.2025.v38i01.01

Indian Journal of Plant Genetic Resources

REVIEW ARTICLE

# Micropropagation and Conservation of Export-Oriented Ornamental Crops in Thailand

**Kanchit Thammasiri[1*], Nipawan Jitsopakul[2], Sutha Klaocheed[3], and Suphat Rittirat[4]**

## Abstract

The ornamental crops in Thailand are grown for house gardens, landscape design, cut flowers, and potted ornamental plants. Orchids, with a production area of about 5,600 acres (21% of the total) rank the highest among the ornamental crops, especially cut-flower crops, that are important to Thai agriculture and economy. The biotechnology used for ornamental crops in Thailand is tissue culture and the new development in cultural practices. Molecular techniques are studied only in universities and institutions because the cultivars are changed in a short time and do not get very high income. Orchid is the major crop using tissue culture due to its popularity, indispensability, and sustainability. In addition, tissue culture protocols for rapid propagation were developed for other ornamental crops, such as monstera, philodendron, aglaonema, alocasia, tillandsia, Piperaceae, Araceae, *etc*., of which production depends on unstable demand. Tissue culture techniques have been interestingly researched and used for enormous species and hybrids. On the contrary, many wild ornamental plant species are in endangered for extinction because of deforestation and natural disasters. Therefore, the conservation of orchids and other ornamental plants is urgently needed by various means, such as living collection, seed and pollen storage, *in-vitro* conservation, and cryopreservation from government agencies, private sectors, and people. The markets for ornamental crops are continuously increasing and new outstanding cultivars are being produced or improved by conventional breeding using the plant genetic diversity.

**Keywords**: Tissue culture, Conservation, Ornamental crops, Thailand.

[1]Center for Gardening and Horticulture, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Yunnan 666303, China.

[2]Department of Plant Science, Textile and Design, Faculty of Agriculture and Technology, Rajamangala University of Technology Isan, Surin Campus, Surin 32000, Thailand.

[3]Department of Agricultural Science and Fishery, Faculty of Science and Technology, Prince of Songkla University, Pattani 94000, Thailand.

[4]Program in Creative Innovation in Science and Technology, Faculty of Science and Technology, Nakhon Si Thammarat Rajabhat University, Nakhon Si Thammarat 80280, Thailand.

***Author for correspondence:**

kanchitthammasiri@gmail.com

**Received:** 19/08/2024 **Revised:** 31/10/2024

**Accepted:** 13/11/2024

**How to cite this article:** Thammasiri K. (2025). Micropropagation and Conservation of Export-Oriented Ornamental Crops in Thailand. *Indian J. Plant Genet. Resour*. 38(1), 1-10. **DOI:** 10.61949/0976-1926.2025.v38i01.01

## Introduction

Thailand is situated in a hot and humid tropical zone of Southeast Asia, with a current population of about 69 million and a total land area of 128.4 million acres. Thailand is the 13$^{th}$ most plant-rich country in the world after Brazil, Colombia, China, Mexico, USSR, Indonesia, Venezuela, USA, Australia, India, Peru, and Malaysia (Cronquist, 1981). Tropical ecosystems, unlike those in temperate zones, provide wider niches and are able to support a much larger variety of plant, animal, and microbe species. It is estimated that there are approximately 15,000 plant species in Thailand, including 3,000 species of mushrooms and fungi, 633 species of ferns, and about 1,200 species of orchids. More than 779 species of plants possess active herbal ingredients used for traditional medicines (OEPP, 1996).

The ornamental crops in Thailand are grown for house gardens, landscape design, cut flowers, and potted flowering and ornamental plants, such as trees, shrubs, climbers, orchids, palms, ferns, grasses, bamboos, cacti, succulents, annuals, bulbs, and other flowering crops. The production area of Thai ornamental crops was estimated of about 26,800 acres (Agricultural Extension, 2022). Orchids, with a production area of about 5,600 acres (21%

of the total) rank the highest among the ornamental crops, especially cut-flower crops, that are important to Thai agriculture and economy, followed by jasmine flowers (3,000 acres), lotus (2,070 acres), *Calotropis gigantea* (1,500 acres), marigold (1,130 acres), rose (635 acres), and chrysanthemum (600 acres). The orchid export value started from less than one million USD to about 82 million USD in 2022. It is estimated that 54% of the orchids produced are exported and the rest 46% consumed in the domestic market. The export of cut-flower orchids (60 million USD) still predominates, but that of orchid plants has also been on a rapid increase, figuring at about 22 million USD in 2022 (DITP, 2022; Department of Customs, 2022) (Figure 1). Apart from orchids, other exported ornamental crops with export value of about 33 million US$ were Sansevieria, Bougainvillea, Tillandsia, Euphorbia, Aglanonema, Ficus, Amaryllis, Philodendron, Encephalartos, and others, respectively (Figure 2).

At present, the biotechnology used for ornamental crops in Thailand is tissue culture and the new development of cultural practices. Molecular techniques are studied only in universities and institutions because the cultivars are changed in a short time and do not get very high income. Orchid is the major crop using tissue culture due to its popularity, indispensability, and sustainability. Other ornamental crops are monstera, philodendron, aglaonema, alocasia, tillandsia, Piperaceae, Araceae, *etc*., of which production depends on unstable demand. Tissue culture techniques have been interestingly researched and used for enormous species and hybrids. On the contrary, many wild ornamental plant species are endangered for extinction because of deforestation and natural disasters. Therefore, the conservation of orchids and other ornamental plants is urgently needed by various means, such as living collection, seed and pollen storage, *in-vitro* conservation, and cryopreservation from government agencies, private sectors, and people (Thammasiri *et al*., 2020). The markets for ornamental crops are continuously increasing and new outstanding cultivars are being produced or improved by conventional breeding using the diversity of plant genetic resources.

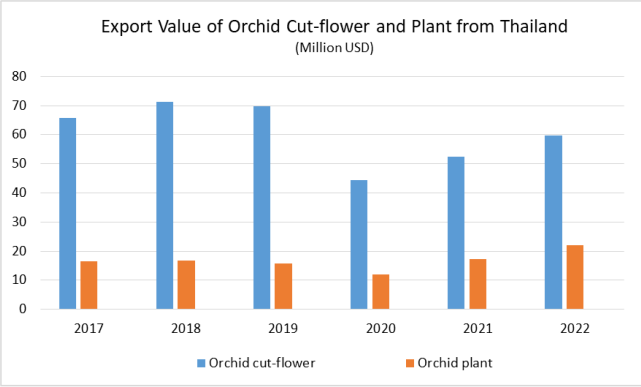


**Figure:** 1: The export value of orchid cut-flower and plant from Thailand (2017-2022)

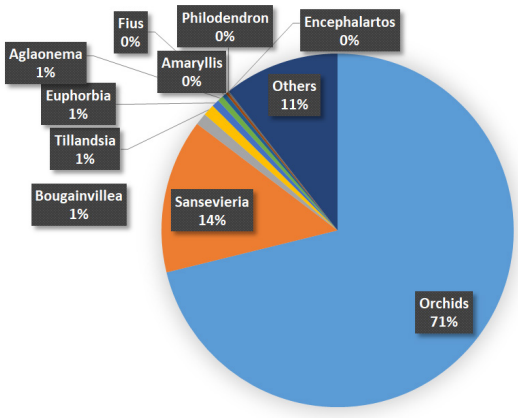


**Figure 2:** Ornamental crops export from Thailand in 2022

### *Ornamental Plant Tissue Culture*

Production technology, breeding, tissue culture, and molecular studies in Thailand started from tissue culture research in orchids in some universities in 1967. Later, in 1972, the orchid tissue culture business expanded rapidly to over 30 million plantlets and employed over 300 workers in 15 labs with about USD 2.4 million. In addition, tissue culture protocols for rapid propagation were developed for other ornamental crops, such as monstera, philodendron, aglaonema, alocasia, tillandsia, Piperaceae, Araceae, *etc*., of which production depends on unstable demand. The suitable protocols and low-cost tissue culture were developed for commercialization, as well as conventional breeding programs for outstanding cultivars for international markets by government organizations, institutions, growers, and private companies. Major growing factors in natural growing habitats are studied for developing new cultural

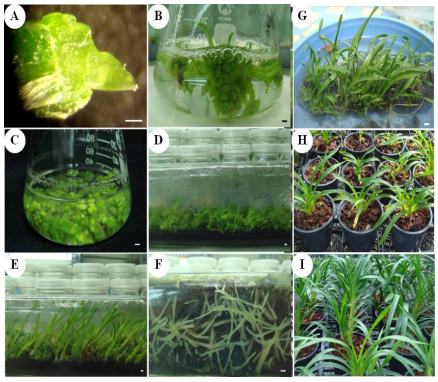


**Figure 3:** Tissue culture protocol of *Grammatophyllum speciosum*. (A) A shoot tip was excised under a stereo microscope, (B) PLBs were induced in ½MS liquid medium (2 months after culture), (C) PLBs were subcultured for multiplication (1 month after culture), (D) PLBs were cultured on ½MS solid medium supplemented with 0.05% (w/v) of activated charcoal, 2.0 mg L-1 NAA, and 1.0 mg L-1 BA, (E) and (F) Shoots and roots were induced (3 months after culture), (G) Plantlets were removed from the bottle and washed with tap water, (H) Plantlets were transplanted to plastic pots filled with small pieces of coconut husk, and (I) Plants grown 2 years in the saran house. Bar = 1 mm. (Sopalun *et al*., 2010)

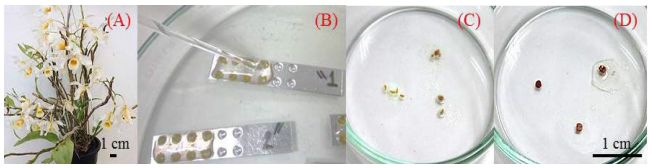


**Figure 4:** *Dendrobium signatum* Rchb. f. (A) blooming flowers, (B) pollinia embedded with 3% sodium alginate gel on aluminum cryo-plates, (C) no survival of pollinia, and (D) survival of pollinia after cryopreservation using V cryo-plate method (Jitsopakul *et al*., 2019).

practices, such as low-cost greenhouse, watering, fertilizer application, pest and disease control, postharvest handling, packaging, marketing, and logistics for new cultivars and tissue cultured plantlets.

Tissue culture is an indispensable tool for the commercial production of elite plant selections because of its low cost, uniformity, fast propagation, and high yield in a short period of time (Arditti and Ernst, 1993). It has been successfully carried out for many Thai orchid species and many ornamental crops (Table 1 and Figure 3). Most cut-flower orchids, *Dendrobium*, *Oncidium*, *Mokara*, *Aranda*, *Ascocenda*, and *Cattleya* alliances are propagated successfully through tissue culture. Within 1 to 2 years, one young pseudobulb multiplies to over 10,000 plants from the laboratory and tissue-cultured plantlets are ready to be grown in the greenhouse.

### *Conservation*

The conservation of ornamental plant genetic resources is very necessary because their population in their natural habitats is decreasing drastically due to natural disasters, deforestation, and plants taken out from their natural habitat for commercial use. At present, ornamental plant germplasms are conserved through *in-situ* and *ex-situ* methods by government organizations, institutions, universities, private sectors, and people. For *ex-situ* conservation, most living collection, seed bank, and *in-vitro* conservation by tissue culture are implemented. Cryopreservation of pollen (*Amorphophallus koratensis*), pollinia, seeds, protocorms, protocorm-like bodies, and shoot tips of some Thai orchid species and hybrids were studied and reported from universities (Table 2 and Figures 4, 5, and 6).

**Table 1:** Study on ornamental crop tissue culture in Thailand

| *Family* | *Species* | *Explant* | *Regenerant* | *Medium* | *References* |
|---|---|---|---|---|---|
| Acanthaceae | *Staurogyne repen* | Nodal segments | Shoots | MS medium + 0.15 mg $L^{-1}$ NAA + 1.0 mg $L^{-1}$ BAP | Rittirat *et al*. (2022a) |
| | | Shoots | Roots | MS medium + 3.0 mg $L^{-1}$ IBA | |
| Apocynaceae | *Adenium obesum* (Forssk.) Roem. and Schult. | Shoot tips | Shoots | MS medium + 22.2 µM BA | Kanchanapoom *et al*. (2010) |
| Araceae | *Aglaonema tenuipes* Engl. | Seeds | Callus | MS medium + 3.0 mg $L^{-1}$ NAA | Tilarux *et al*. (2022) |
| | | Shoots | Shoots | MS medium + 2.0 mg $L^{-1}$ BA | |
| | | Shoots | Roots | MS medium + 2.0 mg $L^{-1}$ NAA | |
| | *Aglaonema simplex* | Apical buds | Shoots | MS medium + 2.0 mg $L^{-1}$ BA | Laohavisuti and Mitrnoi (2005) |
| | | Shoots | Roots | ½ MS medium + 1.0 mg $L^{-1}$ IBA | |
| | *Anthurium andraeanum* 'HC 028' | Shoot tips | Shoots | MS medium + 4.0 mg $L^{-1}$ BAP | Rittirat *et al*. (2022b) |
| | | Shoots | Roots | MS medium + 2.0 mg $L^{-1}$ IBA | |
| | *Anubias barteri* var. *nana* | Shoot tips | Plantlets | MS medium + 7.0 mg $L^{-1}$ TDZ | Rittirat *et al*. (2022c) |
| | | Shoot tips | Shoots | MS medium + 7.0 mg $L^{-1}$ kinetin | Rittirat *et al*. (2023) |
| | | Shoots | Roots | ½ MS medium | |
| | *Anubias heterophylla* | Shoot tips | Shoots | MS medium + 3.0 mg $L^{-1}$ BAP | Rittirat *et al*. (2020) |
| | | Shoot tips | Plantlets | MS medium + 0.1% (w/v) AC +1.0 mg $L^{-1}$ NAA + 1.0 mg $L^{-1}$ BAP | Rittirat *et al*. (2021) |
| | *Cryptocoryne wendtii* | Shoot tips | Shoots | MS medium + 1 mg $L^{-1}$ NAA | Choojun *et al*. (2017) |
| | | Shoot tips | Multiple shoots | MS medium + 3.0 mg $L^{-1}$ BAP | Klaocheed *et al*. (2020) |
| | | Shoots | Roots | MS medium + 1.0 mg $L^{-1}$ NAA | |
| | *Cryptocoryne walkerlii* | Shoot tips | Shoots | MS medium + 3.0 mg $L^{-1}$ kinetin | Rittirat *et al.* (2018) |
| | *Philodendron billietiae* | Shoot tips | Shoots | MS medium + 3.0 mg $L^{-1}$ BAP | Maikaeo *et al.* (2024) |
| | | Shoots | Roots | ½ MS medium + 2.0 mg $L^{-1}$ NAA | |

| | | | | | |
|---|---|---|---|---|---|
| Campanulaceae | *Lobelia cardinalis* L. | Nodal segments | Multiple shoots | MS medium + 1.0 mg $L^{-1}$ BAP | Rittirat *et al.* (2021), Rittirat *et al.* (2022d) |
| | | Micro shoots | Roots | MS medium + 0.5 mg $L^{-1}$ NAA | |
| | *Lobelia cardinalis* L. | Micro shoots | Roots | MS medium + 1.0 mg $L^{-1}$ IBA | Rittirat *et al.* (2022e) |
| | *Lobelia cardinalis* L. | Nodal segments | Multiple shoots | MS medium + 1.0 mg $L^{-1}$ BAP + 2.0 mg $L^{-1}$ NAA | Klaocheed *et al.* (2024) |
| | | Shoots | Roots | MS medium + 1.0 mg $L^{-1}$ IBA | |
| Dioscoreaceae | *Tacca chantrieri* Andre. | Shoots | Multiple shoots | MS medium + 3.0 mg $L^{-1}$ BAP | Rittirat *et al.* (2018) |
| Orchidaceae | *Aerides odorata* Lour. | Protocorms | PLBs | MS + 2.5 mg $L^{-1}$ BAP | Rittirat *et al.* (2019) |
| | | Shoots | Plantlets | MS medium + 3.0 mg $L^{-1}$ IBA | |
| | | Protocorms | Plantlets | MS medium + 15% (v/v) CW + 0.2 % (w/v) AC | Rittirat *et al.* (2022f) |
| | Hybrid *Cattleya* | Shoots (1.0-1.5 cm) | Roots | MS medium + 15% (v/v) CW + 3.0 mg $L^{-1}$ NAA | Rittirat *et al.* (2021) |
| | *Cymbidium finlaysonianum* Lindl. | Protocorm | PLBs | VW liquid medium + 8.84 µM BAP | Rittirat *et al.* (2017) |
| | *Cymbidium finlaysonianum* Lindl. | PLBs | Plantlets | VW medium +0.2% (w/v) AC | Rittirat *et al.* (2017) |
| | *Cymbidium finlaysonianum* Lindl. | Seeds | Protocorms | VW medium | Rittirat *et al.* (2018) |
| | | Protocorms | PLBs | VW liquid medium + 8.84 µM BAP | |
| | | PLBs | Plantlets | VW medium + 0.2 % (w/v) AC | |
| | *Dendrobium cruentum* Rchb. f. | Shoot tips | PLBs | 1/2 MS liquid medium + 1% (w/v) sucrose + 1.0 mg $L^{-1}$ NAA | Sangdum *et al*. (2017) |
| Orchidaceae | *Dendrobium crumenatum* Sw. | Callus | PLBs | MS medium + 0.5 mg $L^{-1}$ TDZ | Rittirat *et al.* (2018) |
| | | PLBs | Plantlets | MS medium + 1.5 mg $L^{-1}$ IBA | |
| | *Dendrobium crumenatum* Sw. | PLBs | Shoots | MS + 15 % (v/v) CW | Klaocheed *et al.* (2021) |
| | | Shoots | Plantlets | MS +15 % (v/v) CW + 0.2 % (w/v) AC | |
| | *Dendrobium palpebrae* Lindl. | Protocorms | Plantlets | VW medium + 7% (w/v) sucrose | Kalawong *et al.* (2020) |
| | *Grammatophyllum speciosum* | Shoot tips | PLBs | 1/2 MS liquid medium + 2% (w/v) sucrose | **Sopalun** *et al.* **(2010)** |
| | *Grammatophyllum speciosum* | Protocorms (2.0 mm) | Shoots | MS liquid medium + 2 mg $L^{-1}$ BA | Samala *et al.* (2020) |
| | *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. | Wounded protocorm | PLBs | ½ MS medium + 0.1 mg $L^{-1}$ NAA + 0.1 mg $L^{-1}$ TDZ | Rittirat *et al.* (2012) |
| | *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. | PLBs | Plant conversion | MS medium + 15% CW + 0.2% AC | Rittirat *et al.* (2012) |
| | *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. | Leaf explants | PLBs | ½ MS medium + 9µM TDZ | Rittirat *et al.* (2014) |
| | *Rhynchostylis gigantea* (Lindl.) Ridl. | Shoot tips | Adventitious shoots | VW liquid medium + 10 g $L^{-1}$ Sucrose | Prasongsom *et al.* (2016) |

| | | | | | |
|---|---|---|---|---|---|
| Orchidaceae | *Rhynchostylis gigantean* var. Sagarik | Embryogenic callus | Somatic embryo (SE) | NDM medium + 2% sucrose + 15% CW + 0.2% (w/v) AC + under light condition | Rittirat *et al.* (2011) |
| | *Spathoglottis eburnea* Gagnep | Shoot tips | Shoots | ½MS medium + 1 mg $L^{-1}$ NAA + 2 mg $L^{-1}$ BAP | Pornchuti *et al.* (2017) |
| | *Spathoglottis plicata* Blume | Protocorms | PLBs | MS medium + 15% (v/v) CW + 3.0 mg $L^{-1}$ BAP | Rittirat *et al.* (2024) |
| | | PLBs | Plantlets | MS medium + 0.2% (w/v) AC | |
| | *Vanda coerulea* | Shoot tips | Adventitious shoots | VW medium + 10 g/l sucrose | Jitsopakul *et al.* (2013) |
| Oxalidaceae | *Oxalis triangularis* A.st.-Hil | Petiole segments | Plantlets | MS medium + 3.0 mg $L^{-1}$ BAP + 0.5 mg $L^{-1}$ 2,4-D. | Rittirat *et al.* (2022g) |
| | *Oxalis triangularis* A.st.-Hil | Petiole segments | Shoots | MS medium + 0.5 mg $L^{-1}$ NAA + 1.0 mg $L^{-1}$ BAP | Klaocheed *et al.* (2024) |
| | | Shoots | Roots | ½ MS medium + 1.0 mg $L^{-1}$ IBA | |
| Zingiberaceae | *Globba schomburgkii* Hook. f. via Bulbil | Microshoots (1 cm) | Shoots | MS medium + 2 mg $L^{-1}$ TDZ | Saensouk *et al.* (2018) |
| | *Kaempferia koratensis* Picheans. | Microshoots (1 cm) | Shoots | Liquid MS medium + 2 mg $L^{-1}$ TDZ + 1 mg $L^{-1}$ kinetin + 0.2 mg $L^{-1}$ NAA | Saliwan *et al.* (2022) |
| | *Kaempferia parviflora* Wall. ex Baker | Terminal buds | Shoots | MS medium + 35.52 µM BA | Prathanturarug *et al.* (2007) |
| | *Kaempferia marginata* Carey ex Roscoe | Microshoots | Shoots | MS medium + 2 mg $L^{-1}$ BA and 1.0 mg $L^{-1}$ TDZ | Saensouk *et al.* (2016) |
| | *Curcuma lithophila* Škorničk. & Soonthornk. | Microshoots (1.5 cm) | Shoots | MS medium + 10 µM BA | Nakdang *et al.* (2023) |
| | *Curcuma longa* Linn. | Rhizomes | Callus | MS medium + 0.5 mg $L^{-1}$ 2,4-D | Kaewthip *et al.* (2021) |
| | *Curcuma comosa* Roxb. | Bud | Shoots | MS medium + 3.0 mg $L^{-1}$ BA | Siringam and Pongprayoon (2022) |
| | *Curcuma singularis* Gagnep. | Rhizome buds | Shoots and roots | MS medium + 2.0 mg $L^{-1}$ BA | Jitsopakul *et al.* (2017) |
| | *Kaempferia galanga* Linn. | | | | |
| | *Zingiber officinale* Rosc. | Rhizome buds | Shoots and roots | MS medium + 1.0 mg $L^{-1}$ BA | |
| | Kaempferia angustifolia | Bud | Shoots | MS medium + 1.0 mg $L^{-1}$ Kinetin + 2.0 mg $L^{-1}$ TDZ + 0.2 mg $L^{-1}$ NAA | Saliwan *et al.* (2022) |

**Table 2:** Successful cryopreservation of *amorphophallus koratensis* and some Thai orchid species and hybrids

| *Genus* | *Species* | *Materials* | *Method* | *Dehydration* | *Survival/ regrowth* | *References* |
|---|---|---|---|---|---|---|
| *Aerides* | *Aerides houlettiana* Rchb.f. | Pollinia | V cryo-plate | 60 min PVS2 | 100% survival, 66.7% capsule set | Jitsopakul *et al.* (2021) |
| *Amorphophallus* | *A. koratensis* | Pollen | Direct plunged into liquid nitrogen, 7 d | Collecting pollen at the first day after anthesis | 33.8% pollen viability | Soonthornkalump *et al.* (2019) |
| *Arundina* | *A. graminifolia* | Protocorms | D cryo-plate | 30 g drying beads in laminar air-flow cabinet | 77.0% regrowth | Cordova and Thammasiri, (2016). |
| *Cymbidium* | *Cymbidium finlaysonianum* Lindl. | PLBs | Encapsulation | stored at 8 ± 2 °C, 105 d | 44.0% conversion frequency | Klaocheed *et al.* (2018) |
| *Cymbidium* | *Cymbidium finlaysonianum* Lindl. | PLBs | Vitrification | precultured with 0.5 M sucrose for 2 d, 60 min PVS2 at 0°C | 33.5% regrowth | Rittirat *et al.* (2019) |
| *Coelogyne* | *C. trinervis* L. | Pollinia | V cryo-plate | 20 min PVS2 | 100% survival, 100% capsule set | Jitsopakul *et al.* (2021) |
| *Dendrobium* | *D. cariniferum* | Protocorms | encapsulation-vitrification | 60 min PVS2 at 25 ± 2°C | 15% survival | Pornchuti and Thammasiri, (2008) |
| | *D. chrysotoxum* L. | Pollinia | V cryo-plate | 20 min PVS2 | 40% survival, 20% capsule set | Jitsopakul *et al.* (2021) |
| | *Dendrobium crumenatum* Sw. | PLBs | Encapsulation | stored at 8 ± 2°C, 105 d | 50.0% conversion frequency | Klaocheed and Rittirat (2018) |
| | *D. draconis* Rchb. f. | Protocorms | V cryo-plate | preculture with 0.4 M sucrose for 3 d, 0.6 M in LS, 10 min PVS2 | 75% survival | Jitsopakul *et al.* (2020) |
| | *D. cruentum* Rchb. f. | Seeds | D cryo-plate | 60 minutes drying beads in a laminar air-flow cabinet | 68.89% survival, 57.78% germination | Prasongsom *et al.* (2020) |
| | *D. signatum* Rchb. f. | Pollinia | V cryo-plate | 40 minutes PVS2 | 55.6% survival | Jitsopakul *et al.* (2019) |
| | | | D cryo-plate | 3 hours in a laminar air-flow cabinet | 50% survival | |
| | *D.* Walter Oumae | Shoot tips | Encapsulation-dehydration | 6–8 hours in laminar air-flow cabinet | 13.33% survival | Lurswijidjarus and Thammasiri, (2004) |
| *Eria* | *E. bractescens L.* | Pollinia | V cryo-plate | 20 minutes PVS2 | 100% survival, 66.7% capsule set | Jitsopakul *et al.* (2021) |
| *Grammatophyllum* | *G. speciosum* | Protocorms | encapsulation-vitrification | 60 minutes PVS2 | 14% regrowth | Sopalun *et al.* (2010) |
| | *G. speciosum* | Protocorms | droplet-vitrification | 30 minutes PVS2 | 38% regrowth | Sopalun *et al.* (2010) |
| | *G. speciosum* | Seeds | D cryo-plate | 120 minutes drying beads in silica gel | 87.22% viability rate | Thanasuttanithi and Thammasiri, (2022) |
| *Paphiopedilum* | *Paphiopedilum exul* (Ridl.) Rolfe | Seeds | Encapsulation-vitrification | 40 minutes PVS2 | 29.68% seed germination, growth index (GI) at 2.03 | Imsomboon and Thammasiri (2020) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Phalaenopsis* | *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. | PLBs | Encapsulation | stored at 25 ± 1°C, 30 days | 100.00% germination | Rittirat *et al.* (2015) |
| *Pomatocalpa* | *Pomatocalpa spicatum Breda.* | Pollinia | V cryo-plate | 40 minutes PVS2 | 100% survival, 100% capsule set | Jitsopakul *et al.* (2021) |
| *Rhynchostylis* | *Rhyn. gigantea* (L.) Ridl. | Pollinia | V cryo-plate | 40 minutes PVS2 | 100% survival, 100% capsule set | Jitsopakul *et al.* (2021) |
| *Seidenfadenia* | *Seidenfadenia mitrata (Rchb.f.)* Garay. | Pollinia | V cryo-plate | 40 minutes PVS2 | 100% survival, 50% capsule set | Jitsopakul *et al.* (2021) |
| *Spathoglottis* | *S. plicata* Blume. | Pollinia | V cryo-plate | 20 minutes PVS2 | 100% survival, 100% capsule set | Jitsopakul *et al.* (2021) |
| *Vanda* | *V. coerulea* | Seeds | Vitrification | 70 minutes PVS2 at 25 ± 2°C | 67% germination | Thammasiri and Soamkul (2007) |
| *Vanda* | *V. tricolor* | Seeds | Vitrification | 180 minutes PVS2 on ice | 13.6% germination | Jitsopakul *et al.* (2012) |
| *Vanda* | *V. coerulea* | Protocorms | Encapsulation-dehydration | 8 hours in a laminar air-flow cabinet | 40% | Jitsopakul *et al.* (2008b) |
| *Vanda* | *V. lilacina* Teijsm. & Binn | Protocorms | V cryo-plate | 20 minutes PVS2 | 33.33% survival | Imsomboon *et al.* (2020) |
| *Vanda* | *V. lilacina* Teijsm. & Binn | Protocorms | D cryo-plate | 1-hour in silica gel | 83.78% survival | Imsomboon *et al.* (2020) |
| *Vanda* | *V. bensonii Batem.* | Pollinia | V cryo-plate | 40 minutes PVS2 | 100% survival, 100% capsule set | Jitsopakul *et al.* (2021) |
| *Vanda* | *V. brunnea Rchb.f.* | Pollinia | V cryo-plate | 60 minutes PVS2 | 100% survival, 100% capsule set | Jitsopakul *et al.* (2021) |

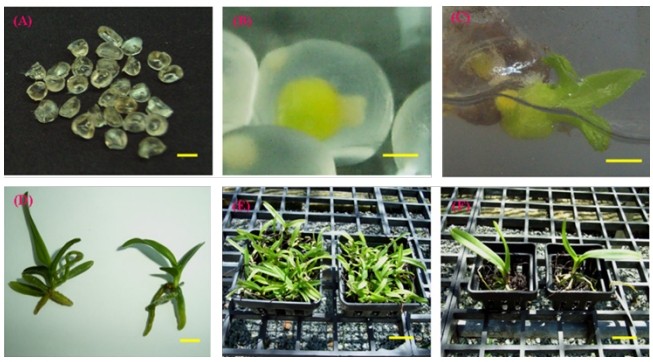

**Figure 5:** Regrowth of *Vanda coerulea* protocorms after cryopreservation by encapsulation-dehydration in combination with loading solution. (A) Precultured beads after sterile air-flow dehydration for 10 hours, (B) Cryopreserved protocorms after 20 days of regrowth, (C) 3 months of culture on modified VW agar medium showing shoot growth, (D) Plantlets after 8 months of culture on modified VW agar medium (left: non-cryopreserved, right: cryopreserved plantlet), (E)Plantlets derived from cryopreserved protocorms after 5 months, and (F) 15 months of culture in the greenhouse. Bar for A-C = 1 mm, for D = 0.5 cm, and for E and F = 1 cm. (Jitsopakul *et al*., 2008)

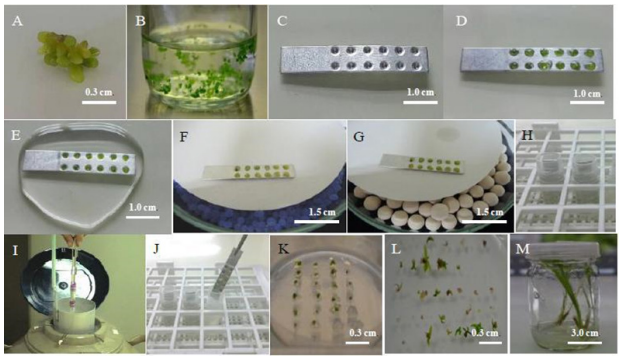

**Figure 6:** Cryo-plate method for *Arundina graminifolia* dehydrated with silica gel or drying beads. (A) Protocorm development, (B) Preculture of protocorms in ½MS liquid medium with 0.7 M sucrose for 1 d, (C) Pour the alginate solution containing 2% (w/v) sodium alginate in calcium-free ½MS basal medium with 0.4 M sucrose in the wells, (D) Place the precultured protocorms in the wells one by one, (E) Pour the calcium chloride solution containing 0.1 M calcium chloride in ½MS basal medium with 0.4 M sucrose, (F) Dehydration with 50 g silica gel, (G) Dehydration with 30 g drying beads, (H) Put each cryo-plate in a 2 mL cryotube, (I) Plunge 2 mL cryotubes into liquid nitrogen for 1 d, (J) Warming in 1.2 M sucrose solution for 20 minutes, (K) Plate on ½MS agar medium, (L) Regrowth, and (M) Regrowth after 60 days. (Cordova II and Thammasiri, 2016)

## Conclusion

Thai ornamental crop cultivation for the international markets has a bright future. The export values are high and quite stable. Orchids will continue to dominate other ornamental crops due to better technology know-how in cultivation, suitable climatic conditions, experienced and skillful growers and exporters as well as their nationwide popularity (Thammasiri, 1997). Orchid cultivation in Thailand is a good example of biotechnology development for an ornamental crop, which does not fall in the category of staple food, to have become the major crop of this country. It took a long time to be accepted gradually but firmly for earning high income and thereby enhancing the agrarian economy, which can follow suit.

## References


Agricultural Extension. (2022) Data on ornamental plant production area in Thailand. Ministry of Agriculture and Cooperatives, Bangkok, Thailand.

Arditti J and R Ernst (1993) Micropropagation of orchids. John Wiley & Sons, Inc., New York.

Choojun W, W Chesu, S Rittirat, S Klaocheed and K Thammasiri (2017) Micropropagation of an Ornamental Aquatic Plant, *Cryptocoryne wendtii* from Shoot Tip Culture. *Proceedings of the 1st National and International Conference on Education for Sustainable Locality Development 2017. Bansomdejchaopraya Rajabhat University, Bangkok, Thailand. 29 July 2017.* 1: 558-564.

Cordova LB, K Thammasiri (2016) Cryopreservation on a cryo-plate of *Arundina graminifolia* protocorms, dehydrated with silica gel and drying beads. *CryoLetters* 37(2): 68-76.

Cronquist A (1981) An integrated system of classification of flowering plants. Columbia Univ. Press, NY.

Department of Customs. (2022) Data on import-export of ornamental crops. Ministry of Finance, Bangkok, Thailand.

Department of International Trade Promotion (2022) Data on import-export of orchids. Ministry of Agriculture and Cooperatives, Bangkok, Thailand.

Imsomboon T and K Thammasiri (2020) Cryopreservation of *Paphiopedilum exul* (Ridl.) Rolfe seeds using encapsulation-vitrification and encapsulation-dehydration methods. *Acta Hortic.* 1298: 195-204.

Imsomboon T, K Thammasiri, P Kosiyajinda, N Chuenboonngarm and N Panvisavas (2019) Cryopreservation of non-precultured protocorms of *Acampe rigida* (Buch.-Ham. Ex Sm.) P.F. Hunt using V cryo-plate and D cryo-plate methods. *Acta Hortic.* 1234: 269-278.

Jitsopakul N, A Chunthaworn, U Pongket and K Thammasiri (2022) Interspecific and Intergeneric Hybrids of *Aerides* Species with *Rhynchostylis coelestis* Rchb.f. and germination of hybrid seeds *in vitro*. *Trends Sci.* 19(8): 3429.

Jitsopakul N, A Chunthaworn, U Pongket and K Thammasiri (2023) Ability of *Seidenfadenia mitrata* (Rchb.f.) Garay, pollinia stored at low temperature on fertilization, pod formation and *in-vitro* hybrid seed germination. *Indian J. Genet.* 83(1): 122-126.

Jitsopakul N, P Homchan and K Thammasiri (2020) Cryopreservation of *Dendrobium draconis* Rchb. f. protocorms using V cryo-plate method. *Acta Hortic.* 1298: 213-218.

Jitsopakul N, P Sangyojarn, P Homchan and K Thammasiri (2017) Micropropagation for conservation of *Zingiberaceae* in Surin province, Thailand. *Acta Hortic.* 1167: 75-80**.**

Jitsopakul N, P Sangyojarn, P Homchan and K Thammasiri (2019) Efficiency of aluminum cryo-plates for cryopreservation of *Dendrobium signatum* Rchb. f. pollinia. *Acta Hortic*. 1234: 279-286.

Jitsopakul N, K Thammasiri and K Ishikawa (2013) Efficient adventitious shoot regeneration from shoot tip culture of Vanda coerulea, a Thai orchid. ScienceAsia. 39: 449-455.

Jitsopakul N, K Thammasiri and K Ishikawa (2008) Cryopreservation of *Vanda coerulea* protocorms by encapsulation-dehydration. *CryoLetters* 29: 253-260.

Jitsopakul N, P Homchan and K Thammasiri (2020) Cryopreservation of *Dendrobium draconis* Rchb. f. protocorms using V cryo-plate method. *Acta Hortic*. 1298: 213-217.

Jitsopakul N, P Homchan and K Thammasiri (2021) Cryopreservation orchid pollinia using the V cryo-plate. *CryoLetters* 42(1): 25-32.

Jitsopakul N, K Thammasiri and K Ishikawa (2008) Cryopreservation of *Vanda coerulea* protocorms by encapsulation-dehydration method. *CryoLetters* 29: 253-260.

Kaewthip W, S Dheeranupattana, P Junta and L Shank (2021) Sterile Tissue Preparation and Callus Induction of *Curcuma longa* Linn. *CMUJ. Nat. Sci.* 20(3): e2021062.

Kalawong S, P Yimyong, S Rittirat, S Suwanno and A Siangsuepchart (2020) Effects of culture media, sucrose and chitosan concentrations on *Dendrobium palpebrae* Lindl. micropropagation. *Khon Kaen Agri. J.* 48(2): 395-404.

Kanchanapoom K, S Sunheem and K Kanchanapoom (2010) In vitro Propagation of *Adenium obesum* (Forssk.) Roem. and Schult. *Not. Bot. Hort. Agrobot. Cluj.* 38(3): 209-213.

Kaewubon P, S Sangdam, K Thammasiri and U Meesawat (2010) Plant regeneration through somatic embryogenesis from callus-derived PLBs of tropical slipper orchid (*Paphiopedilum niveum* (Rchb. f.) Pfitz.). *Floriculture Ornamental Biotechnol.* 4 (Special Issue 1): 29-35.

Klaocheed S, W Jehsu, W Choojun, K Thammasiri, S Prasertsongskun and S Rittirat (2020) Induction of Direct Shoot Organogenesis from Shoot Tip Explants of an Ornamental Aquatic Plant, *Cryptocoryne wendtii*. *Walailak J. Sci. Technol.* 17(4): 293-302.

Klaocheed S and S Rittirat (2018) Synthetic Seeds of Endangered Medicinal Orchid Species, *Dendrobium crumenatum* Sw. *J. Perspectives on Development Policy in the Greater Mekong Region, International College of Mekong Region, Chiang Rai Rajabhat University.* 6(1): 127-139.

Klaocheed S, S Rittirat, S Kalawong and K Thammasiri (2024) Rapid Clonal Multiplication Through In Vitro Axillary Shoot Proliferation of *Lobelia cardinalis* L., an Ornamental Aquatic Plant. *Trends Sci.* 21(8): 7690.

Klaocheed S, S Rittirat, S Kalawong and K Thammasiri (2024) Maximization of Micropropagule Production in an Attractive Ornamental Plant, *Oxalis triangularis* A.st.-Hil. *Trends Sci.* 21(8): 7917.

Klaocheed S, S Rittirat and K Thammasiri (2021) Plantlet Regeneration and Multiple Shoot Induction from Protocorm-Like Bodies (PLBs) of Medicinal Orchid Species, *Dendrobium crumenatum* Sw. *Walailak J. Sci. Technol.* 18(7): Article 9168 (9 pages).

Klaocheed S, S Rittirat, K Thammasiri and S Prasertsongskun (2018).

Alginate-encapsulation, Short-term Storage and Plantlet Regeneration from Encapsulated Protocorm-like Bodies (PLBs) of *Cymbidium finlaysonianum* Lindl.: an Endangered Orchid of Thailand. *Walailak J. Sci. Technol.* 15(10): 725-737.

Laohavisuti N and M Mitrnoi (2005) Micropropagation of Aglaonema simplex. *Proceedings of 43rd Kasetsart University Annual Conference: Fisheries, Natural Resources and Environmental Economics* 1: 267-274.

Lurswijidjarus W and K Thammasiri (2004) Cryopreservation of shoot tips of *Dendrobium* Walter Oumae by encapsulation/ dehydration. *ScienceAsia.* 30: 293-299.

Maikaeo L, V Puripunyavanic, M Limtiyayotin, P Orpong and C Kongpeng (2024) Micropropagation and gamma irradiation mutagenesis in *Philodendron billietiae* L. *Thai J. Agric. Sci.* 57(1): 11-19.

Murashige T and F Skoog (1962) A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Physiol. Plant.* 15: 473-497.

Nakdang S, R Chuengpanya, P Sornyotha, A Muangkroot, T Jenjittikul and N Chuenboonngarm (2023) *In vitro* Propagation of *Curcuma lithophila* Škorničk. & Soonthornk., an Endemic Species of Thailand with High Potential to be used as Ornamental Plant. *J. Appl. Sci.Emerging Technol. (JASET).* 22(2): 1-14.

OEPP (1996). Thailand's biodiversity. Ministry of Science, Technology and Environment, Bangkok, Thailand.

Prathanturarug S, T Apichartbutra, W Chuakul and P Saralamp (2007) Mass propagation of *Kaempferia parviflora* Wall. ex Baker by *in vitro* regeneration. *J. Hortic. Sci. Biotechnol.* 82(2): 179-183.

Pornchuti W and K Thammasiri (2008) Cryopreservation of protocorms of *Dendrobium cariniferum* Rchb. f. *Acta Hortic.* 788: 63-68.

Pornchuti W, K Thammasiri, N Chuenboonngarm and N Panvisavas (2017) Micropropagation of Spathoglottis eburnea Gagnep, a Thai orchid species, through shoot tips. Acta Hortic. 1167: 87-94.

Prasongsom S, K Thammasiri and N Chuenboonngarm (2016) Efficient adventitious shoot regeneration from shoot tip culture of Rhynchostylis gigantea (Lindl.) Ridl. (amethyst-purple), a rare Thai orchid species. Walailak Journal of Science and Technology. 13(9): 757-767.

Prasongsom S, K Thammasiri, N Chuenboonngarm, N Panvisavas, J Narangajavana and S Thitamadee (2020) Conservation of *Dendrobium cruentum* Rchb. f. *Acta Hortic.* 1298: 187-194.

Prasongsom S, K Thammasiri, J Narangajavana, S Thitamadee, N Chuenboonngarm and N Panvisavas (2020) Cryopreservation of *Dendrobium cruentum* Rchb. f. seeds by D cryo-plate and V cryo-plate techniques. *Walailak J. Sci. Technol.* 17(3): 181-191.

Rittirat S, S Klaocheed, S Prasertsongskun and K Thammasiri (2017) Asymbiotic seed germination and Protocorm-like body proliferation of *Cymbidium finlaysonianum* Lindl. *Acta Hortic.* 1167: 101-106.

Rittirat S, S Klaocheed, J Suppapan, P Chaithada, S Kalawong and K Thammasiri (2019) Cryopreservation of an endangered pharmaceutically important orchid, *Cymbidium finlaysonianum* Lindl. using vitrification technique. *Acta Hortic.* 1234: 125-132.

Rittirat S, S Klaocheed and K Thammasiri (2022a) A Reliable protocol for micropropagation of an ornamental aquatic plant, *Staurogyne repen*. *Acta Hortic.* 1339: 227-236.

Rittirat S, S Klaocheed and K Thammasiri (2022b). In vitro shoot organogenesis in *Anthurium andraeanum* 'HC 028' – a highly valued cut-flower and potted ornamental plant. *Acta Hortic.* 1339: 291-299.

Rittirat S, S Klaocheed and K Thammasiri (2022c) Thidiazuron induces high-frequency plant regeneration from shoot tip explants of an ornamental aquatic plant, *Anubias barteri* var. *nana*. *Acta Hortic.* 1339: 273-280.

Rittirat S, S Klaocheed and K Thammasiri (2022d) Organogenesis and efficient *in vitro* plantlet regeneration from nodal segments of an ornamental aquatic plant, *Lobelia cardinalis* L., using BAP. *Acta Hortic.* 1339: 237-243.

Rittirat S, K Thammasiri and S Klaocheed (2022e) *In vitro* Shoot Micropropagation and Plant Establishment of an Ornamental Aquatic Plant (*Lobelia cardinalis* L.). *Proceedings of the 11th International Molecular Biology and Biotechnology Congress (MolBiotech 2022). Çukurova University, Turkey. October 10-12, 2022.* 1: 62-68.

Rittirat S, S Klaocheed and K Thammasiri (2022f) Asymbiotic *in vitro* seed germination, plantlet development and forest reestablishment of *Aerides odorata* Lour., an endangered orchid from Thailand. *Proceedings of the XII International Scientific Conference "Conservation and Cultivation of Orchids". Botanic Garden of Moscow State University named after M.V. Lomonosov, Moscow, Russia. June 7-10, 2022.* 1: 224-232.

Rittirat S, S Klaocheed and K Thammasiri (2022g) Large scale *in vitro* micropropagation of an ornamental plant, *Oxalis triangularis* A.st.-Hil, for commercial application. *Acta Hortic.* 1339: 245-255.

Rittirat S, S Klaocheed, S Kalawong and K Thammasiri (2023) Adventitious shoot organogenesis from shoot tip explants of an ornamental aquatic plant *Anubias barteri* var. *nana*. *Proceedings of the 9th International Agriculture Congress (9th IAC). Çukurova University, Turkey. October 2-4, 2023.* 1: 20-26.

Rittirat S, S Klaocheed, S Kalawong and K Thammasiri (2024) Asymbiotic seed germination and plantlet development of *Spathoglottis plicata* Blume, a handsome terrestrial orchid. *Proceedings of the 23rd World Orchid Conference. Tainan, Taiwan. February 25-28, 2024.* 1: 248-251.

Rittirat S, S Klaocheed and K Thammasiri (2021). In vitro shoot multiplication of *Lobelia cardinalis* L., an aquatic ornamental plant. *Acta Hortic.* 1324(1): 55-62.

Rittirat S, S Klaocheed and K Thammasiri (2014). Enhanced efficiency for Propagation of *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. using trimmed leaf technique. *Int. J. Biol., Food, Veterinary Agric. Engineering (IJABE).* 8(4): 336-339.

Rittirat S, S Klaocheed and K Thammasiri (2015) Short-term storage of alginate-encapsulated protocorm-like bodies of *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. *Acta Hortic.* 1078: 75-80.

Rittirat S, S Klaocheed, K Thammasiri and S Prasertsongskun (2018) *In vitro* Propagation and Forest Reestablishment of *Cymbidium finlaysonianum* Lindl., an Endangered Medicinal Orchid. *Walailak J. Sci. Technol.* 15(10): 711-724.

Rittirat S, S Klaocheed, K Thammasiri and A Walam (2020) An efficient in vitro plantlet regeneration of an ornamental aquatic plant *Anubias heterophylla* through shoot tip culture. *Acta Hortic.* 1298: 265-272.

Rittirat S, S Kongruk and S Te-chato (2012) Induction of Protocorm-

like bodies (PLBs) and Plantlet Regeneration from Wounded Protocorms of *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. *Int. J. Agric. Technol. (IJAT)* 8(7): 2397-2407.

Rittirat S, S Te-chato, N Kerdsuwan and S Kongruk (2011) Micropropagation of Chang Daeng (*Rhynchostylis gigantean* var. Sagarik) by embryogenic callus. *Songklanakarin J. Sci. Technol.* 33(6): 659-663.

Rittirat S, K Thammasiri and S Klaocheed (2021) *In Vitro* Rapid Multiplication of a Highly Valuable Ornamental Aquatic Plant *Anubias Heterophylla*. *Trends Sci.* 18(19): 3.

Rittirat S, S Klaocheed and K Thammasiri (2021). *In vitro* Plantlet Regeneration of Yellow Flowered Hybrid *Cattleya* (Orchidaceae). *Proceedings of the 10th International Molecular Biology and Biotechnology Congress (MolBiotech 2021). Çukurova University, Turkey. October 4-8, 2021.* 1: 49-55.

Rittirat S, K Thammasiri and S Klaocheed (2018) Plantlet Production from Shoot Tip Explants of Aquatic Plant, *Cryptocoryne walkerlii* Cultured *In Vitro*. *Proceedings of International Conference on Innovation, Smart Culture and Well-Beings (ICISW2018). Suan Sunandha Rajabhat University, Bangkok, Thailand. November 8, 2018.* 1: 370-378.

Rittirat S, K Thammasiri and S Klaocheed (2018). *In Vitro* Propagation of an Endangered Medicinal Plant, Bat Flower; *Tacca chantrieri* Andre. for Conservation in Thailand. Proceedings of International Conference on Innovation, Smart Culture and Well-Beings (ICISW2018). *Suan Sunandha Rajabhat University, Bangkok, Thailand. November 8, 2018.* 1: 387-393.

Rittirat S, K Thammasiri and S Klaocheed (2019) Optimisation of Plantlet Regeneration from *Aerides odorata* Lour. *Proceedings of the 13th Asia Pacific Orchid Conference 2019 (APOC 13) "Cultural Exchange Through Orchid". Borneo Convention Centre Kuching (BCCK), Sarawak, Malaysia. July 24-28, 2019.* 1: 166-170.

Rittirat S, K Thammasiri and S Te-chato (2012) Effect of media and sucrose concentrations with or without activated charcoal on the plantlet growth of *P. cornu-cervi* (Breda) Blume & Rchb. f. *Int. J. Agric. Technol.(IJAT)* 8(6): 2077-2087.

Rittirat S, K Thammasiri, S Kalawong and S Klaocheed (2018). *Ex-situ* Conservation of Endangered Medicinal Orchid Species, *Dendrobium crumenatum* Sw. by Micropropagation. *The 13th International Conference in collaboration between Chiang Rai Rajabhat University, Thailand & University of Miyazaki, Japan. "ASIAN Community Knowledge Networks for the Economy, Society, Culture, and Environmental Stability". Miyazaki, Japan. July 8-12, 2017.* 2: 46-52.

Saensouk P, N Muangsan, S Saensouk and P Sirinajun (2016) In vitro propagation of *Kaempferia marginata* Carey ex Roscoe, a native plant species to Thailand. *J. Animal Plant Sci.* 26(5): 1405-1410.

Saensouk P, S Saensouk and P Pimmuen (2018) In vitro Propagation of *Globba schomburgkii* Hook. f. via Bulbil Explants. *Walailak J. Sci. Technol.* 15(10): 701-710.

Saliwan S, S Saensouk and P Saensouk (2022) In Vitro Propagation of *Kaempferia koratensis* Picheans., an Endemic Plant of Thailand. *Koch Cha Sarn J. Sci.* 44(1): 1-13.

Samala S, S Taweerodjanakarn, J Thipwong, K Thammasiri and PP Chareonsap (2020) Effects of BA and NAA on shoot multiplication of *Grammatophyllum speciosum* Blume in vitro. *Acta Hortic.* 1298: 273-280.

Sangdum S, K Thammasiri, N. Chuenboonngarm and K Sopalun (2017) Micropropagation of Dendrobium cruentum Rchb. f., a rare Thai orchid species. Acta Hortic. 1167: 69-74.

Siringama T and W Pongprayoon (2022). Influence of 6-Benzylaminopurine (BAP) and Indole-3-butyric acid (IBA) on shoot and root inductions of *Curcuma comosa* Roxb. through in vitro culture. *Naresuan Phayao J.* 15(2): 99-110.

Soonthornkalump S, U Meesawat and P Sutthinon (2020) Pollen viability and the preliminary study of pollen preservation method of *Amorphophallus koratensis* Gagnep. (*Araceae*), the potential exotic ornamental plant. *Acta Hortic.* 1298: 183-186.

Sopalun K, K Thammasiri and K Ishikawa (2010) Micropropagation of the Thai orchid, *Grammatophyllum speciosum* Blume. *Plant Cells Tiss.Org. Cult.* 101: 143-150.

Sopalun K, K Thammasiri and K Ishikawa (2010) Vitrification-based cryopreservation of *Grammatophyllum speciosum* protocorms. *CryoLetters.* 31: 347-57.

Thammasiri K (1997) *Orchids in Thailand: A Success Story.* APAARI, FAO. Angkor Publishers (P.) Ltd., New Delhi.

Thanasuttanithi D and K Thammasiri (2022) Cryopreservation of *Grammatophyllum speciosum* Blume seeds by D cryo-plate method. *Acta Hortic.* 1339: 111-116.

Thammasiri K (2000) Cryopreservation of seeds of a Thai orchid (*Doritis pulcherrima* Lindl.) by vitrification. *CryoLetters*. 21: 237-244.

Thammasiri K (2002) Preservation of seeds of some Thai orchid species by vitrification. *Proc. 16th World Orchid Conference.* 1: 248-251.

Thammasiri K and L Soamkul (2007) Cryopreservation of *Vanda coerulea* Griff. Ex Lindl. seeds by vitrification. *ScienceAsia.* 33: 223-227.

Thammasiri K, T Jenjittikul, P Soonthornchainaksaeng, U Viboonjun and A Muangkroot (2019) Cryopreservation of *Arundina graminifolia* (D. Don) hochr. seeds using D cryo-plate method. *Acta Hortic.* 1234: 301-308.

Thammasiri K, N Jitsopakul and S Prasongsom (2020) Micropropagation of some orchids and the Use of Cryopreservation. In: J-M. Merillon, H Kodja (eds.) *Orchids Phytochemistry, Biology and Horticulture*. Springer Nature Switzerland.

Tilarux P, A. Suwanposri, S Tachai, P Sasivatchutikool and Y Boonmee (2022). Effect of plant hormones on growth of Wan Khan Mak (*Aglaonema tenuipes* Engl.). *In vitro. J Sci Technol MSU.* 41(5): 227-235.

Vacin EF and FW Went (1949) Some pH changes in nutrient solutions. *Bot. Gaz.* 110: 605-613.