Program and Abstracts

The First International Symposium on

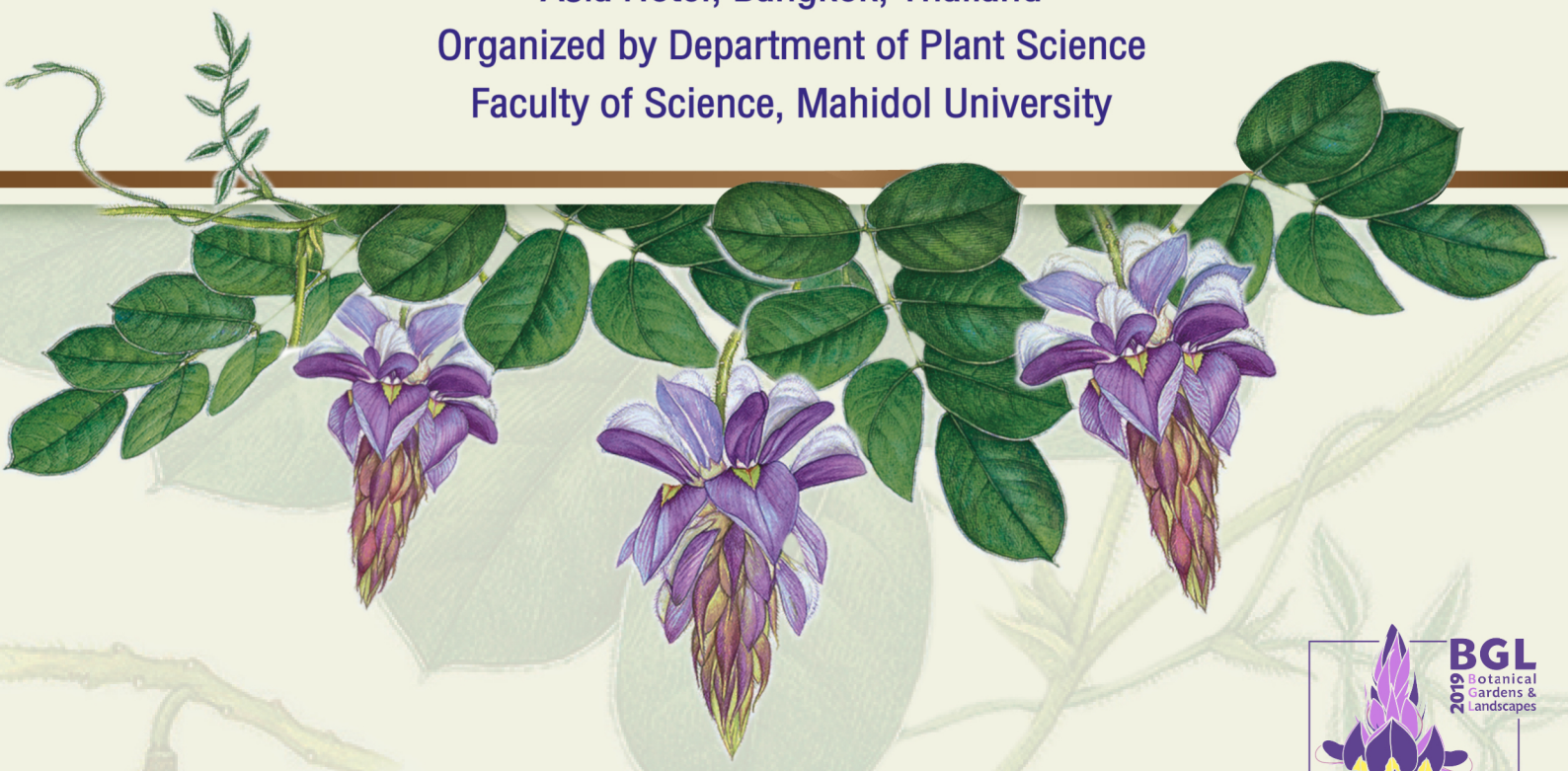
BOTANICAL GARDENS & LANDSCAPES (BGL 2019)

December 2-4, 2019

Asia Hotel, Bangkok, Thailand

Organized by Department of Plant Science

Faculty of Science, Mahidol University



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Department of Plant Science,

Faculty of Science, Mahidol University

In collaboration with

International Society for Horticultural Science: ISHS

Nikita Botanical Gardens

Plant Genetic Conservation Project under the Royal Initiative of

HRH Princess Maha Chakri Sirindhorn: RSPG

Department of Agriculture, Ministry of Agriculture and Cooperatives

Thailand Institute of Scientific and Technological Research: TISTR

and

Suan Luang Rama IX Garden

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Theme Plant: Kan Phai Mahidol (*Afgekia mahidoliae* B. L. Burtt & Chermsir.), the symbolic plant of Mahidol University

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The First International Symposium on Botanical Gardens and Landscapes

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Welcome Address

The Dean, Faculty of Science, Mahidol University, the Head, Department of Plant Science, Chair of Division Landscape and Urban Horticulture, ISHS, distinguished participants, honourable guests, ladies, and gentlemen:

It has been a great pleasure for me and the Symposium Committee members to be assigned by the President of Mahidol University to organize the First International Symposium on Botanical Gardens and Landscapes (BGL 2019) with the collaborations and support from the International Society for Horticultural Science, the Nikita Botanical Gardens, the Department of Plant Science, Faculty of Science, Mahidol University, the Department of Agriculture, Thailand Institute of Scientific and Technological Research, and the Suan Luang Rama IX Garden. Our committee has been working very hard for the preparation and orderly progress to this important event. It is our great pleasure to warmly welcome all the participants to this symposium. We would also like to thank all of you for making this event possible.

The main objective of this symposium is to learn the recent advances in all aspects of plant science which cover Botanical gardens, Landscapes, Urban Horticulture and Gardens, Plant Genetic Resources, Plant Conservation, Plant Taxonomy, Plant Breeding, Plant Propagation, Plant Tissue Culture, Plant Production, Plant Biotechnology, and Ethnobotany. It also focuses on creating an interactive opportunity for people involved in education, research, and industry development on a global scale.

I would like to extend my appreciation to the keynote speaker, Professor Shengji Pei and invited speakers, Professor Dr. Hugh W. Pritchard, Professor Dr. Chunlin Long, Professor Dr. Francesco Orsini, and Professor Dr. Irina Mitrofanova, oral presenters and poster presenters for their excellent cooperation. The research findings to be presented at this international symposium will enable 154 participants from 15 countries to keep abreast of plant science and the research being conducted in this fast-moving field.

As the convener, I would like to assure all participants that we will try our best to make this symposium as fruitful and enjoyable as possible.
Thank you very much.

Associate Professor Dr. Kanchit Thammasiri

Convener of the BGL 2019

Welcome Address

It is with great pleasure that I welcome all participants to the First International Symposium on Botanical Gardens and Landscapes (BGL 2019), held in Bangkok, Thailand on December 2-4, 2019 and organized by the Department of Plant Science, Faculty of Science, Mahidol University in collaboration with the botanical gardens, research institutes, governmental organizations, universities, associations and private sectors in Thailand and abroad and under the aegis of the International Society for Horticultural Science (ISHS) and its Division on Landscape and Urban Horticulture, that I hereby represent as Chair.

I wish to sincerely thank the convenor, Dr. Kanchit Thammasiri for putting together such a diversified and comprehensive programme, which notably also include a number of relevant keynote speeches. Among them, Prof. Shengji Pei (Honorary President of Chinese Association of Ethonobotany, Kunming Institute of Botany, Chinese Academy of Sciences, China) will explore the role of botanical gardens in plant conservation, with a special consideration of bio-cultural diversity and traditional botanical knowledge. The role of horticultural sciences on genetic resource preservation in botanical garden will be targeted by a keynote lecture from Prof. Hugh Pritchard (Head of Comparative Seed Biology, Royal Botanic Gardens Kew, United Kingdom). Consistently, the biocultural diversity conservation in botanical gardens will be further explored by Prof. Chunlin Long (Head of Ethnobiological Program, Minzu University of China, and Deputy Director of Key Laboratory of Ethnomedicine of Ministry of Education, China). The national strategies for plant biodiversity conservation through biotechnology in Russian botanical gardens will be presented by Prof. Irina Mitrofanova (Department of Plant Developmental Biology, Biotechnology and Biosafety, FSFIS "The Labor Red Banner Order Nikita Botanical Gardens – National Scientific Center of the RAS", Yalta, Russian Federation). Finally, I will contextualize green infrastructure within the framework of landscape and urban horticulture by exploring the different options for plant cultivation available within cities.

Within the framework offered by these speeches, the conference will bring together scientists, professionals, businessmen, and growers involved in research, education, industry, and agriculture on a global scale, combining the most recent advances in a range of disciplines, including Plant Genetic Resources, Plant Conservation, Plant Taxonomy, Plant Breeding, Plant Propagation, Plant Tissue Culture, Plant Production, Plant Biotechnology, Ethnobotany, Botanical Gardens, Landscapes, and Urban Horticulture and Gardens.

I sincerely wish all participants a fruitful and inspiring discussion within the intense and stimulating programme of these three days in Bangkok.

Professor Dr. Francesco Orsini
Professor, Vegetable Crops and Urban Horticulture
DISTAL – Department of Agricultural and Food Sciences
Alma Mater Studiorum – Bologna University
Chair, Division Landscape and Urban Horticulture (ISHS)

Welcome Address

On behalf of the Department of Plant Science, Faculty of Science, Mahidol University, it gives me great pleasure to warmly welcome all of the distinguished guests, presenters, and participants to the First International Symposium on Botanical Gardens and Landscapes (BGL 2019).

Thailand is among the world's most biodiverse regions and an important center for tropical plants. We focus on a wide range of plant groups including rare species native to Thailand and economically-valuable plants such as orchids and gingers. Cultivating botanical gardens and landscaping are vital issues that we have to pay close attention to and take action on, not only for displaying the beauty of native Thai plants, but also for the conservation and protection of these important natural resources.

Lastly, I would like to express my gratitude to all of the participants who have given their time to attend this symposium. I am incredibly grateful to Associate Professor Dr. Kanchit Thammasiri and the organizing staff, who have been working tirelessly behind the scenes for many months towards making this symposium possible. I hope that all of the participants enjoy and appreciate the presentations and knowledge shared over these next few days, and explore the innovative work on display at BGL 2019.

Thank you very much

Associate Professor Dr. Puangpaka Umpunjun

Head, Department of Plant Science

Faculty of Science, Mahidol University

Opening Address

The Convener of the BGL 2019, the Head of the Department of Plant Science, Chair of Division Landscape and Urban Horticulture, ISHS, distinguished participants, honourable guests, ladies, and gentlemen:

It is my great honour to have this opportunity to be presiding over, as well as to be the organizer of the First International Symposium on Botanical Gardens and Landscapes with the support from the International Society for Horticultural Science (ISHS), the Nikita Botanical Gardens in Russia, and the governmental and private sectors. The Faculty of Science places a strong emphasis on research and an ongoing commitment to international scientific advancement and national development. The staff at the Faculty have also performed many administrative and advisory functions in various academic organizations at the national, regional, and international levels. Therefore, the main objective of the BGL 2019 which is to learn the recent advances in Botanical Gardens and Landscapes, as well as to create an interactive opportunity for people involved in research, education, and industry development on a global scale, is relevant to the Faculty's objectives.

I would like to extend my appreciation to the keynote speaker, invited speakers, oral presenters, poster presenters, and 154 participants from 15 countries. They have travelled so far to meet friends who have common interests, and the BGL 2019 Organizing Committee for making this international symposium a success. I hope that we will meet again and have collaborations in the near future.

I extend my warmest greetings by wishing the success of the BGL 2019, as well as continued good health and prosperity of all the participants of this event.

At this auspicious moment, I have the honour to declare the First International Symposium on Botanical Gardens and Landscapes open.

Associate Professor Dr. Palangpon Kongsaeree

Dean, Faculty of Science, Mahidol University

The First International Symposium on Botanical Gardens and Landscapes
2-4 December 2019
Asia Hotel, Bangkok, Thailand

Sunday 1 December 2019

Orchid Room, 1st Floor, Asia Hotel

12:00-17:00 hr. Pre-registration

Monday 2 December 2019

King Petch Hall, 3rd Floor, Asia Hotel

8.00-9.00 hr. **Registration and Posting Posters**

9:00-10:00 hr. **Opening Ceremony** **MC:** Asst. Prof. Dr. Alyssa Stewart

- Welcome Address
  by Associate Professor Dr. Kanchit Thammasiri, BGL 2019 Convener
- Welcome Address
  by Associate Professor Dr. Puangpaka Umpunjun, Head of Department of Plant Science, Faculty of Science, Mahidol University
- Opening Address
  by Associate Professor Dr. Palangpon Kongsaeree,
  Dean, Faculty of Science, Mahidol University
- Welcome and Presentation
  by Professor Dr. Francesco Orseni
  Chair, Division Landscape and Urban Horticulture (ISHS)
- Welcome and Presentation
  by Dr. Yuri Plugatar
  Director of the Nikita Botanical Gardens
- Presentation of ISHS certificate and medal to Symposium Convener
- Presentation of Souvenirs to Symposium Sponsors
- Group Photographs

10:00-10:30 hr. **Keynote Presentation:**
Botanic garden and plant diversity conservation in China
Shengji Pei, Kanchit Thammasiri, Zhiwei Yang

10:30-10:45 hr. Coffee Break

Invited Oral Presentations

Chair: Dr. Vladimir Upelniek
Secretary: Assoc. Prof. Dr. Paweena Traiperm

10:45-11:05 hr.	I_1	**COP for botanic gardens** Hugh W. Pritchard, Xiangyun Yang, Kanchit Thammasiri, Yan Zhu, Anders Lindstrom, Anna Nebot, Dani Ballesteros
11:10-11:30 hr.	I_2	**Biocultural Diversity Conservation in Botanical Gardens** Chunlin Long, Zhuo Cheng, Guanhua Li, Yanxiao Fan, Xia Jiang, Liu He, Kanchit Thammasiri
11:35-11:55 hr.	I_3	**From microgarden technologies to vertical farms: Innovative growing solutions for multifunctional urban agriculture** Francesco Orsini, Giuseppina Pennisi, Giorgio Gianquinto
12:00-13:00 hr.	Lunch Break	
13:00-13:20 hr.	I_4	**Biotechnology ways of plant biodiversity conservation in botanical gardens of Russia** Irina Mitrofanova, Olga Molkanova

Session I: Researches in Botanical Gardens (BG)

Chair: Prof. Shenji Pei
Secretary: Asst. Prof. Dr. Wisuwat Songnuan

13:25-13:40 hr.	BG_1	**Water and nutrient management in botanical gardens and horticulture** Uwe Schindler, Frank Eulenstein
13:45-14:00 hr.	BG_2	**Development of the collections of floral-ornamental crops in the Nikitsky Botanical Gardens** Svetlana Plugatar, Yuri Plugatar, Zinaida Klimenko, Vera Zykova, Ludmila Alexandrova, Irina Ulanovskaya, Natalya Zubkova, Natalya Smykova
14:05-14:20 hr.	BG_3	**The Nikitsky Botanical Gardens: record of achievements and prospects** Yuri Plugatar
14:25-14:40 hr.	BG_4	**Development of a master plan and fund-raising plan for the M.S. Swaminathan botanical garden in Wayanad, India** Sarada Krishnan, Anil Kumar, Madhura Swaminathan
14:45-15:00 hr.	BG_5	**Research on the construction of Chinese botanical garden exhibition system based on regional characteristics** Peiyao Hao, Zonghui Hu, Xinyi Shu, Dandan Zhang

15:05-15:20 hr.	BG_6	**People pollinating partnerships: Harnessing collaborations between botanic gardens and agricultural research organizations on crop diversity** Sarada Krishnan, Stephanie L. Greene, Colin K. Khoury, Jeff Kuehny, Allison J. Miller, Tara Moreau, Ari Novy
15:20-15:35 hr.	Coffee Break	

Session II: Researches in Landscapes (LS)

Chair: Prof. Dr. Francesco Orsini

Secretary: Assoc. Prof. Dr. Paweena Traiperm

15:35-15:50 hr.	LS_1	**A taxonomic key for identifying seeds of undesirable plants in landscapes** Phil Allen
15:55-16:10 hr.	LS_2	**Residential garden as green infrastructure: A research-by-design case study in Chiang Mai** Pongsakorn Suppakittpaisarn, Chulalux Wanitchayapaisit, Nadchawan Chareonlertthanakit, Vipavee Surinseng, Ekachai Yaipimol
16:15-16:30 hr.	LS_3	**University-trained volunteers use demonstration gardens as tools for effective and transformative community education** Karrie Reid, Melissa Gable
16:30-17:30 hr.	Poster Presentations (Odd Numbers)	
17:30-18:30 hr.	Poster Presentations (Even Numbers)	
18:30-20:30 hr.	Welcome Dinner and Cultural Show	

Tuesday 3 December 2019

King Petch Hall, 3rd Floor, Asia Hotel

MC: Asst. Prof. Dr. Alyssa Stewart

Session II: Researches in Landscapes (LS) (continued)

Chair: Prof. Dr. Phil Allen

Secretary: Asst. Prof. Dr. Sasivimon C. Swangpol

8:30-8:45 hr.	LS_4	**Design of fire-affected school grounds of special primary and secondary schools** Angeliki Paraskevopoulou, Kyriakos Aggelakopoulos, Eleftheria Stathopoulou
8:50-9:05 hr.	LS_5	**Bridging interdisciplinary knowledge for sustainable urban landscapes: results from the international student competition UrbanFarm2019** Francesco Orsini, Giuseppina Pennisi, Andrea D'Alessandro, Denisa Kratochvilova, Gloria Steffan, Mattia Paoletti, Gianmarco Sabbatini, Michele D'Ostuni, Antonella Trombadore, Giorgio Gianquinto
9:10-9:25 hr.	LS_6	**Floral visitors of Kluai Bua Si Som (*Musa rubra*: Musaceae): an ornamental plant in Thailand** Wipawee Nilapaka, Thaya Jenjittikul, Alyssa Stewart, Kongmaitree Tedsungnoen, Sasivimon C. Swangpol
9:30-9:45 hr.	LS_7	**Identifying obstacles for autonomous mowers in the North American landscape** Alyssa Brown
9:45-10.00 hr.	Coffee break	

Session III: Researches in Plant Conservation (PC)

Chair: Prof. Dr. Maria Papafotiou

Secretary: Asst. Prof. Dr. Wisuwat Songnuan

10:00-10:15 hr.	PC_1	**Conservation strategies for a critically endangered species, *Madhuca insignis* (Radlk.) H.J. Lam - A unique case model** P.E. Rajasekharan
10:20-10:35 hr.	PC_2	**Aquagene: A unique conservatory for aquatic plants of south India at KSCSTE ' MBGIPS, Kerala, India** N.S. Pradeep, K.P. Anoop, P.V. Madhusoodanan, Kumar S. Pradeep
10:40-10:55 hr.	PC_3	**Cryopreservation of *Fragaria* x *ananassa* using different techniques** Sandhya Gupta, Prashant Tewari

Session IV: Researches in Plant Tissue Culture (PTC)

Chair: Asst. Prof. Dr. Kullanart Obsuwan
Secretary: Asst. Prof. Dr. Panida Kongsawadworakul

11:00-11:15 hr.	PTC_1	**Shoot multiplication of HQC34 hybrid pineapple [*Ananas comosus* (L.) Merr.] via bioreactor with different concentrations of 6-benzylaminopurine and MS medium** Lenti Valentina, Yulian Yulian, Orchat Sittichan, Suneerat Sripaoraya
11:20-11:35 hr.	PTC_2	**Establishment of a protocol for micropropagation of *Clausena guillauminii* Tanaka** Supanath Kanjanawattanawong, Natthathida Singbumrung
11:40-11:55 hr.	PTC_3	**Some features of in vitro morphogenesis in endangered *Seseli lehmannii* Degen** Olga Mitrofanova, Irina Mitrofanova, Marina Rudenko, Nina Lesnikova-Sedoshenko, Tatyana Kuzmina
12:00-12:15 hr.	PTC_4	**An efficient in vitro plantlet regeneration of an ornamental aquatic plant *Anubias heterophylla* through shoot tip culture** Ariya Walam, Sutha Klaocheed, Kanchit Thammasiri, Suphat Rittirat
12:15-13:15 hr.	Lunch Break	

Session V: Researches in Production, Physiological, Phytochemical, and Molecular Studies (M)

Chair: Dr. Rujira Deewatthanawong
Secretary: Asst. Prof. Dr. Unchera Viboonjun

13.15-13:30 hr.	M_15	**Phytochemical content and antioxidant activity of leaf extracts from nine bamboo species and determination of flavone C-glycosides by TLC and HPLC** Pennapa Karawak, Supanyika Sengsai, Chockpisit Thepsithar, Sarunyaporn Maksup
13:35-13:50 hr.	M_16	**Anticancer efficacy of *Luisia zeylanica* Lindl., an epiphytic orchid from Eastern Ghats of Andhra Pradesh, India--an in vitro approach** Shaik Mahammad Khasim, Katta Jhonsi
13:50-15:00 hr.	Coffee Break	
15:00-16:30 hr.	Business Meeting and Closing Ceremony	

Tuesday 3 December 2019

Patumwan Hall, 2nd Floor, Asia Hotel

MC: Dr. Saroj Ruchisansakun

Session V: Researches in Production, Physiological, Phytochemical, and Molecular Studies (M)

Chair: Prof. Dr. Chunlin Long
Secretary: Dr. Saroj Ruchisansakun

8:30-8:45 hr.	M_1	**Asexual and sexual propagation of *Muntingia calabura* L.** Fitriana Nasution, Chinawat Yapwattanaphun
8:50-9:05 hr.	M_2	**Vapour phase antifungal activity of essential oils and their raw materials against *Aspergillus* sp., *Curvularia lunata*, and *Fusarium sacchari*** Alex Ahebwa, Rachsawan Mongkol, Mana Kanjanamaneesathian
9:10-9:25 hr.	M_3	**Efficacy of ethanolic extracts of galangal (*Alpinia galanga* L.) in mycelial growth of *Fusarium sacchari* and *Curvularia lunata* and their phytotoxicity on Pak choi (*Brassica rapa* var. chinensis)** Molika Ma, Mana Kanjanamaneesathian, Rachsawan Mongkol
9:30-9:45 hr.	M_4	**Promoted tuber yields in Jerusalem artichoke by controlled spectral distribution lighting with LED** Thitima Seedapalee, Panupon Hongpakdee
09:45-10:00 hr.	Coffee Break	
10:00-10:15 hr.	M_5	**Mechanical stimulation techniques promote compactness in potted sunchoke production** Kesorn Kaewbua, Panupon Hongpakdee
10:20-10:35 hr.	M_6	**Site analysis and development of strategy to enhance the identity of Lycabettus Hill in Athens and support sustainable management** Maria Papafotiou, Angeliki Paraskevopoulou, Anastasia Akoumianaki-Ioannidou, Verina Myroforidou, Matina Galati, Christina Andreopoulou, Anna-Maria Vissilia, Konstantinos Choundas, Ioannis Kontos, Theodora Porfyraki, Feve Christara-Papageorgiou, Dimitrios Gogolos, Eleni-Anna Papakonstantinou

Session V: Researches in Production, Physiological, Phytochemical, and Molecular Studies (M) (continued)

Chair: Prof. Dr. Mohammad Khasim Shaik
Secretary: Asst. Prof. Dr. Aussanee Pichakum

10:40-10:55 hr.	M_7	**Effect of substrate type and cultivation position on growth and safety to consume of the edible medicinal species *Crithmum maritimum* L., in an extensive urban green roof in Athens (Greece)** Aikaterini N. Martini, Maria Papafotiou, Ioannis Massas, Nikoleta Chorianopoulou, Ivana Zivanovic
11:00-11:15 hr.	M_8	**Effect of hydroponic and organic fertilizer on growth, safety, and storage quality of watercress (*Nasturtium officinale* R. Br.)** Sutin Kunyamee, Supraween Suvunnaphom, Kanokporn Sananon, Maliwan Saouy
11:20-11:35 hr.	M_9	**Summer condition promoted growth, development, and carbohydrate content in sacred lotus (*Nelumbo nucifera* Gaertn.)** Sornnarin Suangto, Soraya Ruamrungsri, Panupon Hongpakdee
11:40-11:55 hr.	M_10	**Controlled porosity based sub-surface porous vessel (SSPV) structures for irrigating organic farms of Fruits and Vegetables** Anand Plappally, Lovelesh Dave, Hanwant Rathore, Nirmal Gehlot, Rajkumar Satankar, Sandeep Gupta, Pankaj Jakhar, Amrita Nighojkar, Meraj Ahmad
12:00-12:15 hr.	M_11	**Effect of paclobutrazol on growth of young potted flame tree (*Delonix regia* (Boj. ex Hook) Raf.)** Pichaporn Srikoat, Aussanee Pichakum, Patchareeya Boonkorkaew, Nath Pichakum
12:15-13:15 hr.	Lunch Break	

Session V: Researches in Production, Physiological, Phytochemical, and Molecular Studies (M) (continued)

Chair: Prof. Dr. Irina Mitrofanova
Secretary: Asst. Prof. Dr. Aussanee Pichakum

13.15-13:30 hr.	M_12	**Ethnobotanical study on medicinal dietary plants used by the Yi people in southeastern Yunnan, China** Yong Xiong, Jingxian Sun, Xiangzhong Huang, Chunlin Long

13:35-13:50 hr.	M_13	**Value analysis of *Hedychium flavum*, a Buddhist plant** Guanhua Li, Chunlin Long
13:55-14:10 hr.	M_14	**Acoustic diagnostics of phytopathogenic damage to the trunk wood of *Magnolia grandiflora* L.** Vladimir Gerasimchuk, Yuri Plugatar

Wednesday 4 December 2019

Technical Tour (Starting from Asia Hotel)

8:30-17:30 hr. Visit Suan Luang Rama IX Garden, Bangkok and back to Asia Hotel

Post Tour (Starting from Suan Luang Rama IX Garden)

15.30 hr. Transfer from Suan Luang Rama IX Garden to Suvarnabhumi Airport (BKK) for a 5-day visit to beautiful gardens in Chiang Rai and Chiang Mai in northern Thailand

KEYNOTE AND INVITED ORAL PRESENTATIONS

K_1
Botanic garden and plant diversity conservation in China

Shengji Pei, Kunming Institute of Botany, 132 Lanhei Road, Heilongtan, Kunming, Yunnan, 650201, China; peishengji@mail.kib.ac.cn
Kanchit Thammasiri, Department of Plant Science, Faculty of Science, Mahidol University, Thanon Rama VI, Ratchathewi, Bangkok 10400, Thailand; kanchitthammasiri@gmail.com
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The worldwide contribution of Chinese plants can be simply explained by its rich plant diversity and domestication of cultivated plants in global agriculture development and botanic garden plants. According to updated data to an overview of plant diversity in China (Wang, 2015), China has 35,112 native species of higher plants belonging to 3,818 genera and 545 families, of which 17,439 species are endemic to China. China with its ancient civilization has developed a wide variety of cultivated plants in agriculture, horticulture, and forestry, at least 136 cultivated plants are originated from China (Sheng & Zhang, 1979) making up 20% of the world total cultivated plants (666 species) around the world for their economic importance. Botanic garden in China has a very long history, ancient royal garden is considered as earliest garden established in Chinese history; for example, the Shang-Lin-Yuan Garden was established in Xi'an during the Han Dynasty about 2,000 years ago. Modern botanic garden in China is 130 years old (Pei, S. J., 1985). There are 191 botanical gardens established all over China. Based on data collected from 142 botanic gardens, total land area of these gardens are 99,771 hectares including living collections for ex situ conservation and natural vegetation for in situ conservation, totaling recorded 197,517 plant taxa maintained in botanic gardens, which shows that botanic garden in China plays very important role in ex situ conservation of plant diversity. Recent development of botanic garden in China does not only indicate increased numbers of garden and the number of introduced plant species. but also scientific research activities conducted on plant conservation including eco-regional native plants investigation and conservation; re-introduction of endangered plants, methods of endangered plants conservation, sustainable use of economic plants, compiling and publication of Encyclopedia of Chinese Garden Flora, and many other research activities on conservation plant diversity. Although China boasts abundant plant diversity, this diversity is being depleted according to the China Species Red List (2004). There are 4,408 species of plants are threatened including 226 gymnosperm species and 4,183 angiosperms species, of which wild plants endangered ratio is 15-20% and Gymnosperm and orchids are as high as 40% are endangered. The challenge of plant conservation is seen as a high priority for biodiversity conservation and sustainable development in China today. It is in this concern, botanic garden in China has an important role to play in plant diversity conservation today.

This paper presents a brief review and discussion on botanic garden and plant diversity conservation in China for sharing information and knowledge, to further promote development of botanical garden and landscape conservation.

Keywords: plant diversity, botanic garden, conservation, China

I_1
COP for botanic gardens

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Cycads, orchids, and palms (COP) are three of the most charismatic families of plants. Their species are of significance in the landscape and are often used in botanic gardens to interpret for the public the importance of ecosystem and species conservation. Whilst the families vary in size, from c. 350 (cycads) to c. 26,000 (orchids) species, they all have many representatives that are at risk from a range of extrinsic or intrinsic factors; for example, illegal trade for use in private gardens (cycads), forest habitat destruction (orchids and palms), narrowing genetic bases as a result of small population sizes, etc. Beyond better protection for the species in their natural habitats, developing a range of ex situ conservation options for the families is needed, including conventional seed banking which involves drying and cold storage. In this review we will explore what is known about the storage behaviour of propagules in all three families, based on comparative studies. Future conservation strategies and research objectives will also be considered.

Keywords: cycads, orchids, palms, seed storage, pollen storage, cryopreservation

I_2
Biocultural diversity conservation in botanical gardens

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There is a very close relationship between plants and cultures. Collections of various plants in the botanical gardens show high level of biocultural diversity. Ethnobotanical studies have made and will make great contributions to the collection, conservation, and sustainable uses of plants in developing countries, especially in the areas with rich biocultural diversity. Plant diversity and associated traditional knowledge have faced challenges and lost rapidly because of human activities and climate changes. Botanical gardens, fortunately, may become important zones to conserve biocultural diversity, through their roles in ethnobotanical researches, collections and exhibitions, and public educations. The folk taxonomy, traditional uses including cultural uses, and customary management of plants can be presented and demonstrated in botanical gardens. Examples of botanical gardens which well-conserve plant biocultural diversity including the Xishuangbanna Tropical Botanical Garden, the Royal Botanic Gardens Kew, the Missouri Botanical Garden, and the New York Botanical Garden are provided in the present paper.

Keywords: plant diversity, cultural diversity, ethnobotany, ethnotaxa, public education

I_3

From microgarden technologies to vertical farms: Innovative growing solutions for multifunctional urban agriculture

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In response to the growth of urban population and the reduction of resources availability (e.g., arable land, water, and nutrients), new forms of agriculture that can be developed also in urban environment are gaining increasing popularity. Urban agriculture constitutes a viable opportunity for improving the city food security, also fostering local and circular economies, social inclusion, and environmental sustainability. In the different World regions, a diversity of urban farming systems is encountered with technological levels varying in response to the local socio-economic context, infrastructural networks, and environmental conditions. In developing economies from the South of the World, most interesting innovations include simplified hydroponics, organoponics, and microgarden technologies; whereas, in the Global North, innovative solutions for plant cultivation also include rooftop greenhouses and indoor vertical farms with artificial lighting where vegetable crops, mushrooms, and algae may be grown. Beside plant growing solutions, innovation may also stand in the system integration and mutual relationship with the urban fabric (e.g. in terms of resource use or ecosystem service provisioning), or in the business model adopted. The present review paper will describe a number of innovative solutions for plant cultivation in the urban environment, with a special consideration of the economic, environmental, and social sustainability.

Keyword: urban horticulture, building integrated agriculture, vertical farming, microgarden technologies, business models

I_4

Biotechnology ways of plant biodiversity conservation in botanical gardens of Russia

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According to the Global Strategy for Plant Conservation (2011-2020) to halt the continuing loss of plant biodiversity is possible by maintaining in situ, ex situ and in vitro collections. Botanical gardens are world centers of plant biodiversity conservation. There are 100 botanical gardens and dendroparks in the Russian Federation for the time being. The using of biotechnological approaches in the micropropagation and conservation of valuable horticultural plants, rare and endangered species, and the establishment of genebanks in vitro are becoming increasingly important for the preservation of the plant genepool. Now in the Russian Federation, the largest in vitro plant collections are in the Nikita Botanical Gardens – National Scientific Center of the RAS, main botanical garden, named after N.V. Tsitsin of the RAS and in the Central Siberian Botanical Garden of the Siberian Branch of the RAS. The effective plant biotechnology methods of organogenesis and somatic embryogenesis for more than 155 plant species and 1,160 cultivars and forms related to 61 families were developed. Actinidiaceae, Asteraceae, Cannaceae, Caprifoliaceae, Ericaceae, Lamiaceae, Liliaceae, Moraceae, Oleaceae, Ranunculaceae, and Rosaceae families are the most representative in slow-growing collections in vitro. The optimum temperature during in vitro culture of the plants is 22-24°C. The way of in vitro micropropagation depends firstly on genotype. The main factors, affecting in vitro plant conservation, are concentration of retardants and osmotics in culture medium, temperature, and light intensity. The storage temperature for different types of explant of investigated species, cultivars, and forms is 3-8°C. In the Russian Federation, all plant collections are registered online at Project Office for Bio-Resource Collection Management. The studies were supported by the ST N 0829-2019-0038 of the FSFIS “NBG-NSC”, by the ST N 18021490111-5 of the FSFIS Tsitsin MBG of the RAS, and by the grant N 19-16-00091 of the Russian Science Foundation. The genomic investigation of endemic plants supported by grant No 075-15-2019-1670 for CGIWL.

Keywords: botanical garden, valuable horticultural plants, rare and endangered species, micropropagation, genepool in vitro

ORAL PRESENTATIONS

Session I: Research in Botanical Gardens (BG)

BG_1
Water and nutrient management in botanical gardens and horticulture

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Securing good plant growth conditions in botanical gardens and achieving high and stable yields in horticulture requires sustainable water and nutrient management. Even short-term deficits can lead to growth stress. On the other hand, excessive water can lead to growth depressions as a result of lack of air, as well as losses of water and nutrients due to leaching. A sustainable and resource saving water and nutrient management requires knowledge of (i) physical and chemical soil or substrate properties for quantifying the water and nutrient demand, (ii) effective irrigation and drainage systems and (iii) in situ methods to test the effectiveness of these measures. Basic hydraulic properties are the water retention curve and the unsaturated hydraulic conductivity function. The HYPROP (Hydraulic PROPerty system) allows the simultaneous measurement of both functions and the dry bulk density. In addition, the measurement of hysteresis and shrinkage is possible. All necessary information for a sustainable water management can be derived from these hydraulic functions. Hydraulic properties of different soils and substrates are presented and discussed. Special in situ measurements of water content and tension allow the quantification of the water balance. With additional soil water sampling, quantifying the nutrient balance and leaching is possible. The methodologies have been used successfully on agricultural/horticultural and experimental sites over the last 20 years.

Keywords: water and nutrient management, water retention curve, unsaturated hydraulic conductivity function, Extended Evaporation Method (EEM), HYPROP

BG_2
Development of the collections of floral-ornamental crops in the Nikitsky Botanical Gardens

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Modern collections of floral ornamental crops of the Nikitsky Botanical Gardens (NBG) are formed as a result of long-term introduction and breeding researches for *Rosa* hybrids in 1812 and 1824, *Syringa* L. in 1813 and 1941, *Iris* hybrids in 1812 and 1993 *Hemerocallis* hybrids in 1812 and 1993, *Clematis* L. in 1817 and 1953, *Tulipa* L. in 1812 and 1960, *Canna* hybrids in 1812 and 1960, and *Chrysanthemum morifolium* Ramat. in 1812 and 1939. Today each collection includes cultivars of both foreign and domestic breeding, including those created in the NBG, and the total volume of collections is 2,406 species, cultivars and forms. Collections of roses, clematis, cannas, and chrysanthemums are the largest in the Russian Federation. The *Rosa* collection includes 35 garden groups from 36 existing ones, *Syringa* – 6 from 7 groups of flower coloring, *Iris* – all 3 garden groups, *Clematis* – 14 garden groups (the grand part of the available diversity), *Tulipa* – 14 garden classes from 15, *Canna* – both existing garden groups, *Chrysanthemum* – all 11 classes of this culture. Thus, the formed collections adequately reflect the created varietal diversity of each of these crops and provide a complete material for further selection and identification of assortment for landscaping in the South of Russia.

Keywords: *Rosa* × *hybrida*, *Syringa* L., *Iris* × *hybrida*, *Hemerocallis* × *hybrida*, *Clematis* L., *Tulipa* L., *Canna* × *hybrida*, *Chrysanthemum morifolium* Ramat.

BG_3
The Nikitsky Botanical Gardens: record of achievements and prospects

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The Nikitsky botanical gardens (NBG) was established in 1812 and hastened the coming of an agricultural industry development in the South of Russia on the ground of introduction, acclimatization, breeding and widespread fruit, flower, decorative, essential oil, medicinal and other useful plants, of study and an active acquisition the aboriginal plant resources.

NBG has over 1,150 awards. The State Nikitsky botanical gardens won the USSR Labour Red Banner Order in 1962. Since January 2016 NBG has become Federal State Funded Institution of Science “The Labour Red Banner Order Nikitsky Botanical Gardens – National Scientific Center of the Russian Academy of Sciences”.

NBG is patriarch of some sectors of the Russian national economy: viticulture, essential oil crop science, tobacco growing, a southern decorative horticulture, and a southern and subtropical pomiculture.

The famous scholarly traditions in breeding and introduction of the southern fruit, decorative and essential oil crops, in biotechnology, virology and biochemistry of plants,

acarology, perennial plant science, plant sociology, algology, and a landscape design have been formed in NBG.

NBG as a significant site of a garden art is an eidetic museum and a green depository out in the open.

NBG is the largest Russian disposal space of a genetic plasma for specific and varietal diversity of southern fruit cultivars. It includes 11,000 varieties of peach, apricot, cherry plum, sweet cherry, apple, pear, quince, fig, pomegranate, olive, jujube, persimmon, and others.

There are over 6,000 species in the unique collections of decorative woody and herblike plants. The essential oil, medicinal, aromatic plants amount to 250 varieties. It has been first brought under cultivation more than 400 new plant species, over 800 cultivars have been created and sent over to the national economy.

The unique Arboretum (the park for the study of trees) brought NBG its global fame. The collections of woody and bush plantings of a world flora are concentrated here over 40 hectares.

It is certain that in the long run the development of the Arboretum with the use of the modern interactive technologies is very important. The core facilities center and the unique scientific instruments are hosted by NBG as a scientific institution. They allow to use actively the most advanced scientific base and to rump up an intellectual potential in biotechnology, genomics, horticulture breeding research, etc.

Keywords: NBG, the South of Russia, Labour Red Banner order, scholarly traditions, an eidetic museum, a disposal space, a genetic plasma, arboretum, modern interactive technologies, the core facilities center

BG_4

Development of a master plan and fund-raising plan for the M.S. Swaminathan botanical garden in Wayanad, India

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The M.S. Swaminathan Research Foundation (MSSRF) established the Community Agrobiodiversity Centre (CAbC) in Wayanad, India in 1997 with the purpose of starting a community center for conserving and utilizing agrobiodiversity to achieve food, nutrition, health, and livelihood security of the local forest-dependent and small holder farm families. In 2010, the Center expanded its area to about 20 ha primarily to conserve important plant diversity in ex-situ collections which included agricultural biodiversity and rare, endemic and threatened species of the Western Ghats through the creation of the M.S. Swaminathan Botanical Garden (MSSBG). In 2014, the Denver Botanic Gardens in Denver, Colorado, USA, partnered with MSSBG to develop a master plan to provide a future vision for growth and development of the M.S. Swaminathan Botanical Garden. The master plan identifies three zones and their programmatic components – 1) Community Zone displaying major plant collections in an aesthetic manner for visitor interaction and appreciation with potential for revenue generation; 2) Agrobiodiversity Zone predominantly concentrating on ethnobotanical

plant collections programmed to reach the diverse local tribal and farming populations; and 3) Rare, Endemic, Threatened (RET) Conservation Zone maintained in a near-natural state emphasizing the conservation of local biodiversity. In 2017, an advisory committee was formed to spearhead the implementation of the master plan and develop clear strategies for action, an outcome being the development of a fund-raising plan. The process of development of the master plan and fund-raising plan will be discussed.

Keywords: agrobiodiversity, biodiversity, botanical garden, conservation, master plan, Western Ghats

BG_5
Research on the construction of Chinese botanical garden exhibition system based on regional characteristics

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As a crucial type of urban green space, there is no doubt that botanical garden has an irreplaceable great advantage for the regional characteristics shaping of urban gardens, against the background of the lacking of urban regional characteristics. It is necessary to fully consider the scientific, systematic, and comprehensive nature of the exhibition system of botanical gardens and reflect the regional natural characteristics and cultural characteristics of the region due to the differences in natural environment, social culture, and economic technology in different regions. This paper systematically analyzes the differences in regional natural characteristics and cultural characteristics, and summarizes the characteristics and connotation of regional plant landscapes, and proposes a method for constructing the Chinese Botanical Garden exhibition system with regional characteristics – that is researching how to construct the characteristic road of the botanical garden exhibition system and provide the guidance for the reconstruction and planning design of the Chinese Botanical Garden which takes representative botanical gardens in Northeast China, North China, Central China, East China, South China, Southwest China and Northwest China as the research objects by following the existing site conditions and landscape structure and relying on existing plant resources and humanities. The Fundamental Research Funds for the Central Universities (No. 2019ZY44); Special Fund for Beijing Common Construction Project.

Keywords: botanical garden, planning and design, regionality, landscape characteristics

BG_6

People pollinating partnerships: Harnessing collaborations between botanic gardens and agricultural research organizations on crop diversity

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Plants nourish people and are key to human well-being. Botanic gardens around the world are repositories of plant diversity but are seldom considered to be major contributors to conservation and research of crop diversity. Thus, botanic gardens and agricultural research organizations have had somewhat limited interactions historically. An unprecedented three-year collaboration between the American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, the American Public Gardens Association, and the World Food Prize Foundation brought together experts from botanic gardens and the agricultural research community, culminating in a Symposium in April 2019 in Des Moines, Iowa. Funded by a grant from the United States Department of Agriculture – National Institute of Food and Agriculture (USDA – NIFA), one of the major outcomes of this collaboration was the development of a shared Road Map for conservation, use, and public engagement around North America's crop wild relatives and wild utilized plants – species of interest to both communities. Key takeaways from this collaboration will be discussed.

Keywords: botanic gardens, collaborations, conservation, crop diversity, crop wild relatives

Session II: Research in Landscapes (LS)

LS_1
A taxonomic key for identifying seeds of undesirable plants in landscapes

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The seeds of invasive plants and noxious weeds are commonly found in topsoils and commercial seeds used in landscapes. Their presence can lead to less desirable landscape outcomes and significant costs associated with weed control following germination. The ability to identify seeds of these undesirable plants is increasingly important, especially where government regulations restrict their presence in crop seeds for purchase or topsoils for landscape use. The primary objective of this research is to develop an interactive, web-based seed taxonomy that will help with identification of noxious weed seeds (i.e., indicated as invasive by state or federal governments in the United States) and seeds that are presently considered invasive. Our seed sample library of over 1,000 species was acquired directly through field collection and through donations from collaborators around the world. Seeds of each species were measured, described in detail, and photographed. The primary basis for describing the seeds and keying them were seed shape, length, length to width ratio, seed surface characteristics, and seed color. The key is made interactive by using Lucid Software.

Keywords: invasive species, noxious weeds, weed seeds

LS_2
Residential garden as green infrastructure: A research-by-design case study in Chiang Mai

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In recent years, Chiang Mai has lost agricultural and forested areas to urbanization. The traditional agriculture and green spaces used to provide ecosystem services to the city. Residential landscapes can act as a part of green infrastructure that provides these ecosystem services, but they need design strategies to avoid the design failures that can harm the residents or the environment. This study took an evidence-based approach to the designing of a residential landscape as a part of green infrastructure through a case study in Hang Dong, Chiang Mai. We selected a residential site which was an agricultural landscape. The change had altered its landscape functions and reduced its ecosystem service potentials. Then, we analyzed the site and designed it with empirical evidence. Afterward, we conducted the post-occupancy evaluation (POE) to evaluate the design. The designed landscape, containing food, herbal, and ornamental plants, has become a habitat for wildlife native to Chiang Mai. It also received positive comments on users' satisfaction and perceived naturalness of the garden. The design has suggested to the field the possibility of using residential landscapes to produce different types of ecosystem service benefits. The strategies used in this design procedure can be developed into a guideline in designing residential landscapes as a part of green infrastructure. However, it is only a pilot study. Future studies must be developed to understand the measurable impacts of such design to the ecosystem, along with the economic values of the design in the perspectives of designers, residents, and the surrounding communities.

Keywords: research-by-design, landscape architecture, residential garden, biodiversity

LS_3

University-trained volunteers use demonstration gardens as tools for effective and transformative community education

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The University of California Division of Agriculture and Natural Resources (ANR) has developed a volunteer master gardener program that provides research-based educational outreach to the public through a variety of venues including a network of 76 demonstration gardens, 156 community gardens, and 594 school gardens distributed throughout 40 California counties. In fiscal year 2017-2018, master gardener volunteers gave 107,097 service hours to the development and maintenance of these outreach gardens at a total independent sector value of $3,115,448. Both passive education, through permanent informational signage, and active instruction carried out in workshops and "open garden" events provide local urban community members with training on a wide variety of sustainable gardening principles and practices. These efforts center around ANR's strategic initiatives: promoting sustainable natural ecosystems, supporting urban food production sustainability and security, responsible integrated pest detection and management, protecting water quality, quantity, and security, and supporting family and community health through science education and outdoor activity. Participant-reported behavioral changes from these garden-

based events include an increase in the use of landscape plants that attract and support pollinators (70%) and those that are water-conserving and regionally appropriate (67%), improved food growing skills (68%), increased use of compost for soil and plant health (46%), reduced use of pesticides (55%), and an increase in the amount of time spent in outdoor activity, including gardening (71%). With over 500,000 people served through garden-based educational activities, positive impacts are being made on California's urban ecology and the people who live there.

Keywords: sustainable gardening, regionally appropriate plants, gardening education, urban ecology, volunteer engagement, garden-based education, master gardener, demonstration garden

LS_4
Design of fire-affected school grounds of special primary and secondary schools

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The design proposal for the school grounds of a primary and secondary special school affected by fire is presented based on the post-fire perceptions of its users (pupils and teachers). The studied secondary school provides special vocational education and training workshops. Both special schools are located adjacent to each other in a peripheral mountainous area of Athens. The 2018 fire that engulfed the region caused damages to the schools. Perceptions on the school ground design of both teachers and pupils from both schools were determined through a questionnaire survey. The school grounds additionally to break time are used for teaching, holding outdoor activities, and sport events. Both primary and secondary school teachers state that appropriate school ground design can have a positive effect on pupils' school performance and that pupil contact with plants is necessary (93.3% and 100%, respectively). Most primary school pupils would like to have more trees in the school grounds and less ornamental herbaceous plants; this was the opposite for most secondary school pupils. Moreover, most primary school teachers and pupils would like to have a combined play structure (40.0%). On the otherhand most secondary school teachers and pupils would like to have a football field (42.9%), followed by a basketball court (35.7%). The results of the survey formed the basis of the design proposal. For the primary school the main aim is to develop pleasant and safe recreational open spaces; whereas, for the secondary school spaces to support the educational pupil needs.

Keywords: inclusive, pupil, special needs, horticulture, education

LS_5
Bridging interdisciplinary knowledge for sustainable urban landscapes: results from the international student competition UrbanFarm2019

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In a rapidly urbanizing world, urban agriculture represents an opportunity for improving food supply, health conditions, local economy, social integration, and environmental sustainability altogether. While a diversity of farming systems is encountered in the different world regions, it is estimated that about a third of urban dwellers is involved worldwide in the agro-food sector. In recent times, urban agriculture projects have sprouted across the world, both guided and promoted by governments than born by bottom-up community based initiatives. Accordingly, the concept of edible urban landscapes (edible cities, foodscapes) is today finding application all over the world. In order to facilitate a wider uptake of innovative policies and tools for the promotion of the sustainable goals associated with urban agriculture, it is therefore crucial to create awareness on both institutional actors and the civil society as a whole through innovative and interdisciplinary approaches. The international student challenge “UrbanFarm 2019” aimed to tackle the current need for cross-pollination between different disciplines by bringing together students from different fields of study into international teams addressing the regeneration of three vacant urban spaces in Italy. Target projects differ from their original purpose and include a former agricultural farm that was absorbed by the urban-sprawl in the second half of the XX century and acquired by the Bologna city council in the late eighties, a factory of domestic appliances, that largely contributed to the evolution of Conegliano city in the last 70 years, but was finally closed in

2003 after the company moved away the production and a primary school that suffered from the progressive abandonment of Belluno city outskirts and was closed in 1992. The three locations shared their current vacant status and the fact that they all today constitute a cost and a missed opportunity for their cities. The UrbanFarm2019 challenge aimed at showing that another use for these spaces is possible, overall contributing to creating cities that are more attractive, more livable, more inclusive and overall more sustainable. To reach this target, young minds from all over the world were engaged in international and interdisciplinary teams. UrbanFarm2019 became an opportunity to bridge viewpoints and approaches and integrate state-of-the-art technologies and design for urban farming with functional urban planning. Innovative ideas, visions and approaches were brought together by student teams with enthusiasm and dedication. Starting from these project ideas, inspired local administrators and urban planners will have tools to foster sustainability and livability of their cities. Beyond the elevate project quality, the major achievement of the UrbanFarm2019 competition stands upon the geographical distribution and expertise covered by the participating teams. The UrbanFarm international student challenge, achieved to engage a network of experts and urban agriculture practitioners from universities from all over the world in the evaluation of 35 projects prepared by teams involving more than 130 students. Looking at the projects it clearly appears how competences were successfully integrated and communicated in both project redaction and visual materials.

Keywords: problem based learning, team work, landscape architecture, urban horticulture

LS_6

Floral visitors of Kluai Bua Si Som (*Musa rubra*: Musaceae): an ornamental plant in Thailand

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Musa rubra, a native wild banana in Thailand, has aesthetic value as an ornamental plant given its showy inflorescence with colorful orange bracts. It flowers year-round, attracts birds and other animal visitors, and offers popular photo spots in gardens. The aim of this study was to examine the flowering time, both diurnal and nocturnal flower visitors, and mating system of *M. rubra* in Mae Yom National Park, Phrae, Thailand. Diurnal visitors were recorded using direct observation and a camera trap between 6.00 and 18.00 hr. Nocturnal visitors were recorded by an infrared camera trap between 18.00 and 6.00 hr. In order to assess the mating system, we conducted a pollination experiment with three treatments: open (inflorescences exposed to all flower visitors), closed (inflorescences enclosed in mesh bags), and hand-pollinated (pollen transferred by hand from a male inflorescence to a female inflorescence). We then collected all fruits 40 days later to determine seed set. It was found that bracts of female and male inflorescences open at 10.30 ± 0.08 hr and 10.27 ± 1.11 hr, respectively. Birds (*Arachnothera* spp.), hoverflies (*Graptomyza longirostris*), stingless bees (Apidae), and several butterflies (Nymphalidae, Papilionidae) visited *M. Rubra*. Surprisingly, none of the pollination treatments resulted in seed set. It is suspected that *M. rubra* is self-incompatible, and that our population study may be the result of vegetative propagation, i.e. all individuals are clones, thus explaining the lack of seed set in spite certain pollen transfer. This study may provide important information about *M. rubra* cultivation and breeding for commercial purposes.

Keywords: *Musa rubra*, Musaceae, pollination biology, ornamental plant, plant-animal interactions

LS_7
Identifying obstacles for autonomous mowers in the North American landscape

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Autonomous (i.e., robotic) lawnmowers offer a number of sustainability and labor-reduction benefits. Despite increasing popularity throughout Europe, autonomous mowers have yet to gain significant market share in the United States (U.S.). Common U.S. landscaping styles present obstacles for expanded robotic mowing. We compiled a list of these limitations, then evaluated 118 elite properties submitted to the Awards of Excellence program administered by the National Association of Landscape Professionals. Award submissions included landscape architecture plans and photos of completed projects, which allowed evaluation of each property for its ease of maintenance by autonomous mowers. Each property was scored based on limitations present and severity of the obstacle in each case. Of the 118 properties surveyed, 70% were classified as “non-friendly to autonomous mowing”, meaning they had obstacles that impeded successful property maintenance. The obstacles that received a severity ranking leading to this classification were predominantly associated with the accessibility of lawn areas. Thus, the obstacles that most frequently occurred on the property were separated lawn areas, obstructions at lawn edges, and obstructions within the lawn area, but the obstacles that most frequently led to a property being disqualified for autonomous mower care were separated lawn areas, planned entities obstructing access, and stairs. This research identified areas of technological improvements that manufacturers could make for U.S. landscapes to be more easily maintained by autonomous mowers. However, of greater benefit would be for landscape architecture professionals to incorporate design modifications that would greatly improve the success of autonomous mowers.

Keywords: robotic, lawn mower, deficiencies, robot, technology, lawn care, sustainability

Session III: Research in Plant Conservation (PC)

PC_1

Conservation strategies for a critically endangered species, *Madhuca insignis* (Radlk.) H.J. Lam - A unique case model

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Madhuca insignis (Radlk.) H.J. Lam is a critically endangered riparian tree species, endemic to India which existence was documented in the pages of taxonomic history, once thought to be extinct, only to be rediscovered after 120 years. Soon after, a number of field surveys were undertaken that recorded this fewer numbered species among the vast stretch of the Western Ghats in India, which soon led to the realization that this species is in the brink of extinction owing to various anthropogenic activities and changing climatic scenario. This further led to the realization that in situ methods alone do not meet the requirement for successful conservation, but a highly dynamic integrated in situ model comprising of Ecological, Molecular, Physiological, and Biotechnological methods holds the key for a successful conservation of this critically endangered species. With this line of thought, modern tools, such as ENM modelling has been employed to generate models to help reconstruct the species ecological requirements and/or predict geographic distributions of the *M. insignis*. Followed by Marker studies, it has been employed to support taxonomic identification of this species, as well as to understand its phylogenetic systematics. Finally, this study also provides snapshots of an ex situ measure: Reintroduction in terms of augmentation and introduction of the species in its natural habitats by firstly propagating the species; this feat carried out by restoring the particularly associated microflora to support the species physiological needs for growth and survival through means of symbiotic relations. All of the work combined to the successful establishment of these propagated individuals in wild leading to increase species population in their own niche habitats; leading to the actual realization of so said conservation of a critically endangered species. In a nutshell, an effort has been made to chalk out a simple but effective way for conservation of *M. insignis* which can be further extended to many more such endangered species.

Keywords: conservation, *Madhuca insignis*, ex situ, in situ reintroduction

PC_2

Aquagene: A unique conservatory for aquatic plants of south India at KSCSTE ' MBGIPS, Kerala, India

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The aquatic and wetland situations in general form highly specialized but subtle ecosystems supporting abundant and much diversified life forms are fast diminishing due to indiscriminate and detrimental anthropological activities. Since most of those ecosystems are located in plains where population pressure is excessive. At present about 700 aquatic plants were reported from South India, many of which are under threat due to the habitat deterioration destruction and pollution. Thorough field explorations conducted throughout South India, we have collected and studied over 400 aquatic plant species of which 25 species are found to be under the threatened category, which include *Aponogeton appendiculatus, Crinum malabaricum, Cryptocoryne sivadasanii, Cyanotis burmaniana, Limnopoa meeboldii, Lagenandra keralensis, Lagenandra meeboldii, Lindernia manilaliana, Nymphoides krishnakesara, Erioucaulon cuspidatum, Heliotropium keralense,* etc. These species are under threat due to eutrophication and other types of water pollution and habitat destruction consequent to land filling for construction purposes. Under these situations, these plants may become extinct in future. We made concerted efforts for the ex situ conservation of these plants by propagating in the aquatic plant conservatory providing maximum natural conditions possible at Malabar Botanical Garden and Institute for Plant Sciences and initiated the in vitro multiplication of certain species for the reintroduction in its natural habitat. Each plant species collected during the field explorations were preserved also as herbarium specimens and deposited in the herbarium of KSCSTE– MBGIPS for future references. All the specimens were identified through detailed laboratory studies with the help of authentic literature and standard floras and live plants are carefully maintained in the Aquatic plant conservatory (Aquagene) of our Institute and have been established successfully. All the plants are labelled depicting their common name, scientific name, family, uses, etc. to provide eco education to visitors in the Malabar Botanical Garden and Institute for Plant Sciences and inculcate enthusiasm and ecological awareness among the younger generation.

Keywords: aquagene, ex situ conservation, in vitro, threatened aquatic plants

PC_3
Cryopreservation of *Fragaria* x *ananassa* using different techniques

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The strawberry (*Fragaria* spp.) is a genus of plants in the rose family. There are more than 20 named species and many hybrids and cultivars. The most common strawberries grown commercially are cultivars of the Garden Strawberry, a *Fragaria* x *ananassa* hybrid. Cultivar Earliglow is one of the most popular, best-tasting strawberries. This excellent variety produces large, jewel-like, dark red berries. Cryopreservation is the use of very low temperature to preserve structurally intact living cells and tissue. This method of conserving germplasm is gained wide importance in recent years with the use of tissue culture technology, cryoprotectants, and liquid nitrogen freezing. There are many different techniques and methods available. Commonly used techniques, such as encapsulation-dehydration, vitrification, and etc., are based on phenomenon of vitrification. Encapsulation-dehydration is a method which involves the formation of artificial seeds of alginate and then conservation in liquid nitrogen. Whereas vitrification involves the use of cryoprotectants, such as dimethylsulphoxide and glycerol. Use of cryo-plate is a modified way for the vitrification. encapsulation-dehydration, vitrification, V-cryoplate, and D-cryoplate methods were applied to the in vitro grown shoot tips of *Fragaria* x *ananassa* cv. Earliglow for cryopreservation. The D-cryoplate method was found the best where 40% regrowth of liquid nitrogen treated plants was obtained. This was followed by vitrification, encapsulation-dehydration and V-cryoplate methods; whereas, post thaw recovery ranged 0-15%. Modification in pre-treatments may increase the post-thaw recovery rate. These cryopreservation techniques can be used for long-term conservation of ornamental strawberry cultivars and closely related species.

Keywords: strawberry, *Fragaria* spp., plant genetic resources, conservation, encapsulation-dehydration, vitrification, D-cryoplate, V-cryoplate

Session IV: Research in Plant Tissue Culture (PTC)

PTC_1

Shoot multiplication of HQC34 hybrid pineapple [*Ananas comosus* (L.) Merr.] via bioreactor with different concentrations of 6-benzylaminopurine and MS medium

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Pineapple is an imperative crop contained high nutrition and economic value. New pineapple hybrid variety "HQC34" has superb characteristics. However, conventional propagation provides fewer pineapple suckers and takes longer time. Bioreactor is efficient for mass rapid shoot multiplication and less cost. Furthermore, previous results showed that there were suckers occurred before flowering caused high 6-benzylaminopurine (BA) concentration and impacted to small fruit. The aim of this research is to determine better potential concentration of BA combined with MS medium and economic analysis to increase HQC34 plantlets. Completely randomized design was used with seven treatments and two replications following as ½MS+BA 0.5mg L^{-1}, ½MS+BA 1 mg L^{-1}, ½ MS+BA 2 mg L^{-1}, MS+BA 0.5 mg L^{-1}, MS+BA 1 mg L^{-1}, MS+BA 1.5 mg $L^{-1}$and MS+BA 2 mg L^{-1} as control. Ten young shoots per unit were used and fed 8 times daily for 5 minutes each time. Total number of shoots (TNS), height, and classified number of shoots based on height (< 1.0 cm, 1.0-1.5 cm, >1.5 cm) were measured after cultured for 30 days. DMRT was used to mean different analysis. The results showed that *TNS* and TNS (< 1.0 cm) were significantly different. MS+BA 1.5 mg L^{-1}were highly promoted 119 shoots which were not significantly different to control which gave 135 shoots. Cost of MS+BA 1.5 mg L^{-1} is 0.0010 US$ whereas 0.00092 US$ for MS+BA 2 mg L^{-1} per plantlet. Hence, MS+BA 1.5 mg L^{-1} is perhaps potential for shoot multiplication and grow effectively in the field considering lower BA concentration.

Keywords: *Ananas comosus*, 6-benzylaminopurine, bioreactor, HQC34, shoot multiplication

PTC_2
Establishment of a protocol for micropropagation of *Clausena guillauminii* Tanaka

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Song Fa (*Clausena guillauminii* Tanaka) is a native Thai medicinal plant that has properties to cure flatulence, discoloration, feces, sore eyes, fever, headaches, anticancer, anti-HIV, and anti-inflammatory activity. Song Fa can be propagated only by seeds with a small number of seeds and low germination rate. The Thai Traditional Medical Center, Phana Hospital has the demand to use for raw material in developing new unique products. Because of low quantity in nature, tissue culture was applied to increase their quantity to meet the demand. Firstly, young shoots and seeds were surface sterilization with Clorox® and Hydrogen peroxide. After cultured on semi-solid Murashige and Skoog (MS) medium for 4 weeks, 50% of shoots and 100% of seeds were recorded for uncontaminated explants. Of these, all seeds were germinated within 4 weeks on MS media supplemented with 0, 2 and 4 mg L^{-1} BA. Next, the lateral bud explants were induced for multiple shoot formation on semi-solid MS media supplemented with 0, 2 and 4 mg L^{-1} BA. After cultured for 8 weeks, the highest average number of shoots (3.7 shoots) and lateral bud (21.7 ± 10.35 buds/explant) were formed on semi-solid MS medium supplemented with 2 mg L^{-1} BA. Approximately 21-time multiplication rate could be produced from a lateral bud within 8 weeks of each subculture. Then, the rooted plantlets were induced on semi-solid MS medium supplemented with 0, 0.1, 0.3 and 0.5 mg L^{-1} NAA. After cultured for 8 weeks, the highest average root numbers were achieved on semi-solid MS medium supplemented with 0.1 and 0.3 mg L^{-1} NAA at 3.81 roots and 1.6 roots, respectively. Finally, all complete plantlets were survived after acclimatization and transplanting to the greenhouse. Consequently, this protocol could be applied for mass propagation of Song Fa for commercial use and conservation.

Keywords: tissue culture, plant growth regulators, in vitro, medicinal plant, Song Fa, native plant, endemic plant

PTC_3

Some features of in vitro morphogenesis in endangered *Seseli lehmannii* Degen

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Seseli lehmannii Degen (genus *Seseli* L., family Apiaceae) is a rare endemic species of the Mountain Crimea flora which is listed in the European Red List and regional Red Book. In nature, the number of *S. lehmannii* local populations ranges from 300 to 600 individuals, depending on climatic conditions of the year. Preservation of the genepool of regional flora rare endangered species is particularly relevant. According of the Global Strategy of Plant Biodiversity Conservation, in many countries, biotechnological methods have been used to conserve rare endangered plants. The objective of the presented study was to examine the morphogenetic capacity of a rare endangered species of the Crimean flora *S. lehmannii* under in vitro conditions. For the first time, the studies to identify the ways of in vitro morphogenesis in *S. lehmannii* have been carried out. The initial material was inflorescences collected from donor plants in the summer. An effective method for explants sterilization was developed and the number of aseptic explants was up to 70%. It was demonstrated that the realization of the morphogenetic capacity in *S. lehmannii* under in vitro conditions took place via indirect regeneration through adventitious shoot formation from callus and somatic embryogenesis. It was revealed that 1.0-2.0 mg L^{-1} BAP and 0.5-2.0 mg L^{-1} NAA in RG culture medium induced organogenesis. The formation of etiolated haploid and diploid seedlings and morphogenic callus occurred after 70-90 days of culture in the dark at a temperature of 24±1°C. The initiation of adventitious bud development, single microshoots, as well as somatic embryogenesis was observed after 2-3 weeks of culture. Histological analysis of the morphogenic structures in *S. lehmannii* revealed the formation of meristematically active zones with subsequent differentiation of adventitious buds and somatic embryoids. This study was funded by the SA No. 0829-2019-0038 of the FSFIS "NBG-NSC".

Keywords: rare endemic species, regeneration capacity, callus, inflorescence, somatic embryogenesis

PTC_4

An efficient in vitro plantlet regeneration of an ornamental aquatic plant *Anubias heterophylla* through shoot tip culture

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Anubias heterophylla is a commercially important ornamental aquatic plant species with traditional uses. Due to low growth of plantlets, propagation by conventional means has been met with many difficulties. In this study, an efficient micropropagation protocol of a valuable ornamental aquatic plant, *A. heterophylla* was developed successfully. Plant regeneration of *A. heterophylla* was achieved through organogenesis in shoot tip cultures. Multiple shoots were induced from cultured shoot tips on a MS (Murashige and Skoog, 1962) medium supplemented with 6-benzylaminopurine (BAP) and 1-naphthalene acetic acid (NAA). 100% of shoot regeneration frequency and 3.40±0.24 shoots per explant were achieved when cultured on a medium supplemented with 3.0 mg L-1 BAP. The multiple shoots formed on agar-gelled medium were vigorously growing with well-developed leaves and roots after 8 weeks of culture. Acclimatization was done in a humid growth chamber for two weeks and the plantlets were gradually transferred to the greenhouse. More than 97% in vitro plants survived and grew vigorously without any morphological abnormalities during acclimatization in the greenhouse. The current protocol is the first reported successful establishment of in vitro clonal propagation of *A. heterophylla*. This phytohormones and shoot tip explants based micropropagation can open up the route for in vitro clonal multiplication of this commercially important *Anubias* species.

Keywords: acclimatization, aquatic plant, 6-benzylaminopurine, greenhouse, micropropagation, naphthaleneacetic acid, ornamental

Session V: Research in Production, Physiological, Phytochemical, and Molecular Studies

M_1
Asexual and Sexual Propagation of *Muntingia calabura* L.

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Muntingia calabura as a colonize plant has potential for human's life, due to the beneficial of this tree, propagation of *M. calabura* is one of strategy in developing of this tree as commercial fruit in future. There are limited literatures of asexual propagation of *M. calabura*, hence this study to support mass propagation or asexual technique in *M. calabura*. Results revealed that the seeds broke the dormancy at two months, thus the tree will need longer time to propagate. The seed germination in the box can be viable for 150 days. The different hormones tested significantly effect on percentage of rooting ability, days to root initiation, average number of roots, and average length of roots. The layers which treated IBA (2,500 ppm, 5,000 ppm, 7,500 ppm, and 10,000 ppm) and NAA (2,500 ppm and 3,000 ppm) had visible roots (100%), NAA 2,000 ppm produced 60% roots; while, NAA 1,500 ppm and control had 40% rooting. IBA (5,000 ppm, and 10,000 ppm) gave the highest of root number. In root length, layers treated with IBA 5,00 ppm (10.30 cm) gave significant effect with NAA 2,000 ppm (1.50 cm); whereas, other treatments were not significantly different. This study can be a fundamental in asexual and sexual propagation of *M. calabura*.

Keywords: *Muntingia calabura*, asexual, sexual, propagation, seed, hormone

M_2

Vapour phase antifungal activity of essential oils and their raw materials against *Aspergillus* sp., *Curvularia lunata*, and *Fusarium sacchari*

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Volatile oils from plants can be an effective biofungicide to suppress the growth of microorganisms. This study aims to determine the effect of raw plant materials and their

essential oils from cloves (*Syzygium aromaticum*) and makrut limes (*Citrus hystrix*) to the growth of *Aspergillus sp*., *Curvularia lunata* and *Fusarium sacchari* by vapour toxicity. Powder from dried flower-buds of cloves (PCB) at 0.25 g, 0.5 g, and 1 g completely inhibited the mycelial growth of all tested fungi, whilst chopped makrut lime fruit peels (CMP) only at 1 g was more effective than at 0.25 g and 0.5 g in suppressing the mycelial growth of the three pathogens. *Aspergillus* sp. was the most sensitive to the volatile oils from CMP, followed by *F. sacchari* and *C. lunata*. In the second screening test using essential oils extracted by hydro-distillation from PCB and CMP, pure volatile oils from cloves at 5 µL was the most efficient in suppressing *C. lunata* and *Aspergillus sp.*, whilst volatile oils from fruit peels of makrut limes at 20 µL was effective in inhibiting the mycelial growth of all pathogens. Volatile oils from the peels of makrut limes showed more toxicity to *F. sacchari* than cloves at 10 µL and 20 µL and completely inhibited the mycelial growth of *C. lunata*. The volatile oils from cloves and makrut limes have potential to suppress the growth of *Aspergillus* sp., *C. lunata*, and *F. sacchari*. Further research is needed to determine how these volatile oils should be used in the real settings.

Keywords: biofungicides, *Citrus hystrix*, fungal pathogens, grain discolouration disease, *Syzygium aromaticum*.

M_3

Efficacy of ethanolic extracts of galangal (*Alpinia galanga* L.) in mycelial growth of *Fusarium sacchari* and *Curvularia lunata* and their phytotoxicity on Pak choi (*Brassica rapa* var. chinensis)

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The extracts of galangal (*Alpinia galanga* L.) have a rich background as antimicrobial agents. Therefore, this study determined the efficacy of galangal rhizome ethanolic extracts (CE) in controlling *Curvularia lunata* and *Fusarium sacchari* and the phytotoxicity of CE to seed germination and seedling growth of Pak choi (*Brassica rapa* var. chinensis). The extracts were obtained by maceration with different concentrations of ethanol, such as 40% CE, 50% CE, 60% CE, 70% CE, 80% CE, and 95% CE. The antifungal activity was tested at a concentration of 10% ethanolic extracts. The 60% CE, 80% CE, and 95% CE significantly inhibited the mycelial growth of *F. sacchari* with 85.12% to 90.83% inhibition. The 60% CE was the strongest inhibitor of *C. lunata* displaying 82.12% inhibition. Seedling vigor index (SVI) was determined to assess the effect of the extracts on the seedling growth. SVI variables included percent germination, shoot length, and root length. Fresh weight of the seedling of

Pak choi was also determined. Seedlings treated with 40% CE showed the highest SVI (significant $p > 0.05$), compared with 50% CE and 60% CE. In contrast, 80% CE registered the weakest vigor. Overall, no significant effect on seedling growth was observed when compared to the control. Therefore, the CE has potential to suppress *F. sacchari and C. Lunata*, two major causal agents of plant diseases. Nevertheless, this CE has a minimal effect on seedling growth but this can be mitigated if appropriate dose is applied in the field.

Keywords: *Alpinia galanga* L., biocontrol, *Curvularia lunata*, *Fusarium sacchari*, seedling vigor index

M_4

Promoted tuber yields in Jerusalem artichoke by controlled spectral distribution lighting with LED

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In controlled environment crop production, light is one of the most important limited factors for plant growth. Light emitting diodes (LED) usually provide specific quality, quantity of light, and high intensity source of visible radiation for better growing commercial horticultural plant production. The objective of this study was to examine growth and development of Jerusalem artichoke (*Helianthus tuberosus* L; JA) which growth in controlled lighting conditions under different light source treatment i.e. natural light (NL) as a control, Red light LEDs (R), Blue light LEDs (B) and Red + blue LEDs (R+B), respectively. The results showed that the relative growth rate was the lowest under B light. The net assimilation rate and SPAD value were higher under R, B, and R+B light when compare with NL. The higher photosynthetic pigments were found in leaves of JA under R light. This condition increased greater chlorophyll a and chlorophyll b than other light treatments. The higher carotenoids were found in JA under R, B, and R+B light treatment. JA grown under R, B, and R+B light were suitable for new tuber growth, as bigger size and also higher fresh and dry weight. Our findings demonstrate that LED light could enhance Jerusalem artichoke tuber yields and qualities in controlled conditions.

Keywords: LEDs, sunchoke, pigment, new tuber

M_5
Mechanical stimulation techniques promote compactness in potted sunchoke production

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Mechanical stimulation (MS) by PVC bar moving is one of the effective method to control plant height by suppressing their growth and avoiding the use of plant growth retardant. This technique clearly takes the benefit for less chemical residue in plant. Jerusalem artichoke: JA (*Helianthus tuberosus* L.) is known as nutritional plant which has beautiful long lasting yellowish blooming flowers. However, it was still too high, brought to unsuitable use as potted plants. Therefore, MS technique was applied to JA No. 3 or CN 52867 for 15 weeks after sowing (WAS). Plants were grown in plastic bag, contain with mixed media sand: coir dust: rice husk chacoal ratio 1: 1: 1. The different MS techniques were applied in each plant as the treatment i.e. Control (non-bar movement) (T1), bar movement 15 min + stop 2 h (T2), and bar movement 30 min + stop 2 h (T3) at 7 days after planting (DAP). The results showed that MS by PVC bar moving has resulted in significantly reduced plant height, canopy width, and average internodes length per plant more than 30% at 15 DAP. This finding led the plant more compact canopy and gave the highest tuber yield when compare with normal plant. However, all MS treatment did not promote flowering in JA.

Keywords: thigmotropism, Jerusalem artichoke, compactness, bar movement, containerized plant

M_6
Site analysis and development of strategy to enhance the identity of Lycabettus Hill in Athens and support sustainable management

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Lycabettus is a Cretaceous limestone hill in the center of Athens, being the highest point of the city. It stands opposite the Acropolis, pine trees cover its base, and the breath-taking view at its top make it one of the main tourist destinations. The main principle of our proposal for the regeneration of Lycabettus Hill was to combine the natural, historical, and cultural values of the Hill, while protecting the character of the Attica Landscape. Based on understanding the landscape, we propose an indicative zoning of the hill with the aim of building resilience and establishing a balance between uses and biodiversity, taking into account the interaction of the human element with the natural element and the geomorphology of the Hill. The site analysis poses as a strategic basis for the harmonious integration of architectural interventions into the place; the promotion and protection of the flora, the highlight of the element of water and its connection with the historical and cultural elements, and the emergence of the particular geological elements of the Hill. The strategic proposal for the activation of the Hill based on the above, concerns the creation of three Thematic Routes, based on existing paths, which will highlight the natural characteristics of the Hill: the Botanical Route, the Geological Route, and the Water Route. Existing old small quarries will be part of the above Routs, converted into a botanical garden with native and endemic plants, a Geological “Garden” exhibiting types of rocks found on the Hill, and a Rain Garden. The research was supported financially by A.G. Leventis Foundation.

Keywords: urban forest, zoning for biodiversity protection, thematic routes, resilience

M_7

Effect of substrate type and cultivation position on growth and safety to consume of the edible medicinal species *Crithmum maritimum* L., in an extensive urban green roof in Athens (Greece)

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Considering the beneficial role of green roof technology in urban agriculture, in the present work, the effect of substrate type and cultivation position on growth of *Crithmum maritimum* L. (Apiaceae) and accumulation of heavy metals in its edible tissues were studied. Plantlets were planted at the end of June 2016 in plastic containers with a green roof infrastructure fitted (moisture retention and protection of the insulation mat, drainage layer, and filter sheet) and placed on a fully exposed second floor flat roof at the Agricultural University of Athens, as well as at the level of Iera Odos street (a moderate traffic street). Two types of substrates were used, grape marc compost: perlite: pumice (3: 3: 4, v/v) and grape marc compost: perlite: pumice: soil (3: 3: 2: 2, v/v) at 10 cm depth. Plants were regularly irrigated in the April-October period and their growth was evaluated every month. At the end of June 2017, the upper part of the plants was collected in order to determine its content of heavy metals (Cu, Pb, Ni, Mn, and Zn) by atomic absorption spectrometry. Half of the samples of each treatment were washed with running tap water. Eleven months after planting, plants placed at street level were taller and had greater diameter than those placed on the green roof, irrespectively substrate type. Concentrations of heavy metals Pb, Ni, and Mn exceeded permissible limits in all treatments, making thus unsafe to consume leaves of *C. maritimum* produced within the urban fabric.

Keywords: grape marc compost, perlite, pumice, soil, urban agriculture, heavy metals accumulation

M_8

Effect of hydroponic and organic fertilizer on growth, safety, and storage quality of watercress (*Nasturtium officinale* R. Br.)

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Watercress is healthy vegetable which contains natural antioxidants. However, plant production methods affect difference in quality of product. This study investigated the effect of production methods on growth, safety, and antioxidant capacity of watercress during production and low temperature storage. The 15 days old seedlings were transplanted to soil culture (no fertilizer), soil with organic fertilizer (cow manure), and non-circulating hydroponic (Hoagland solution). The results showed that hydroponic treatment presented significantly higher growth than organic treatment. Growth of the 40-day-old (after transplantation) organic plant was similar to the 30-day-old hydroponic plant. Cow manure in organic treatment caused contamination of *Escherichia coli* and coliform. After harvest, organic treatment (40 days old) and hydroponic treatment (30 days old) were stored in OPS plastic box at 8 °C and 25 °C for 0, 3, 6, 9, and 12 days. The low temperature (8 °C) could extent shelf-life and reduced leaf yellowing. Hydroponic treatment could be stored for 9 days at 8 °C; while, organic treatment could be stored for 6 days. During storage period, hydroponic treatment revealed statistically higher nitrate content (3,018 - 3,704 mg/kg FW) than organic treatment (436 - 759 mg/kg FW). However, nitrate content of hydroponic treatment was reduced by water soaking (1 day) before harvesting (2,434 mg/kg FW). The total antioxidant capacity was similar in watercress of both treatments. Among these results, hydroponic watercress represented an interesting alternative due to its rapid growth, no *E. coli* and coliform contamination, long shelf-life, and water soaking could reduce nitrate content before harvesting.

Keywords: cow manure, nitrate, *Escherichia coli*, coliform, antioxidant

M_9

Summer condition promoted growth, development, and carbohydrate content in sacred lotus (*Nelumbo nucifera* Gaertn.)

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Sacred lotus (*Nelumbo nucifera* Gaertn.) is one of the most important flowering crops in Thailand, commonly used as cut-flower for cultural purposes. The knowledge to control flowering is poorly known. One of the important factors to control flowering in sacred lotus could partially be a food reserve, as carbohydrate metabolism was affected via the changes of environmental condition. The experiment was conducted in CRD by 6 months of different tropical environmental conditions in Thailand which can be divided into 2 seasonal

conditions; Summer (Apr-Jun) and rainy season (Jul-Sep). It was found that summer condition stimulated vegetative growth of the plant due to more leaves (9.14 and 5.16) and wider size (10.12 and 8.79 cm), but rainy season gave better results in only flowering percentage. Summer condition induced more dry weight distribution to flower than another condition (35.29 and 16.92 %); while, rainy season distributed the largest dry weight proportion to stolon. Rainy season condition gave higher reducing sugar (RS) content in stolon than summer; while, in other organs were not significantly different. In contrast, higher total non-structural carbohydrate (TNC) content in all organs was found in summer months. The RS content in flower was not different between summer and rainy season, but the TNC content in flower was found to be higher in summer. The highest RS and TNC contents were distributed to stolon in all 6 months of grow stage, except in Apr which the lotus plant distributed the highest RS and TNC to flower (48.45 and 58.83%). Nevertheless, better growth, development, and carbohydrate content in summer condition, could not promote flowering percentage in sacred lotus.

Keywords: *Nelumbo nucifera* Gaertn., seasonal effect, total non-structural carbohydrate, reducing sugar

M_10

Controlled porosity based sub-surface porous vessel (SSPV) structures for irrigating organic farms of Fruits and Vegetables

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The application of location specific controlled porosity based frustum shaped sub-surface porous vessels (SSPV) for irrigation is discussed. For manufacture of the SSPV, clay and sawdust were taken in percent by volume specific to location, press formed to frustum shapes under a 50-ton load and baked to a temperature of 750-800 ^{o}C. The SSPV is hybridized with surrounding animal dung leaching. The experiment is set on saline loamy soils of the

Thar Desert Region in India for vegetable and fruit productivity. The farmers get their SSPV vessels from the traditional potter in the same village making this irrigation technology economic and sustainable.

For this pilot study, cluster beans (*Cyamopsis tetragonoloba*), cucumber melon (*Cucumis callosus*), cucumber (*Cucumis sativus*), and water melon (*Citrullus lanatus*) were grown on an area of 0.02 ha during the Kharif season. This controlled porosity based SSPV technology can be viewed as a modified form of pitcher irrigation. The desert soil showcased steep rise in carbon content with reduction in salinity after this technological intervention. The production rate of cluster beans, cucumber melon, cucumber, and water melon was 530 kg, 2,010 kg, 940 kg, and 2,110 kg, respectively in the given area. The results indicate a 60-70 % productivity compared to results from a flood irrigated field of similar crops with fertile soil and maximum inorganic fertilizer application. The implication illustrates a possible scale-up for this low cost, inorganic-fertilizer-free, water and soil conserving hybridized SSPV irrigation based farming technology across the Thar Desert and other similar areas around the globe.

Keywords: sub-surface, desert, conservation, organic, vegetables, fruits, potter, controlled, porosity, carbon

M_11
Effect of paclobutrazol on growth of young potted flame tree (*Delonix regia* (Hook.) Raf.)

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The planting of street trees is common feature to support good urban environment. The negative interaction between tree roots and construction resulting sidewalk damage often happens especially in the city of tropical region due to longer period of seasonal growth. Thus, the technique for retarding growth should be investigated. This study aimed to evaluate the effect of paclobutrazol (PBZ) application on growth responses in young flame tree (*Delonix regia* (Hook) Raf.). Uniform five-month-old seedlings were cultured in plastic pots and once applied as soil drench at 0 (control), 2, 4, and 8 g. ai. The study was carried out at the Faculty of Agriculture, Kasetsart University, Bangkok, Thailand (N 13.847531, E 100.571396). Six and a half months later, shoot and root growths were evaluated. PBZ treated plants were found progressively short shoot length and vice versa to increasing doses. High PBZ at 4 and 8 g.

ai. reduced total root length; however, low dose; 2 g. ai. enlarged instead. Soil PBZ application might be a potential way to retard growth performance for street trees.

Keywords: city, landscaping, plant growth retardant, anti-gibberellin

M_12
Ethnobotanical study on medicinal dietary plants used by the Yi people in southeastern Yunnan, China

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There are 25 ethnic groups in Yunnan Province, China. The Yi is the largest one with a population of over 5 million. The objectives of this study are to document the medicinal dietary plants and associated traditional knowledge, and analyze the inheritance of Yi traditional medicinal dietary knowledge. Field investigations were carried out in 6 villages. Information was collected using participatory rural appraisal (PRA), direct observation, semi-structured interviews, key informant interviews, and focus group discussions. In total 124 species belonging to 58 families and 104 genera were documented. The plants were classified into different life forms, including herbs (48.8%), trees (27.6%), vines (9.8%), and shrubs (13.8%). The medicinal parts were used to treat diseases, such as anti-tussive, gastric disease, and so on. These plants occupy an important position in the Yi diet and medicine. The plants are not only nutritious, but also have medicinal values. Ethnobotanical surveys of medicinal dietary plants are conducive for the protection of food culture and medicine in the Yi people.

Keywords: medicinal dietary plants, ethnobotanical surveys, Yi people, Southeast Yunnan

M_13
Value analysis of *Hedychium flavum*, a Buddhist plant

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Hedychium flavum is a pseudostems plant that grows up to 1.5–2 m. It is distributed in China's Guangxi, Guizhou, Sichuan, Tibet, Yunnan, and other Asian countries. Flowering takes place between August and September with yellow flowers like butterfly. *H. flavum* is known as holy flower belonging to Buddhism, because its scent is refreshing and invigorating, which is also an important nectar source plant. Its flowers are also used to decorate the Buddhist temple and dye kasaya. *H. flavum* is mainly used as fresh cut flower, garden greening and landscape embellishing plant which has tolerances on low temperature, disease, and poor soil. Ethnobotanical investigations revealed that its flowers are used to treat digest disorders. Roots of *H. flavum*, called *ye han su*, were used to treat chill cold, headache, pantalgia and fall-injuries by Miao people. On the whole, *H. flavum* has high cultural, ornamental and medicinal values. Rapid propagation via tissue culture and development of cultivation techniques of *H. flavum* will promote the sustainable uses of this plant resources.

Keywords: *Hedychium flavum*; traditional uses; development potential

M_14
Acoustic diagnostics of phytopathogenic damage to the trunk wood of *Magnolia grandiflora* L.

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The studies were carried out in situ in the parks of the Arboretum of the Nikitsky Botanical Gardens. Using Arbotom ABT05-S acoustic ultrasound tomography complex, the condition of the trunk wood tissue of *Magnolia grandiflora* L., widely used in landscaping in the Southern Coast of the Crimea, was studied. The most old-aged trees of *M. grandiflora* planted in 1860 and 1895 were selected as the objects of the study. Digital two-dimensional images of phytopathogenic damages of trunks of the studied trees were received; the characteristic of relative indicators of damage degree of wood was given. Low level of phytopathogenic damage was observed in *M. grandiflora* in the upper part of the trunk. In the butt-log portion of the tree trunks, the wood was characterized by the highest rate of phytopathogenic degradation. Graphic image of ultrasound scanning of the trunk wood of *M. grandiflora* in the butt-log portion was characterized by yellow, orange and red colors, which

indicate the active stage of degradation of wood tissues and a significant decrease in the vital functions of damaged plants. Correlation analysis of the level of phytopathogenic damage and dendrometric characteristics of the studied *M. grandiflora* showed that the intensity of trunk rot development in the basal part of the plants showed a positive relation with its age. It was found that individuals of active growth are most exposed to the negative effects of bracket fungi. The correlation between the level of phytopathogenic damage to the trunk wood and external indicators of the living condition is observed at the level of the trend. This is determined by the fact that the external signs of plant disease do not appear immediately, in most cases, the visualization of damage is noted at the stage of formation of the fruit body of the phytopathogen, when destructive processes cover a significant part of the volume of wood of the tree trunk. The negative impact of bracket fungi is one of the most significant factors reducing vital functions and limiting the age of longevity of *M. grandiflora* under the conditions of the Southern Coast. Phytopathogenic damage to wood and the formation of trunk rot affected the implementation of the bioecological program of plant growth and development, reducing the time scale of the passage of individual stages of ontogenesis.

Keywords: *Magnolia grandiflora* L., trunk wood tissue, phytopathogenic damage, ultrasound tomography, adaptive potential

M_15

Phytochemical content and antioxidant activity of leaf extracts from nine bamboo species and determination of flavone C-glycosides by TLC and HPLC

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Bamboo leaf extract (BLE) is a rich source of phytochemicals and antioxidants, which have been use to stimulate immuno activity and alleviate several chronic diseases. The effective ingredients in alcoholic BLE are phenolic acid and flavonoids, especially flavone C-glycosides. This study aimed to examine the alcoholic solvents that could generate the highest content of phytochemicals and antioxidants and evaluate the simplest method to determine the flavone C-glycosides in BLE by TLC and HPLC. The results showed that the total phenolic content (TPC) was the highest in 60% ethanol BLE of Phai Sang Mon (*Dendrocalamus sericeus*) (4.667 ± 0.226 mg GAE/g DW). TPC, total flavonoid contents, anthocyanin, and antioxidant activities in 60% ethanol BLE of nine bamboo species were then analyzed and it was found that Phai Pakking (*Dendrocalamus* sp.) contained the highest

contents of phytochemicals and antioxidant activity. Moreover, TLC showed that flavone C-glycoside content was the highest in BLE of Phai Pakking, Phai Sang Mon, and Phai Dam (*Phyllostachys nigra*), respectively corresponded to HPLC analysis. HPLC showed that BLE of Phai Pakking significantly contained higher contents of orientin (6.60 µg/ml) and vitexin (2.81 µg/ml) than Phai Sang Mon and Phai Dam; while, the contents of isoorientin (2.18 µg/ml) and isovitexin (2.05 µg/ml) were not significantly different. This study suggested that TLC could be used as the simplest method for screening the effective flavone C-glycosides in the commercial BLE.

Keywords: antioxidants, bamboo leaf extract, *Dendrocalamus*, flavonoids, orientin

M_16

Anticancer efficacy of *Luisia zeylanica* Lindl., an epiphytic orchid from Eastern Ghats of Andhra Pradesh, India--an in vitro approach

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The present study aims to evaluate the anticancer potentiality of *Luisia zeylanica* Lindl. against cancer cell lines. *L. zeylanica* belongs to the tribe Vandeae of subfamily Epidendroideae (Orchidaceae). The plants were collected from wild and grown in the Botanic Garden of the Acharya Nagarjuna University. The shade-dried leaf sample of these plants was extracted with ethyl acetate and methanol solvents, the resultant extracts were filtered and then concentrated. Cytotoxic effect of these extracts against cancer cell lines, viz., MCF-7 (breast cancer cell line) and HeLa (cervical cancer cell line) was evaluated by MTT assay maintaining six concentrations of crude leaf extracts in triplicates. The results of MTT assay revealed that the percentage of viability of both the cell lines have been reduced with the increase of concentrations of leaf extracts. The % viability of cell lines in ethyl acetate and methanol extracts on MCF-7 cell lines at concentration of 100 µg/ml was found to be 44.44% and 36.39%, respectively. Similarly, for HeLa cell lines the viability was 40.93% and 39.65%. Methanol leaf extract showed the most significant IC_{50} value of 18.36µg/ml on MCF-7 cell lines when compared to ethyl acetate (49.49 µg/ml). Hence, the findings of this study proved that leaf extract of *L. zeylanica* has anticancer effect and this species could be used to develop the anticancer drugs.

Keywords: *Luisia zeylanica*, epiphytic orchid, cancer cell lines, cytotoxic effect, in vitro studies

POSTER PRESENTATIONS

Session I: Research in Botanical Gardens

P_1
Exposition collection complex of spring-blooming plants presented in the Nikita botanical gardens

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The project proposal of a new exposition that includes a number of spring-blooming, arboreal-shrubby, herbaceous, and bulbous collections was worked out in the Nikita botanical gardens. As a rule, botanical gardens have a lack of area to dispose all their accumulated collection funds. Most collections consist of many specimens as a result of introduction and breeding. In common they are based on out-of-view territories, though contain exclusive cultivars and forms, devoted to be available for a wide audience. The objective of this work is to optimize anthropogenic landscape in the Nikita botanical gardens due to thematical expocomplex as an object of scientific researches, exhibition of results, and conservation of a biological diversity. The project proposal of a new thematical exposition was worked out; where, arboreal-shrubby and herbaceous collections, blooming in winter and spring periods, interconnect harmoniously. The ground of exposition is presented by *Tulipa* L. and flowering fruit-bearing plants from *Prunus* L., *Chaenomeles* Lindl., *Malus* P. Mill., *Crataegus* Tourn ex L.; while *Syringa* L., *Paeonia lactiflora* Pall., *Wisteria* Nutt. and spring-blooming perennials complement it. Flowering in exposition will continue for 4-5 months from January-February till the end of May.

Keywords: thematical garden, collection, spring blooming

P_2

The botanical gardens of the University of Bologna: proposal for a tech-savvy walk throughout history

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The University of Bologna Botanical Gardens (UBBGs) are among the oldest germplasm collections in the world. Currently, the aging of living arboreal collection poses typical problems from senescence, with some specimens already missing. Furthermore, attendance is low and the institution has difficulty in revive visitors' interest and emotional attachment. The trial occurs in subsequent phases. Firstly, arboreal collection undergo detection of physiological and mechanical issues. A GIS-based system is used to geotag each tree with respective information. Hence, a long-term management plan for the arboreal collections is worked out, consistently with renovation, restoration and research programmes. Contemporarily, historical recordings concerning living collections life are digitized. In the second phase, representative "totem" trees are selected to host interpretive digital features available to users via digital application on their smartphones and tablets. Extemporary quizzes, digital puzzles and themed treasure hunts are also delivered via digital application basing on visitors' preference and choices. To play any of them, people are asked to log in with basic information, namely (I) age, (II) provenance, (III) motivation, and available time for visiting. At the end of the tour, personal satisfaction is assessed by standard scale of values besides selecting the most and the least enjoyed feature. Anyway, the use of digital app is not compulsory to enjoy the UBBGs. Rearrangement of paths, signage and furniture within the area is also desirable, congenial to the new setting and against overcrowding and disorientation. As long-term experimentation, data collection occur both to carry on multidisciplinary research projects and tailor digital features to meet user's interests and facility. Overall, the proposal focuses on wide-ranging aspects mainly related to the employment of the latest technologies in arboreal collections and data management, along with the involvement of foreign and domestic visitors by interpretive and first-hand educational features.

Keywords: ex situ plant collection restoration, interactive learning, plant genetic resource conservation

P_3
Ex situ conservation at the Taipei Botanical Garden

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Since this year (2019), we have launched an ex situ conservation plan that integrates Taiwan's botanical gardens and several experimental forest or farms of university to investigate and collect threatened plants in Taiwan. At the headquarter, Taipei Botanical Garden, we have collected more than 250 species of threatened plant species, bringing the rate of threatened plant ex situ conservation in Taiwan to 25%. In the past, species collection was only for preservation or research use. After the study, those living plant were often neglected to take care of and died or missing. We believe that if those species can be promoted and utilized, they will not only enrich the activity and Interpretation materials in the botanical garden, but also increase their number and survive probability. In order to monitoring the growth information of various threatened plants, we organized a team of volunteers to regularly inspect the plants in the garden, assist in weeding and climber removal, record plant growth, phenology status, and collect samples of plant pests and diseases. The participation of volunteers enables the public to know the tasks of the botanical gardens and to ease the burden on the gardeners. In this report, we describe the mission and framework of this conservation project, the collection process at the Taipei Botanical Garden, the achievements of our native plant displays, and the finding of volunteers' monitoring works.

Keywords: Taipei Botanical Garden, ex situ conservation, volunteer participation

Session II: Research in Landscape

P_4
Reflecting properties of ornamental plants for directing traffic in public park

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One of effective ways to reduce electricity consumption is planting of ornamental plants that have light-reflecting properties along the traffic path in public park. This research project focused on 60 ornamental plant species that have light-reflecting properties. Plant samples were categorized into three groups; tree, shrub, and ground cover group. The experiment was arranged in a Completely Randomized Design (CRD) with 10 replications. The experiment was carried out in the 1.45x2x2 m. chamber that adjusted the condition to imitate the surrounding of public park at night. Ten mature leaves per sample were collected and then placed at the center of the completely dark room. After that, the light bulb was turned on for 20 minutes. A light meter, model LI-250A was used as a tool for measuring the intensity level of reflecting light.

The results revealed that the most reflecting light from leaves of three plant groups were: the tree group was *Pisoniagrandis*, with an average reflecting light of 5.66 lux. For the small shrub group, the highest average light intensity of 5.73 lux was obtained from *Dieffenbachia* 'Tropic Snow'. The ground cover group, *Pandanus baptistii* 'Aureus' showed the highest reflecting light of 6.16 lux. These three species are the most appropriate plant for directing traffic in public park.

Keywords: reflecting properties, ornamental plants, public park

P_5
Integrated fish and vegetable production at *Aquaponic Design* (Bologna, Italy)

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In the short term, an increased role will be played by cities in the decisive shift to create more resilient communities. *Aquaponic Design* aims to be part of this change through the design and construction of modular and customizable urban aquaponic systems, fostering public awareness on environmental issues, specifically targeting food production and distribution. By promoting short food chains, reduction of greenhouse gas emissions associated with both transport and packaging, is achieved. In the present study, results from a real environment aquaponic prototype are presented. The growing system, hosted at Le Serre – Kilowatt sustainable food and co-working hub in Bologna, Italy, includes a productive part (230 plants grown in vertical towers) and a table with 12 integrated and communicating mini ponds. The system is also connected with a raised pond (10,000 litres), hosting 400 fishes (including goldfish, koi, medaka and gambusias). Part of the system is accessible to the public and used for demonstrative and training purposes. Preliminary data on productive potential and system resilience are also presented.

Keywords: urban agriculture, aquaponics, vertical farming, soil-less, circular economy, social agriculture

P_6
PINECUBE: technologies for sustainable plant production and urban renewal in Belluno, Italy

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Under the international challenge Urban Farm 2019, a requalification programme was designed for the former Elementary School of Orzes (Belluno Province, Italy). Since the post-WW2 period and until the 80's, this historical building guaranteed an education to the children that used to live in the surrounding agricultural neighborhoods. Orzes village is surrounded by the rural areas of Belluno Province, which lays at the bottom of the Dolomites Mountains, a landscape featuring elevate biodiversity. In 1987 Orzes School was declared unfit for use, and regional authorities slowly but inexorably lost interest on it. To design its requalification, the planimetry of the building was considered first; then it was re-adapted for hydroponic indoor cultivation system (NFT) targeting the production of aromatic and officinal herbs. A market survey in Belluno province was conducted, aiming at evaluating the current sales channels and the market demand for plants, highlighting the request for local production of aromatic species. A literature survey and the creation of a business model canvas allowed to compile a SWOT analysis that allowed for defining optimal features for sustainable food production and the requalification of the abandoned building. The research also confirmed that in addition to the production of raw materials (to be sold as fresh or after being proceeded on-site), other complementary activities (including social services) would be suitable to integrate the core activity of production. Among identified strengths, a strong cohesion within the territory and the active involvement of local (and non-local) actors allowed for generating new job opportunities, including consultancy services specialized for agricultural businesses and possible partnerships with research institutions and universities.

Keywords: international student challenge, teamwork; urban regeneration, circular economy, aromatics

P_7
Acer truncatum for landscapes and gardens

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The cultivars of maples (*Acer* spp., Sapindaceae) have been widely used for landscapes and gardens for their graceful tree performance and colorful leaves. Famous species with higher valuable varieties include *Acer saccharum, A. pictum, A. platanoides, A. palmatum, A. buergerianum, A. saccharinum, A. campestre, A. negundo, A. macrophyllum*,

and *A. rubrum*. Among them, less species is from China, where has been regarded as the distribution center and diversity center of aceraceous plants. *A. truncatum*, known as Shantung maple, Chinese purpleblow maple, or yuan bao feng in Chinese, is native to East Asia, particularly in the arid and semi-arid areas of North China. It has been cultivated in the subtropical regions in a variety of edaphic conditions and may be adaptable to the environmental stress. *A. truncatum* is a useful tree with multiple purposes based on ethnobotanical investigations. Our recent researches revealed that compounds from leaves, branches, bark, and fruits of *A. truncatum* are with antioxidant and cytotoxic activities. The seed oil extracted from the kernel of *A. truncatum* has been approved as a new edible oil resource. In particular, the nervonic acid in seed oil of *A. truncatum* benefits brain development by protecting aging neurons and perhaps enhancing intelligence in premature infants. More significantly, the seed residue extracts were rich in bioactive components with strong cytotoxic and AChE inhibitory activities. Therefore, *A. truncatum* will be very potential for landscape and garden uses in different ecological environments, for production of valuable health food, and possibly for new drug development.

Keywords: *Acer truncatum*, landscape and garden use, multiple purposes

P_8
Traditions and modern use of floral-ornamental crops in the landscape design of the South of Russia

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As a result of long-term researches, it is established that despite existence of traditions of use in landscape design of the South of Russia of separate floral-ornamental crops in general, but they are used insufficiently. Modern cultivars are poorly represented in landscape gardening. In the Nikitsky Botanical Gardens, the long-term research has been carried out with eight main

collections of flower and ornamental crops, numbering 2,406 cultivars, allowing to form an assortment for different types of landscape design of highly decorative and resistant cultivars. *Rosa* × *hybrida* cultivars for decoration of small architectural forms, decoration of walls, slopes, creation of hedges, flower beds, ridges, borders, mixborders, groups of plants, single trees, standard roses, as well as for growing in containers as a substitute culture were identified. Among *Syringa* L. cultivars, the ones for creating single trees, groups of plants, alleys, and solid woods were picked up. Among *Clematis* L., there were chosen cultivars for vertical gardening in the form of groups, single plants, hedges, and also for mixborders, rockeries and for container culture. Among *Chrysanthemum morifolium* Ramat. cultivars - for borders, solid and group plantings, and container culture. Among *Iris* × *hybrida* cultivars - for rockeries, borders, group, and single plantings. Among *Tulipa* L. cultivars - for rockeries and solid and group plantings. Among *Hemerocallis* × *hybrida* cultivars – for container culture, single plants, and mixborders. Among *Canna* × *hybrida* cultivars - for single plants, group of plants, ridges, borders, hedges, and container culture.

Keywords: *Rosa* × *hybrida*, *Syringa* L., *Iris* × *hybrida*, *Hemerocallis* × *hybrida*, *Clematis* L., *Tulipa* L., *Canna* × *hybrida*, *Chrysanthemum morifolium* Ramat.

P_9
Preservation of clematis plants in genebank in vitro

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The main task of a biological diversity preservation is a complex study of genetic resources, adjunction and maintenance of living plant collections, as well as search of regimes for a long-term preservation of explants that ensure their slow growth and viability. In the Plant Biotechnology and Virology Laboratory of Plant Developmental Biology, Biotechnology and Biosafety Department of the Nikita Botanical Gardens, an in vitro conservation method of clematis plant cultivars 'Crystal Fountain', 'Nikitsky Rozovy', and 'Madame Julia Correvon' during 12 months has been developed. The method is based on a long-term preservation of cultures at low positive temperatures on a culture media, supplemented with osmotics and retardants. Microshoots of the studied cultivars in clematis plants, cultured in vitro for 12 months, were used as an initial material for deposition. The preservation was carried out at the temperature of 4, 6, 8, 10, 12, and 14°C on ¼-strengh MS medium, supplemented with sucrose and chlorocholin chloride (CCC), under light intensity of 1.25–3.75 μM $m^{-2}s^{-1}$. The plant material was evaluated after 6 and 12 months of culture according to qualitative and quantitative characteristics of explants. It was found that preservation of viability and reduction of growth kinetics in clematis explants of the studied cultivars within 12 months of deposition were ensured by the complex effect of a number of factors: temperature (4-6°C), concentration of sucrose (60 g L^{-1}), and CCC (0.2-0.4 g L^{-1}) in

the culture medium. With decrease in growth kinetics by 2-3 times compared with the control, the viability of the explants was reached 95-98%. Anatomical and morphological changes occurring during of explants preservation process in in vitro genebank were demonstrated. This study was funded by the ST No. 0829-2019-0038 of the FSFIS “NBG-NSC”.

Keywords: *Clematis* L., explant, osmotic, retardant, temperature, growth kinetics, leaf blade structure

P_10
Structural and functional changes in some Lamiaceae species during genebank creating in vitro

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Due to the high content of essential oils and biologically active substances in the tissue of Lamiaceae plants, they are widely used in medicine, cosmetic, and food industries. In vitro deposition of plant objects by creating genebanks of valuable species and forms expands the possibilities for the preservation of bio-resource collections ex situ. The aim of our work was to identify morphological, histological, and physiological characteristics of lavender and lavandin microshoots under the prolonged in vitro preservation, and subsequent assessment of their viability. The studies included explants of two *Lavandula* L. cultivars from the collection of the Nikita Botanical Gardens: ‘Record’ (*L. angustifolia* Mill.) and ‘Rabat’ (*L.* × *intermedia* Emeric. ex Loisel). The deposition was carried out on the modified MS culture medium with sucrose (60-90 g/L) and CCC (0.2-0.4 g/L). The explants were maintained at low positive temperatures, from 4 to 14°C, light intensity 1.25-3.75 μM $m^{-2}s^{-1}$ and 16-hour photoperiod. The explant parameters were recorded after 12 months of preservation. Shoot length was up to 1.9-2.6 cm, the total number of leaves was 6–9 per shoot. Leaf blades were linear-lanceolate and small (up to 0.6 mm long). Their thicknesses decreased to 54–92 μm, the intercellular spaces in chlorenchyma were large; a homogeneous mesophyll was noted in most leaf blades. Chloroplasts were diffusely arranged in the cells, less often they were near-wall. A thin cuticle and trichomes were structurally remained, the same as in native plants. The structure of the leaves varied from hypostomatic to amphystomatic type. Viability of 95% was revealed under depositing at 4 and 6°C. The growth kinetics slowed down by 3-4 times compared with the control, relative photosynthetic activity was $(F_m-F_{st})/F_m$ = 0.42 ...0.54 a.u. This study was funded by the ST No. 0829-2019-0038 of the FSFIS “NBG-NSC”.

Keywords: *Lavandula* sp., deposition in vitro, morphology, anatomy, viability

P_11
Pollen viability and preliminary study of pollen preservation method of *Amorphophallus koratensis* Gagnep. (Araceae), the potential exotic ornamental plant

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Amorphophallus koratensis Gagnep., a native species in Indochina, has become a potential ornamental plant. According to an asynchronous maturation of male and female organ on its spadix, pollen viability, as well as preliminary study of pollen preservation method of *A. koratensis* are conducted to open the future opportunity for its artificial pollination which could be useful in *Amorphophallus* breeding program. Pollen viability and longevity after various storage conditions were tested by 2,3,5-triphenyl tetrazolium chloride assays. The results showed that the highest number of viable pollen was 93.2% at the first day after anthesis and dramatically declined at the third day after anthesis until floral senescence. Cryopreservation (-196°C) is the suitable preservation method providing the maximum rate of pollen viability (33.8%) after 7 days of storage. Further study on stigma receptivity and the optimal condition for *A. koratensis* pollen germination are needed to investigate.

Keywords: cryopreservation, ex situ conservation, pollen longevity, pollen storage, TTC test

P_12
Conservation of *Dendrobium cruentum* Rchb. f.

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Conservation of plant genetic resources is an important role to protect endangered species from genetic loss. In case of native Thai orchid species, *Dendrobium cruentum* Rchb. f. faces extinction problem because of various factors including over collection, deforestation, and climate change. Therefore, conservation of this species is needed. In this study, the different conservation aspects including natural growth habitat observation, seed germination, and long-term conservation by cryopreservation were described. From the experiment, observation of *D. cruentum* natural habitat in Ko Phra Thong in Phang Nga Province of Thailand was done, and it was found that the optimum environment for *D. cruentum* growth is in swamp forest as an epiphyte. In addition, specific host trees for this species were observed in *Melaleuca cajuputi* Powell and *Syzygium gratum* (Wight) S. N. Mitra. The quality of *D. cruentum* seed is potentially affected by a number of standard practices associated with attempts to maximize growth in vitro by using seeds from 16-week-old capsule and cultured on modified VW agar medium to reach 80.6% seed germination. However, for the long-term conservation was determined by using different cryopreservation techniques including encapsulation-vitrification, encapsulation-dehydration, V cryo-plate, and D cryo-plate with the same dehydration time at 60 minutes. The cryopreservation results showed that the highest seed germination at 68.9% was by D cryo-plate method.

Keywords: *Dendrobium cruentum* Rchb. f., cryopreservation, seeds

P_13
Cryopreservation of *Paphiopedilum exul* (Ridl.) Rolfe seeds using encapsulation-vitrification and encapsulation-dehydration methods

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Paphiopedilum exul (Ridl.) Rolfe seeds were cryopreserved using encapsulation-vitrification method (EV) and encapsulation-dehydration method (ED). For EV method, *P. exul* seeds were dehydrated with PVS2 solution for 0, 20, 40, 60, and 120 min. For ED method *P. exul* seeds were dehydrated in a laminar air-flow cabinet for 0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 h. Dehydrated *P. exul* seeds were plunged into liquid nitrogen (LN) for 1 h. All treatments were cultured on ½ MS agar medium in dark condition at 25±2°C for 8 w, and then moved to culture in light condition at 25±2°C for another 8 w (white fluorescent at intensity of 37 µmol $m^{-2}s^{-1}$ for 16 h per d). For control (non-cryopreserved) treatment, dehydrated *P. exul* seeds were carried out the same as EV and ED methods. They were not plunged into LN. The results showed that the optimum protocol for EV method was using PVS2 solution for 40 min. It

gave seed germination percentage at 29.68% and Growth Index (GI) at 2.03. For ED method, the optimum protocol was dehydration in a laminar air-flow cabinet for 2 h. It gave seed germination percentage at 14.02% and GI at 2.2. Comparing seed germination percentage and GI of EV and ED conditions with unpaired t-test, the suitable treatment for cryopreserving *P. exul* seeds was EV method using PVS2 solution for 40 min in dehydration step.

Keywords: plant cryopreservation, encapsulation-vitrification, encapsulation-dehydration, slipper orchid

P_14
Conservation and clonal micropropagation of rare species *Gladiolus palustris* Gaudin

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In order to conserve plant biodiversity in vitro, methods have been successfully used in recent years. A collection of rare plant species preserved in the form of meristem has been created in y of Plant Biotechnology laboratory of the FSFIS The Main Botanical Garden named after N.V. Tsitsin RAS. *Gladiolus palustris* Gaudinc is a rare European species with limited habitat, gradually shrinking due to anthropogenic impact. This species is listed in the Red Book of Russian Federation as endangered one. For this species, the technology of micropropagation has been developed for the first time, including sterilization of seeds, obtaining seedlings, propagation of microbulbs, their subsequent rooting, and adaptation of regenerated plants to ex vitro conditions. During sterilization of seeds, the optimal result was achieved by using calcium hypochlorite at a concentration of 7% with the addition of Tween-20. The optimal stage of micropropagation turned out to be MS medium supplemented with 12 mg L^{-1} 6-BAP and 0.1 mg L^{-1} NAA. The microbulbs were rooted in ½ MS medium supplemented with 0.3 mg L^{-1} IBA and containing 20 mg L^{-1} sucrose. The developed technology is a basis for obtaining material for reintroduction of rare species and replenishment of collections of botanical gardens.

Keywords: *Gladiolus palustris*, in vitro tissue culture, ex situ conservation

P_15

Cryopreservation of *Dendrobium draconis* Rchb. f. protocorms using V cryo-plate method

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Cryopreservation of *Dendrobium draconis* Rchb. f. protocorms, a beautiful Thai orchidwas achieved using V cryo-plate method. Protocorms were selected from seeds after sowing for 30 d and then precultured on modified VW agar medium supplemented with 0.4 M sucrose at room temperature (29±2 ^{O}C) for 1, 2, and 3 d. Precultured protocorms were placed in wells on the aluminium cryo-plate containing 12 wells and then embedded with 3% sodium alginate gel. Osmoprotection was performed using cryo-plates with protocorms immersed in loading solution (0.4, 0.6, and 0.8 M sucrose) for 15 min at 29±2 ^{O}C and then dehydrated with PVS2 solution for 0-40 min at 29±2 ^{O}C. Cooling was performed by transferring the cryo-plates with protocorms into cryotubes and then directly plunged into liquid nitrogen for 40 min. Cryo-plates with protocorms were rapidly warmed in 1 M sucrose for 15 min at 29±2 ^{O}C. Non-cryopreserved and cryopreserved protocorms were cultured on modified VW agar medium supplemented with 100 g L^{-1} banana, 150 ml coconut water, 50 g L^{-1} potato at pH 5.2. The results showed that survival of cryopreserved protocorms increased with increasing time for preculture. The highest survival of cryopreserved protocorms was 75 % when precultured for 3 d, treated with 0.6 M sucrose in LS and dehydrated with PVS2 for 10 min. No survival of cryopreserved protocorms was observed for 1 d of preculture, treated with 0.4 and 0.6 M sucrose in LS. Cryopreserved protocorms developed into plantlets and tillerd when cultured on modified VW agar medium for 6 months. Morphology of non-cryopreserved and cryopreserved plantlets developed from protocorms was not different.

Keywords: *Dendrobium draconis*, protocorms, aluminium plate, orchid, Vacin and Went

P_16
Current status of DOA Genebank Thailand in plant genetic resource conservation and utilization in 2019

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The conservation of plant genetic diversity is an assurance for the national food security. Thailand is one of the South East Asian Countries. Thailand is responsible for the conservation of Plant Germplasm by participating and accomplishing to the success story of the country in valuable plant genetic conservation. DOA Genebank is under the responsibility of Genebank Research and Development Group, Biotechnology Research and Development Office. It is also under Department of Agriculture (DOA), Ministry of Agriculture and Cooperatives. DOA Genebank was established in 2002, mandated to conduct conservation of plant genetic resources (PGR) both native and wild species and parent materials of major economic crops, including new plant species that has potential for research and breeding which purposes to enhance crop productivity, serves as a center of database for information

of plant species. It also provides storage services for seeds to public and private agencies under the conditions specified in accordance with The Plant Protection Act. At present, DOA genebank stores seed samples totaling 184 kinds of plants and 32,917 accessions. Potential capacities for the conservation of PGR in DOA Genebank are as follows: 1) Medium-term storage room (5°C and 60% Relative Humidity) - the room area is 76 sq. m. wide and the 24 meters high, with 150,000 sample capacity and is controlled by automatic bullet crane system. The seed re-vitalization period is up to 10 years. 2) Long-term storage room (-10°C) - the seed viability expecting up to 50 years. The collected seeds are mainly rice (24,852), corn (130), wheat (15), barley (2), sorghum (10), soybean (2,296), groundnut (2,029), sesame (268), cowpea (89), pigeon pea (51), wild legume (199), mungbean (1,208), blackgram (451), other beans (114), safflower (71), cotton (459), jute (42), roselle (36), kenaf (54), castor bean (68), job's tear (4), rapeseed (22), camellina (44), flowers (25), tree plants (59), other vegetables (297), and other plants (22). DOA Genebank has 16 government officers, 16 technical officers, 1 permanent staff and 15 temporary staff. Seed drying room, in vitro conservation room, the molecular laboratory, and cryopreservation at research stage are in DOA genebank as well. The scope of DOA genebank is involved-survey and collection, seed laboratory process including in vitro laboratory, plant regeneration, evaluation, PGR research, and utilization.

Keywords: DOA Genebank, Thailand, conservation, utilization

Session IV: Research in Plant Tissue Culture

P_17

Low concentration of 5-aminolevulinic acid regulates organogenesis of protocorm like-bodies (PLBs) in *Phalaenopsis*

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This study was undertaken to investigate the effects of 5-aminolevulinic acid (5-ALA) on in vitro regulation of organogenesis of PLBs in *Phalaenopsis* with various concentrations at 0, 0.01, 0.1,1 and 10 mg/L in modified MS medium. In this experiment, the highest number of PLBs and PLBs induction rate (100%) was found in the medium containing 0.01 mg/L 5-ALA. In case of shoot formation, the highest number of shoots per explant and the maximum shoot formation rate was observed at containing 10 mg/L 5-ALA. Results showed that low concentration of 5-ALA enhanced PLBs induction when compared with control. In this study, the efficiency of 5-ALA was observed only in PLBs formation but no satisfactory enhance on shoot formation of *Phalaenopsis.*

Keyword: protocorm like-bodies (PLBs), *Phalaenopsis,* 5-aminolevulinic acid (5-ALA)

P_18

Effects of BA and NAA on shoot multiplication of *Grammatophyllum speciosum* Blume in vitro

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Grammatophyllum speciosum Blume is the largest orchid species in the world with many medicinal properties. It is also listed in Appendix II of CITES (Convention on

International Trade in Endangered Species of Wild Fauna and Flora) because of relatively rare in its natural habitat. The effects of N^6-benzyl adenine (BA) and a-naphthaleneacetic acid (NAA) on shoot multiplication of *G. speciosum* were investigated in this study. The 2 mm diameter of protocorms were cultured in Murashige and Skoog (MS) liquid and solid medium supplemented with BA (0, 1, 2, and 4 mg/L) and NAA (0, 0.5, and 1 mg/L) for 8 weeks. The results showed that the MS liquid medium was more effective for shoot multiplication (shoot number, shoot height, and leaf number) compared to the MS solid medium. The MS liquid medium supplemented with 2 mg/L BA gave the highest average shoot multiplication at 44.20 shoots per protocorm; while, the lowest was found in the MS agar medium supplemented with 0.5 mg/L NAA at 4.60 shoots per protocorm.

Keywords: *Grammatophyllum speciosum* Blume, BA, NAA, shoot multiplication

P_19
Effect of BA, NAA, and activated charcoal on in vitro micropropagation of *Nepenthes mirabilis*

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Nepenthes mirabilis (Lour.) Druce, a carnivorous plant in the Nepenthaceae family, has been brought out of nature for a large amount of commercial results. This study aims to investigate the influence of plant growth regulators (BA, NAA) and activated charcoal on in vitro micropropagation of *N. mirabilis* for conservation. The sterile young shoots were cultured on Murashige and Skoog (MS) media containing BA supplemented with NAA and activated charcoal at different concentrations for 4 weeks. The results showed that the MS media supplemented with 2 mgL^{-1} BA with 0.2 mgL^{-1} NAA and 0.25% activated charcoal is the suitable condition for shoot induction, 8.48 ± 1.12 shoot per explants, and the MS with 1 mgL^{-1} BA, 0.2 mgL^{-1} NAA and 0.25% activated charcoal gave the highest number of leaf, 10.45 ± 1.05 leaves per explants. The MS media supplemented with 1 mgL^{-1} BA with 0.1 mgL^{-1} NAA and 0.5 % activated charcoal could provide the highest number of plant height (2.72±0.26 cm), and pitcher production (1.60± 0.51pitchers per explants).

Keywords: carnivorous plant, Nepenthaceae, shoot multiplication, plant tissue culture

P_20
In vitro culture of *Enhalus acoroides* (L.F.) Royle

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In vitro culture of *Enhalus acoroides* (L.F.) Royle, a very important tropical seagrass in terms of biomass production, were assessed for marine conservation and commercial production for restoration projects. Leaf, rhizome, and seed explants of *E. acoroides* collected from Para bay, Phuket, Thailand were surface sterilized and maintained on artificial sea water under sterile conditions. After 7 days of culture, only fruits had 0% contamination while leaf and rhizome preparations had 100% and 50% contamination, respectively. The fruits were separated into 4 stages ranked by their size. The fruit at stages 2 and 3 (26 – 36 mm and 15 – 25 mm in diameter, respectively) provided higher germination and growth. They were collected and cultured on the artificial sea water and natural seawater media containing 3% sucrose. The results showed that even though there was no effect of sucrose on *E. Acoroides* seed germination, it affected root hair production. The suitable conditions for multiple shoot induction is needed to be further clarified.

Keywords: seed germination, seagrass tissue culture, sucrose, synthetic sea water

P_21
Competent callus induction from shoot segments of Sang Mon ‘Nuan Rajinee’ bamboo (*Dendrocalamus sericeus* Munro)

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Callus was induced from 1 cm length of Sangmon ‘Nuan Rajinee’ bamboo; subsequently shoot multiplication was produced from callus using MS medium supplemented

with plant growth regulators with or without plant growth promoting substances. Our results indicated that there was no callus formation on MS medium without plant growth regulators. However, when BA at 1.0 mgL^{-1} or kinetin at 2.0 mgL^{-1} in combination with 2,4-D at 3.0 mgL^{-1} were supplemented with or without casein hydrolysate, L-proline, and L-glutamine at a concentration of 500 mgL^{-1}, 73.3%-86.6% callus were found in all media. Afterwards, calli were transferred to shoot induction medium. The results showed that MS medium supplemented with 2.0 mgL^{-1} kinetin gave the highest number of shoots at 12.4 shoots, significantly different from number of shoots obtained from other treatments.

Keywords: micropropagation, multiple shoots, auxin, cytokinin, proline, glutamine, casein hydrolysate

P_22

Enhancement of adenine sulphate and growth promoting substances on multiple shoot induction of Sang Mon `Nuan Rajinee´ bamboo (*Dendrocalamus sericeus* Munro)

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Multiple shoot induction of Sangmon 'Nuan Rajinee' bamboo was induced from a clump of 3-5 small shoots using MS medium with 1.0 mgL^{-1} BA and 0.1 mgL^{-1} TDZ supplemented with various concentrations of adenine sulphate ($AdSO_4$) or plant growth promoting substances, namely L-proline (LP), L-glutamine (LG), polyvinylpyrrolidone-40 (PVP-40), and ascorbic acid (AA). Our results in the first experiment showed that all concentrations of $AdSO_4$ were able to induce shoot multiplication ranging from 3.0 to 8.3 averaged new shoots with no statistical difference. However, $AdSO_4$ at 40 mgL^{-1} was the most appropriate for multiple shoot growth in terms of maximum averaged shoot height (3.58 cm), as well as induced uniform shoots size with healthy green color without excreted phenolic compound. The second experiment was to induce multiple shoots from a clump of 3-4 small shoots using MS medium with 1.0 mgL^{-1} BA and 0.1 mgL^{-1} TDZ supplemented with 500 mgL^{-1} LP alone or in combination with 500 mgL^{-1} LG or supplemented with 200 mgL^{-1} PVP-40 alone or in combination with 100 mgL^{-1} AA in liquid or semi-solid medium. The results indicated that multiple shoots cultured in liquid medium supplemented either with 500 mgL^{-1} LP or 200 mgL^{-1} PVP-40 gave the average of 4.3-5.9 healthy uniform green shoots with maximum shoot length.

Keywords: in vitro culture, TDZ, BA, proline, glutamine, PVP, ascorbic acid

P_23

Shoot initiation and multiple shoot induction of Sang Mon `Nuan Rajinee´ bamboo (*Dendrocalamus sericeus* Munro)

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Effects of plant growth regulators on shoot initiation from a node segment and multiple shoot induction from a shoot clump of Sang Mon 'Nuan Rajinee' bamboo (*Dendrocalamus sericeus* Munro) were investigated. A surface-sterilized nodal segment was cultured for 3 weeks on Murashige and Skoog (MS) medium supplemented 6-benzyladenine (BA) at different concentrations (8.88-22.20 µM). The results showed that MS medium supplemented with 17.76 µM BA provided the highest average number of shoots (2.5 shoots) from a node with the average shoot length at 10.52 mm. For multiple shoot induction, a shoot clump (about 3-5 shoots per clump), initiated from a node, was cultured for 3 weeks on modified MS medium supplemented with BA (1.11 or 2.22 µM) or thidiazuron (TDZ) (0.45-1.36 µM) or brassinolide (BL) (0.001-10.0 µM). The medium containing TDZ at the concentrations of 0.45 and 0.90 µM gave the highest survival rate (100%) and the highest number of shoots increased at 10.8 and 9.0 shoots, (3.6-fold and 3.0-fold increase) with average shoot length at 20.33 and 14.94 mm, respectively. However, BA (1.11 µM) in combination with TDZ (0.45-1.36 µM) or with BL (0.001-10.0 µM) in modified MS medium was used for multiple shoot induction from a 1-2 shoot clump. It was found that the medium supplemented with 1.11 µM BA in combination with 0.45 µM TDZ provided 100% survival and the highest number of shoots increased at 2.4 shoots (2.8-flod increase) with 34.32 mm shoot length. For BL supplemented in the medium containing 1.11 µM BA, the low concentration of BL (0.001 and 0.1 µM) showed the better results than the high concentration (10.0 µM); however, the number of shoots did not increase.

Keywords: in vitro culture, nodal segment, 6-benzyladenine, thidiazuron

P_24

Effects of some organic additives on shoot initiation and shoot multiplication of Sang Mon `Nuan Rajinee´ bamboo (*Dendrocalamus sericeus* Munro)

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Shoot initiation from nodal segments and shoot multiplication from a shoot clump of Sang Mon 'Nuan Rajinee' bamboo (*Dendrocalamus sericeus* Munro) using some organic additives supplemented in culture media were carried out. A surface-sterilized nodal segment was cultured for 3 weeks on modified solid Murashige and Skoog (MS) medium, containing 3.0 mg/l benzyl adenine (BA) and 0.1 mg/l thidiazuron (TDZ), supplemented with 2.0 g/l tryptone or 0.5 mg/l biotin or 0.1 mg/l folic acid or 1.0 g/l monosodium glutamate (MSG). MSG in the solid medium gave the better result in number of shoots (3.0 shoots per node) with greener and healthier shoots than those from other treatments. For shoot multiplication, a shoot clump, as explant, was cultured on modified liquid MS medium (containing 1.0 mg/L BA, 0.1 mg/l TDZ, and 0.5 g/l L-proline) supplemented with different concentrations of MSG (0.5, 1.0, 2.0, and 3.0 g/l) or L-glutamine (0.1, 0.2, 0.3, and 0.4 g/l) compared to 0.04 g/l adenine sulphate as a positive control. It was found that medium supplemented with 1.0 g/l MSG gave the highest multiplication rate of 3.7 folds from shoots of initial explant. Furthermore, medium supplemented with 0.1 and 0.2 g/l L-glutamine also gave the high multiplication rate of 3.4 folds from shoots of initial explant. The same results of medium supplemented with 0.1 g/l L-glutamine were found on medium containing 0.04 g/l adenine sulphate with a clump of small green shoots.

Keywords: in vitro culture, adenine sulphate, monosodium glutamate, L-glutamine

P_25

In vitro propagation and callus induction of *Hedychium longicornutum* Griff. ex Baker using different explants

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Hedychium longicornutum Griff. ex Baker (Zingiberaceae) is an endemic plant of the Malay Peninsula. This plant has a high potential to develop to a new ornamental plant because of wonderful multicolor with an exotic form of its inflorescence. However, the limited number of *H. longicornutum* in nature cannot support consumer demand. Therefore, this study aimed to establish the efficient in vitro *H. longicornutum* propagation method through organogenesis. For direct organogenesis, shoot tips and leafy-shoot bases were cultured on Murashige and Skoog (MS) gelrite medium supplemented with different concentrations of N^6-benzyladenine (BA) or thidiazuron (TDZ) for 4 weeks. Then, explants were transferred onto PGRs-free MS gelrite medium for another 12 weeks. The results revealed that shoot regenerated from leafy-shoot bases showed more amount and higher height when compared to regenerated shoots from shoot tips in every culture medium. Leafy-shoot bases that had been cultured on MS gelrite medium supplemented with 4 mg/L BA generated a large number of new plants (14.00$\pm$1.05 shoots/explant) with the longest shoot (14.21$\pm$0.37 cm). Plants regenerated from this medium spontaneously rooted and exhibited a survival rate at 85% after acclimatization for 4 weeks. In indirect organogenesis, this study firstly investigated a suitable callus condition before establishing indirect *H. longicornutum* organogenesis in further study. Leaves and leafy-shoot bases were cultured on *Hedychium* callus induction medium (HEDM) supplemented with various combinations of 2,4-dichlorophenoxy acetic acid (2,4-D) and kinetin (KN) under light and dark condition. After 8 weeks, leaf explants failed to induce callus in all treatments. In contrast, leafy-shoot bases cultured on HEDM supplemented with 1 mg/L 2,4-D and 2 mg/L KN under light condition induced callus at 100% with the highest callus fresh weight (1.78$\pm$0.37 g/explant). The results from this study are useful for mass-rapid in vitro multiplication of *H. longicornutum*, a valuable plant, on a commercial scale.

Keywords: *Hedychium longicornutum*, Zingiberaceae, ornamental *Hedychium*, in vitro propagation, callus induction

P_26
Effect of BA and NAA on leaf explants of *Dorcoceras brunneum* C. Puglisi in vitro

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Dorcoceras brunneum C. Puglisi (Gesneriaceae) is an endemic plant that only found in Thailand. This species is classified as a rare plant and its population number is restricted. With the tiny size and beautiful purple flower of *D. brunneum*, it has a high potential for promoting as a new decorative potted plant. Therefore, mass propagation of this plant should be done to encourage *D. brunneum* to ornamental market. This study established an efficient in vitro proliferation method for this plant. Fruits were used as starting materials for initiating clean cultures. Then, 1 cm^2 leaves of 16-week-old in vitro seedlings were excised and cultured on semi-solid Murashige & Skoog (MS) medium supplemented with 0, 0.1, 0.5, and 1 mg/L N^6-benzyladenine (BA) alone or in combination with 0.1 and 0.5 mg/L 1-napthaleneacetic acid (NAA). The best direct shoot organogenesis was achieved from the treatment of 0.5 mg/L BA and 0.5 mg/L NAA (13.29 shoots/leaf) after 16 weeks of culture. After separating a single shoot from bunches of regenerated shoots, they were subsequently cultured on MS agar medium. Shoots spontaneously rooted within 8 weeks of culture. This simply mass-rapid multiplication method will provide benefit for supporting *D. brunneum* to the commercial path. Moreover, it might prevent the illegal trade and harvest this plant from its natural habitat.

Keywords: *Dorcoceras brunneum*, Gesneriaceae, ornamental plant, in vitro propagation, endemic plant

P_27
In vitro propagation of *Juniperus phoenicea* L

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Juniperus phoenicea L. is a native evergreen shrub or small tree of a rare coastal forest ecosystem in Attica, Greece threatened by human activities. It has a low regeneration post-fire rate, poor fertilisation, and pollen vitality; hence, producing reduced amounts of live seeds. In vitro propagation of the species could facilitate its use and conservation. Nodal explants were excised from apical parts of actively growing stems of a wild mature tree during the end of May and June. Explants were cultured on Murashige and Skoog (MS) medium with no plant growth regulator or with 1 mg L^{-1} BA. In both experiments, shoot formation ranged between 65-75% consisting of 1.4-2.3 stunted shoots. The use of 0.1 mg L^{-1} NAA combined with 1 mg L^{-1} BA or zeatin did not affect shoot formation. Following four different culture media were tested; MS, Woody Plant Medium (WPM), Rugini Olive Medium (OM), and Juglans Medium (DKW) containing 1 mg L^{-1} BA. The highest percentage of shoot forming explants was observed on OM and DKW (85% and 90%, respectively); while, on WPM the percentage was very low (20%). Both the number of shoot formation and length increased threefold on OM. Subsequently the effects of BA, Kinetin, and 2-isopentenyladenine at 0.2 and 1 mg L^{-1} on DKW and OM medium were studied. OM containing 2-isopentenyladenine was efficient on shoot formation of *J. phoenicea*. Finally, full or half strength OM, supplemented with IBA at 0.1, 1, 2, 3, and 4 mg L^{-1} was employed for the rooting stage, with no results.

Keywords: tissue culture, *Phoenicean juniper*, culture medium, 2iP, shoot formation

P_28
Investigation of micropropagation of the Mediterranean xerophyte *Thymelaea hirsuta* (L.) Endl. (Thymelaeaceae)

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Thymelaea hirsuta (L.) Endl. (Thymelaeaceae) is a dioecious and sometimes monoecious, perennial, evergreen, shrub, which is considered suitable for use as an ornamental landscape plant in xeriscaping, due to its particular morphology and tolerance to drought and poor rocky soils. In the present study, the effect of various cytokinins on in vitro establishment and shoot multiplication, as well as of various auxins and techniques on rooting were examined in order to find an effective micropropagation protocol, since seed germination is low and stem cuttings fail to root. Shoot tip and nodal explants, excised from in vitro grown seedlings were initially cultured on MS medium with 0.0-2.0 mg L^{-1} zeatin. The presence of cytokinin increased the number of shoots produced per explant compared to the control. After two subcultures on MS medium with 0.5 mg L^{-1} zeatin, explants were cultured on MS medium with 0.0, 0.25, 0.5, 1.0 or 2.0 mg L-1 BA or zeatin or kinetin or 6-γ-γ-(dimethylallylamino)-purine (2iP). Almost all explants produced shoots, excepting those cultured on medium with BA (> 75%). More shoots per explant were produced in media containing 0.5-2.0 zeatin or kinetin or 0.25 BA (mg L^{-1}); while, shoot length was greater in media with 0.25-1.0 2iP or 0.25 zeatin (mg L^{-1}). However, the produced shoots, excepting

those cultivated in zeatin, exhibited a variety of morphological abnormalities, such as hyperhydration, deformation, and drying. Considering explants productivity and shoots normality, zeatin at 1.0-2.0 mg L^{-1} was considered the most appropriate for shoot multiplication; whereas, rooting of microshoots was not succeesful. NSRF 2007-2013, OPERATIONAL PROGRAMME EDUCATION & LIFELONG LEARNING - THALES - ARCHAEOSCAPE.

Keywords: xeriscaping, native plant, cytokinins, shoot proliferation, rooting, abnormalities

P_29

Effects of plant growth regulators and agar concentration on shoot multiplication and hyperhydricity of *Anthyllis barba-jovis*

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The increase of agar concentration and the addition of auxin into the shoot proliferation medium were tested as for their effectiveness on eliminating hyperhydricity in *Anthyllis barba-jovis* L. micropropagation. Single node explants of adult- or seedling-origin were cultured on MS medium supplemented with 4.0 mg L^{-1} 6-benzyladenine (BA) in combination with 0.0, 0.1 or 0.5 mg L^{-1} 1-naphthaleneacetic acid (NAA) solidified with 8.0 or 12.0 g L^{-1} agar. Hormone free-MS medium with 8.0 g L^{-1} agar, used as control, produced the lowest shoot number and length (1.0 shoot per explant, 0.6-0.8 cm), and no hyperhydricity. Both explant types responded in a similar way in all treatments. MS medium with BA solidified with 8 g L^{-1} agar induced the highest shoot proliferation (12.5 shoots per explant, 1.8 cm shoot length) but more than 75% of the shoots were hyperhydric. The addition of NAA (independently of concentration) into the BA-medium, or the increase of agar concentration resulted to reduced hyperhydricity, and the combination of both almost eliminated it. In BA-NAA-media, the highest number of normal shoots was produced when BA was combined with 0.1 mg L^{-1} NAA and 12.0 g L^{-1} (7.6 or 7.9 shoots per explant of adult and seedling origin, respectively). Both agar increased and NAA reduced slightly shoot length (1.0-1.2 cm). Therefore, increasing agar concentration to 12.0 g L^{-1} and supplementing the medium with 4.0 mg L^{-1} BA and 0.1 or 0.5 mg L^{-1} NAA, resulted to the elimination of hyperhydricity and in the best shoot multiplication response.

Keywords: micropropagation, explant origin, 6-benzyladenine (BA), 1-naphthaleneacetic acid (NAA), hyperhydricity, native plants

P_30
In vitro culture of mandarin orange [*Citrus reticulata* (L.) Blanco] via organogenesis

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In vitro culture of mandarin orange (*Citrus reticulate*) was carried out. Seeds without seed coats were cultured on Murashige and Skoog (MS) medium without plant growth regulator, provided the highest percentage of germination (75%), shoot number (1.6), and shoot length (1.3 cm). Seed-derived shoots were cultured on MS medium supplemented with different concentrations of 6-benzyladenine (BA) at 1.5 and 3.0 mg/l alone or with 500 mg/l malt extract for multiple shoot induction. It was found that BA alone gave more numbers of shoots (3.6 and 4.0, respectively) than BA with malt extract did (2.8 and 3.8, respectively). However, malt extract provided higher shoot length (1.9 cm) than BA alone did (1.4 – 1.7 cm). For rooting, 0.7 roots, 3.0 cm root length with 67% rooting or 0.7 roots, 1.4 cm root length with 73% rooting were obtained from a half strength of MS containing 1.0 mg/l indole-3-butylric acid (IBA) or 1.0 mg/l IBA in combination with 1.0 mg/l 1-naphthalene acetic acid (NAA), respectively.

Keywords: mandarin orange, multiple shoot induction, malt extract, in vitro culture

P_31
Effects of BA and TDZ for in vitro shoot multiplication of three *Hedychium* species

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Hedychium is a terrestrial zingiberaceous species with underground rhizomes, as a source of raw materials for pharmaceutical and cosmetic products. The demand for raw plant materials have increased, resulting in over collection from the wild. In this study, two types

of cytokinin were used for in vitro shoot multiplication of three *Hedychium* species. The sterile young shoot tips of *H. stenopetalum*, *H. neocarneum*, and *H. flavescens* were cultured on solidified Murashige and Skoog (MS, 1962) medium supplemented with various concentrations of 6-benzyladenine (BA) and thidiazuron (TDZ). All cultures were incubated under 16 h illiumination day^{-1} at 25±2 ^{o}C for 8 weeks. The results showed that the medium supplemented with 2.7 µM TDZ gave the highest shoot multiplication of *H. flavescens* and *H. stenopetalum* at 5.7 and 5.9 shoots per explant, respectively. The medium supplemented with 0.9 µM TDZ gave the highest shoot number at 5 shoots per explantin *H. neocarneum*. This significant study could be applied for a large scale production of these valuable species.

Keywords: zingiberaceae, micropropagation, thidiazuron, 6-benzyladenine

Session V: Research in Production, Physiological, Phytochemical, and Molecular Studies

P_32

The effect of preventing transition from MCI to early dementia by hand care treatment in the environment of horticultural therapy garden

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Nearly 47.5 million people worldwide have dementia in the world in 2015. In Japan the challenge to families and health and social services is substantial. We believe that some treatments for the elderly should be based on the idea that the activity being performed also stimulates the senses. In this study, we examined whether hand care treatment was effective in preventing transition from MCI to early dementia. In addition, if the operation environment for hand care treatment was a horticultural garden, we also examined whether there was a difference in the transition prevention effect from MCI to initial dementia. The subjects were elderly people who participated in community activities over 70 years old. In the pre-evaluation, the pre-evaluation, people with an MMSE score of 24-27 and those with an MMSE score of 28 or more and a Moca-J score of 25 or less were considered MCI. We conducted hand-care treatment once a week, and evaluated the cognitive ability, the degree of depression of the elderly and the daily living activity for 3 months. As a result, it is generally said that MCI people shift to about 10% dementia in one year except 3% of MCI people who received care reatment. The transition rate to dementia among MCI people who received hand-care treatment in horticultural therapy garden was 2%, which was even lower than that of indoor hand care treatment without significant difference. Using the environment of gardening therapy garden to prevent progression of cognitive impairment is effective in creating a trigger for the target person to move with their own intentions, so the utility of promoting stimulation of aerobic exercise and five senses is fully expected. Therefore, it is necessary to further study in the future.

Keywords: dementia protect, horticultural therapy garden, sensory stimulation, emotional health

P_33
Comparative effectiveness of various protection systems of the pear from *Psillapyri* L. in the Crimea

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Pyruscommunis L. (Rosaceae) is one of the most valuable fruit cultures on the territory of the Crimean Peninsula. The areas occupied by pear culture in the Crimea is constantly decreasing under the influence of a number of adverse factors, one of which is the mass distribution of *Psyllapyri* L. (*Homoptera, Psyllidae*). As a result of its mass reproduction, the losses of fruit production in some years can reach 70.0%. Ontogenesis of phytophagans is six generations, developing throughout the vegetation period.

The range of protective products permitted for use on pear is limited, and the existing control schemes are based on the repeated use of highly toxic insecticides, the use of which adversely affects the density of the population of entomophagans in pear orchards. The current situation dictates the need to develop environmentally low-risk and cost-effective schemes for the protection of pear culture.

As a result of our studies, it was found that the treatment of insecticides from the class of synthetic pyrethroids can reduce the number of imagos of *P. pyri* by 88.0%. To limit the number of pests in the period of egg laying the growth and development regulators of insects showed the greatest efficiency – 93.0%.The biological effectiveness of the use of combinations of neonicotinoids and regulators of growth and development of insects during the mass appearance of larvae and nymphs of *P. pyri* reached 94.0%.

We have tested and patented several experimental, environmentally acceptable schemes for the protection of pear plantations with different pesticide loads. The schemes make it possible to effectively control the population density of *P. pyri* during the growing season, with damage to the removable crops within 5.0%.

Keywords: agrocenosis, *Psillapyri* L., biological efficiency, protection schemes

P_34
Physicochemical and prebiotic property of Champedak (*Artocarpus integer* Merr.) seed starch

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Chempedak (*Artocarpus integer* Merr.), a native fruit tree in southern Thailand, belongs to the Moraceae family. Chempedak seeds are considered as a waste composing mainly of starch. Physicochemical and prebiotic property of champedak seed starch were analyzed in this study. The chemical composition of its seed starch contained 0.47% protein, 0.37% fat, 0.32% ash, 27.31% amylose, and 3.75% resistant starch. The starch morphology was round and polygonal in shapes with average granular size of 6.50±1.25 micron analyzing by scanning electron microscopy (SEM). The swelling power and solubility of Champedak seed starch were 11.52% and 10.71%, respectively. Pasting properties analyzed using a rapid visco analyzer (RVA) displayed that the peak and trough viscosity of Champedak seed starch were 157.28 and 107.69 RVU, respectively. In addition, the gelatinization temperature monitoring by differential scanning calorimetry showed a range of 77.1–86.7°C. Champedak seed starch also exhibited essential prebiotic property of resistance under mimic gut stresses. It showed 16.66, 14.85, and 13.00% hydrolysis after sequential exposure to upper part of gastrointestinal tract in stomach at pH 1, 2, and 3, respectively for 4 h and duodenum (pancreatic α-amylase) for 6 h. These results suggested that Champedak seed starch could be used for development in functional food products.

Keywords: Champedak seed starch, physicochemical, prebiotic

P_35
Effect of different combinations of NAA and TDZ for in vitro shoot induction of *Aglaonema simplex* (Blume) Blume

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Wan Khanmak [*Aglaonema simplex* (Blume) Blume] is a kind of Thai herb. The ripe fruits are extensively used as longevity enhancer and anti-asthma medication, but the number of fruits per plant was only 3-14. This research project aims to find the most appropriate tissue

culture protocol for mass propagation of Wan Khanmak herb. The experimental design was Completely Randomized Design (CRD). Wan Khanmak lateral buds were incubated in MS medium supplemented with 1-Naphthaleneacetic acid (NAA) and Thidiazuron (TDZ) at various doses; 0:0, 0.25:0.5, 0.25:1, 0.25:1.5, 0.25:2 and 0.25:2.5 mg/L. The results showed that the most effective medium was MS medium supplemented with NAA and TDZ at 0.25:2.5 mg/L ratio, which produced the highest number of shoots per culture (4.5 shoots) in 8.5 days.

Keywords: *Aglaonema simplex*, tissue culture technique, NAA, TDZ

P_36
Effects of time and concentration of ethyl methane sulfonate (EMS) on of Chia (*Salvia hispanica* L.)

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This experiment was conducted to determine the time and concentration of Ethyl methanesulfonate (EMS) that will be used as the EMS mutagen of Chia (*Salvia hispanica* L.). Due to Chias predominantly self-pollinating and has low genetic variability. It makes breeding by standard methods difficult and takes a long time to select. Mutation induced by EMS is another method used to create genetic variability. Experimental design used in this research was 5 x 4 factorial experiments in RCBD. Factor A: the five levels of the concentration, 0%, 0.2%, 0.4%, 0.8%, and 1.6%. Factors B was the four levels of exposure duration 3, 6, 9, and 12 hours. After that, seedling will be evaluated at day 10. The graph was plotted in order to examine the relationship between the concentration and duration of the EMS dosage which results in 50% reduction in the seedling. The results showed that germination percentages of those seeds soaked in 0.37% EMS for 12 hours and 0.76% EMS for 9 hours were 50% decreased. On the other hand, 3 hours and 6 hours at the highest concentration (1.6%) showed that the germination percentage decreased by 10% and 27%, respectively. Therefore, EMS solution should be used in the concentration of 0.37% - 0.76% by volume, using a time of 9-12 hours to induce Chia mutation.

Keywords: mutation, plant breeding, germination test, lethal dose fifty

P_37
DolomiNet: building a network of vertical farms in the heart of Italian Alps

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In 2019, the international student competition UrbanFarm invited students from all over the world and different disciplines to join forces in order to reconvert three abandoned buildings into productive structures using soil-less technologies. One of the target locations was the abandoned school of Orzes village, in the Italian Alps, a mountain area that, along the last decades, has experienced lack of job opportunities and depopulation processes.

Building on these social and economic obstacles, a landscape and collective re-generation project was designed in order to offer a new local economic identity, creating a network of indoor farms within abandoned buildings and targeting the production and processing of medicinal mushrooms and herbs. Such a network, called DolomiNet, defined the Orzes School as an administrative reference and productive model to be replicated and exported on the several abandoned buildings within the region. Furthermore, it allowed for the creation of a training and research center within the former school, where future network members could be trained and investigation on new pharmaceutical products and lighting technologies could take place.

The three pillars of innovation of the project stands on the following elements:

- The forest biosystem: a sustainable productive model inspired by forest connections and based on CO_2-O_2 exchange among mushrooms and plants growing chambers.

- The green Exo-Scheleton: a bioclimatic greenhouse applied on the building external shell with the double function of increasing productive volumes and provide thermal insulation to the building.

- Coofarming App: an immediate communication system between farmers and administrative center, which concurrently guarantee a remote control of cultivation parameters.

Keywords: urban agriculture, vertical farming, soil-less, building reconversion

P_38

Evaluation phenotypic and genotypic for resistance against tomato yellow leaf curl Thailand virus (TYLCTHV) validated by Ty-2 Ty-3 and Ty-4 genes in tomato

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Tomato yellow leaf curl virus (TYLCV) caused by whitefly-transmitted begomovirusesis, one of the most destructive and causing heavy losses in tomato yields, especially in sub-tropic and tropic regions including Thailand. Therefore, breeding tomato for resistance to TYLCV is necessary. The purpose of this research was to evaluate tomato varieties which were resistant to TYLCV for Thailand's strain (TYLCTHV) with agronomic traits. The 35 tomato accessions obtained from The World Vegetable Center (AVRDC) were compared with the susceptible variety (Seedatip: KKU-T12002). The results of field evaluation showed that the 11 tomato accessions performed moderately resistant to TYLCTHV and their good agronomic traits. The results for resistance were classified into 3 groups based on their responses to TYLCTHV. The first group, i.e. KKU-T24003 and KKU-T23160 were identified as highly resistant level. The second group, i.e. KKUT23176 was identified as resistant level and other 7 tomato varieties were identified as moderately resistant level. In addition, Ty-2, Ty-3, and Ty-4 genes were validated by 2 SCAR markers and 1 SSR marker in the 12 tomato accessions.

Keywords: whitefly, SCAR markers, SSR marker

P_39

Flavonoid contents and antityrosinase activity in various parts of *Dendrobium* `Sonia Jo Daeng´ and *Dendrobium* `Khao Sanan´ at different growth stages

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Dendrobium 'Sonia Jo Daeng' (DSJD) and *D.* 'Khao Sanan' (DKS) are widely known as cut-orchids of Thailand. As several researches indicated that various parts of orchids contain high phenolic and flavonoid contents. Thus, the flavonoid contents and antityrosinase activity in various parts of DSJD andDKS at different growth stages were evaluated. The analyses were performed in roots, leaves, pseudobulbs, flowers, and peduncles of 1 and 4 years old of both cultivars. The results showed that various parts of both orchids contained

different flavonoid contents and antityrosinase activity. In DSJD, total flavonoid contents (6.34 ± 0.41 mg QE/g DW) were the highest in leaves of 4-year-old plants consistanted with the antityrosinase activity (55.33 ± 7.44 % tyrosinase inhibition). Moreover, the high contents of total flavonoids were observed in stems (5.52 ± 0.19 mg QE/g DW), flowers (5.47 ± 0.20 mg QE/g DW), and peduncles (3.59 ± 0.20 mg QE/g DW) of 1-year-old DKS and also in stems (3.38 ± 0.15 mg QE/g DW) and peduncles (3.50 ± 0.07 mg QE/g DW) of 4-year-old plants. These results in agreement with the antityrosinase activity which found the highest in peduncles of 1- and 4-year-old plants (38.72 ± 3.52 and 42.44 ± 4.17 %tyrosinase inhibition, respectively). Therefore, leaves of 4-year-old DSJD are a rich source of flavonoids and had the highest antityrosinase activity. Taken together, this finding suggested that flavonoids play an important role in inhibition of tyrosinase activity which could be further useful as anti-melanogenesis in cosmetic industry.

Keywords: anti-melanogenesis, cut orchid, flavonoid, phenolic, tyrosinase inhibition

P_40
Influence of geographical and genetic variation on GABA content in *Annona muricata* grown in Thailand

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Annona is a genus of tropical fruit trees in the family Annonaceae. Among *Annona* species, fruit pulp of *A. muricata* contained the highest amount of gamma-aminobutyric acid (GABA), but GABA content is normally affected by many factors including genetic makeup and environment. The objective of this study was to determine the influence of genetic variation and geographical environment on GABA content in fruit pulp of *A. muricata*. For genetic variation study, sequences of ITS2 and *psbA-trnH* were used to construct phylogenetic trees. Young leaves of *A. muricata* were collected from different geographic locations including Chumphon, Trang, Nakhon Ratchasima, Nakhon Si Thammarat, Burirum, NongKhai, Udon Thani, and Prachuap Khiri Khan provinces in Thailand. Sequences of ITS2 and *psbA-trnH* were aligned and the datasets were analyzed with maximum likelihood (ML) and neighbor-joining (NJ) method. The results showed that ITS2 sequence variation was observed within and among samples from different locations. GABA measurement from *A.*

muricata fruits harvested from different locations contained different amounts of GABA. Fruits of *A. muricata* from eight provinces, namely Chumphon, Trang, Nakhon Ratchasima, Nakhon Si Thammarat, Burirum, NongKhai, Udon Thani, and Prachuap Khiri Khan contained 19.75, 35.02, 32.91, 28.18, 42.37, 32.17, 65.02, and 31.58 mg/100 mg FW GABA, respectively. Our results indicated that geographical environment and genetic variation had a significant effect on the content of GABA in *A. muricata* fruits.

Keywords: soursop, phylogenetic analysis, geographic environment, gamma-aminobutyric acid

P_41
The effect of salinity on *Chrysanthemum* 'Amiko red'

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High salinity in irrigation water is considered to be amongst the most important factors of plant stress that can cause reduced growth, nutrient deficiencies, and toxicities. In addition, salinity can reduce the commercial value of ornamental plants depending on genotype tolerance. *Chrysanthemums* are popular ornamental plant species. The effect of irrigation water containing 0 (control), 2.5, 5, 10, 20 or 40 Mm NaCl on the plant growth of potted *Chrysanthemum* 'Amiko red' under greenhouse conditions is presented. Toxicity symptoms started to appear on the leaf edges of the plants two weeks after the start of the treatments. Maximum plant height was measured at 40 mM NaCl, maximum efficiency of PSII (Φ_{PSIIo}) was significantly reduced at 40 mM NaCl. The operating efficiency of PSII photochemistry (Φ_{PSII}) was significantly reduced at the lower concentration of 20 mM NaCl; while, a significant increase in leaf thickness was observed. Maximum fresh weight of shoots and roots were obtained at 0 and 2.5 mM NaCl; while, corresponding dry weights showed no significant differences between the various NaCl treatments. While salinity did not affect the substrate's moisture retention capacity, it did affect the saturated hydraulic conductivity. Shortly after treatments were applied, the commercial value of *Chrysanthemum* 'Amiko red' was negatively affected even at low NaCl concentrations. Generally, the growth of greenhouse potted plants of *Chrysanthemum* 'Amiko red' was negatively affected at concentrations greater than 5 mM NaCl which became significant at 20 and 40 mM NaCl.

Keywords: NaCl, irrigation water, *Chrysanthemum*, potted plants, greenhouse

P_42
Effects of Carnauba wax and temperatures during storage on antioxidants and granulation in "Manee-Esan" pummelo

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Pummelo is the economic fruit in Thailand. "Manee-Esan" is a new promising pummelo cultivar of Northeast of Thailand. The problems of pummelo during storage and export are the quality of the products decreased and not acceptable to consumers. Coating and storage temperatures have been used as to prolong shelf life of fresh fruits. The aim of this study was to investigate the effect of carnauba wax and temperatures during storage on antioxidants and granulation in "Manee-Esan" pummelo. Experiments were conducted based on 3 x 2 Factorials in Completely Randomized Design. Three carnauba wax concentrations at 0, 20, and 25% and two storage temperature were 10 and 25 °C. Samples were randomly collected every 15 days. The results showed that phenolic, flavonoid, β-carotene, and anthocyanin content tend to decrease after extensive time of storage. Moreover, granulation in "Manee-Esan" pummelo was raised following storage time. Granulation were the highest at 0% carnauba wax storing at 25 °C, 20% carnauba wax storing at 10 °C, 20% carnauba wax storing at 25 °C, 25% carnauba wax storing at 25 °C, 0% carnauba wax storing at 10 °C, and 25% carnauba wax storing at 10 °C, respectively and granulation were measured at 25.04, 17.03, 16.35, 15.90, 9.53 and 2.67%, respectively. The "Manee-Esan" pummelo fruits were coated with 25% carnauba wax storing at 10 °C extended the longest storage life for 135 days when compared with 0% carnauba wax storing at 25 °C (control) can be stored for 45 days.

Keywords: "Manee-Esan", phenolic, flavonoid, β-carotene, granulation

P_43
Effect of light-emitting diodes (LEDs) on growth of sweet basil (*Ocimum basilicum*) in aquaponic system

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The study of sweet basil (*Ocimum basilicum*) production in vertical aquaponic system with laterite and soilless media, using fish manure from Tilapia fish, of which, it provides rich nutrient required by the plants. Light Emitting Diode (LED) is a good source of energy because the light intensity can be adjusted; it has a low temperature when operated, as well as long shelf life, and it uses less energy when compared to other light sources. The aim of this research was to study the differences between light intensity and light color ratio based on growth, quality, photosynthesis, and bioactive of sweet basil of which, they were investigated under plant factory environment. The twelve LEDs light treatment that were tested are as follows: 1) white as a control, 2) blue, 3) red, 4) green, 5) far-red, 6) red: white (1:1), 7) red: white (2:1), 8) red: white (3:1), 9) red: blue (3:1), 10) red: blue (5:1), 11) red: white: blue (1:1:1), and 12) red: white: blue (3:1:1). The result was remarkable significant; the growth and quality of sweet basil showed significantly difference between diverse light treatments; the sweet basil under red: white LEDs light (2:1) had the highest plant high, plant dimeter, leaf length, leaf number, leaf width, photosynthetic (QY_{max}), and SPAD value. While red: white: blue LEDs light (3:1:1) and white affect to higher fresh and dry weight of stem and roots. But found that red: white LEDs light (2:1) and red: white: blue LEDs light (1:1:1) and (3:1:1) affect to higher phenolic compound and fresh root. The combination of red: white LEDs light (2:1) was found the most suitable light environment for maximum growth and high quality of commercial sweet basil production under vertical aquaponic system in plant factories.

Keywords: laterite, vertical, plant factory

P_44
Study on organic acid and antioxidant properties of *Elaeagnus latifolia* Linn

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Bastard oleaster (*Elaeagnus latifolia* Linn.) is indigenous fruit trees growing in many areas, especially in the North and Northeastern Thailand. The fruits are considered in having nutritional values i.e. vitamins, minerals, the medicinal applications including the uses of unripe fruits as astringent and the ripe fruits as laxative for diarrhea and constipation. This study was carried out to investigate organic acid contents, sugar, total polyphenol contents, and anti-oxidation properties of bastard oleaster fruits collected from 16 clones growing in

Loei and Nong Khai provinces. The comparisons were made between the fruits in early ripening stage with orange color and the red fruits in fully ripening stage. Organic acids, i.e. malic acid, tartaric acid, and citric acid were found in both stages but the higher contents were found in early ripening stage. Sugar contents, glucose, and mannose were higher in early ripening stage and fructose and sucrose were higher in fully ripening stage. Total polyphenol contents and anti-oxidation properties were higher in early ripening stage as compared to fully ripening stage. Results of this study showed that bastard oleaster fruits have outstanding anti-oxidation properties and malic acid content, especially in early ripening stage. This study provided basic information which can be used in food and cosmetic industry in the future.

Keywords: Bastard oleaster, nutritional value

P_45
The results of studying the adaptive potential of the walnut

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Abiotic stressors cause significant economic damage to horticulture and are one of the main causes that negatively affect the productivity of crops. Along with social and economic problems, the efficiency of industrial fruit growing in the Russian Federation depends to a large extent on the low adaptive potential of cultivated cultivars. Without the creation of new integrated systems that increase the production of domestic fruit products, it is difficult to solve the task of replacing fruit imports. In such conditions, the use of the most effective methods for evaluation the genetic potential of the initial forms and hybrid material will allow to increase the productivity of the selection process and to obtain the new generation of highly productive and adaptively resistant cultivars of walnut. In the course of the research, 27 walnut cultivars from the gene fund collection in the Nikita Botanical Gardens were compared in 10 main economic characteristics with the developed ideal model of the cultivar: the period of entry into fruiting (4 years), fruit size (3 points), fruit mass (26 g), kernel taste (5 points), kernel output (60%), fat and protein content (70% and 22%, respectively), productivity (50 kg/t), frost resistance (3 points), drought resistance (32 points), and heat resistance (3 points). Cluster analysis of the experimental data was carried out using the computer program Statistics 10. The distribution of cultivars in 4 groups was carried out using the calculated integral criteria of all determined indicators that characterize their degree of similarity with the ideal model: I – ‘Sladkoyaderny’, ‘Gurzufsky’, ‘Doliny’, ‘Skabery’, ‘Partizansky’, ‘Yuzhnoberezhny’, ‘Pozdnetsvetushchy’, ‘Arkad’ and ‘Bubenchik’; II – ‘Bospor’, ‘Starokrymsky’, ‘Kacha’, ‘Pioner Kryma’, ‘Originalny, Zhemchuzhny’, ‘Belbeksky Ranny’, ‘Krymsky Skoroplodny’ and ‘Uigursky’; III – ‘Alminsky’, ‘Burlyuk’, ‘Konkursny’ and

'Pamyaty Pasenkova'; IV – 'Moldovskaya Bomba', 'Podarok Valentiny', 'Bomba Chkalovskaya', and 'Purpurovy'. The following cultivars proved to be the closest to the model of the cultivar (18 units): 'Karlik 3' (16 units), 'Purpurovy' (11 units), and 'Moldavskay Bomba' (10 units).

Keywords: walnut, cultivars, variety model, clusters analysis

P_46
The quality of the DNA isolated from the leaves of *Lavandula angustifolia* Mill

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Lavender is commercially valuable aromatic plant grown due to the great value of its essential oil used in medicine and cosmetology. To identify the genetic relationships between various lavender cultivars, to determine molecular and genetic mechanisms that encode their economically valuable characteristics, it is necessary to work out methods of a molecular genetic analysis for these particular objects. The objective of the presented work was to assess the quantity and quality of DNA isolated from *L. angustifolia* cultivar 'Belyanka' by different methods. Lavender plants, grown in the collection plots in the Nikita Botanical Gardens (ex situ), and microshoots, cultured in vitro in BIOTRON growth chamber, were used as the initial material. The accumulation of essential oils was assessed by measuring lipid droplets on the leaf blades cut-off area stained with Sudan III using AxioScope A.1 light microscope. To isolate DNA, young leaves (20–200 mg) were excised from the shoots. DiamondDNATM commercial kits (DiamondDNA, Russia) and GeneJET Plant Genomic DNA Purification Kit (Thermo Scientific™, USA) were used, as well as an automated sample preparation system (MagNA Pure LC 2.0, Roche, Switzerland). The amount and quality of DNA was assessed by spectrophotometry technique (Implen NanoPhotometer NP80, Germany), DNA fragmentation was made with Agilent 4200 TapeStation (Agilent Technologies, Germany). The essential oil droplet diameter in leaf mesophyll cells was 3-5 μm (up to 23% of the area) and 15-26 μm (up to 50% of the area), respectively in vitro and ex situ. High molecular DNA was isolated from in vitro plants using GeneJET kit (54605 bp, 30.5 ng/μl). DNA purity at

A260/280 ratio was determined for GeneJET and MagNA Pure. This study was funded by the grant № 19-76-00023 of the Russian Science Foundation and done on the base of the Unique Scientific Installation "Scientific Center of Plant Biotechnology, Genomics, and Conservation".

Keywords: lavender, ex situ, in vitro, leaf, essential oil drop, DNA isolation

P_47

Growth of golden oregano on an urban extensive green roof as affected by substrate type and irrigation frequency

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Internationally, the construction of green roofs in the cities, as well as urban horticulture are expanding. In this study doth these trends were combined and the growth of *Origanum vulgare* 'Aureum' (golden oregano), a culinary and simultaneously an ornamental herb, was investigated on an urban green roof under the effect of two substrate types and irrigation frequencies. The green roof was of an extensive type, in Athens, Greece that is in a semi-arid environment. Beginning of November 2014 rooted cuttings were planted in experimental modules, with a green roof infrastructure (substrate moisture retention and protection of the insulation, drainage element, and filter sheet) on a fully exposed flat roof. The substrate used was 10 cm deep and consisted of either grape marc compost: perlite: soil: pumice (3:3:2:2, v/v) or grape marc compost: perlite: pumice (3:3:4, v/v). During the dry period (May-September) the plants were watered either every 2-4 days (normal, 17-20% substrate moisture) or every 4-6 days (sparse, 8-11% substrate moisture), depending on month. After 17 months of culture, plants developed larger horizontal diameter and dry weight of canopy in the soil containing substrate, while irrigation frequency did not affect plant growth. Plant height and flower number were similar in all treatments. Golden oregano, although did not develop very dense canopy, had satisfactory soil coverage and in all treatments, and thus could be suggested for use on urban extensive green roofs in semi-arid areas, employing sparse irrigation to save water and lightweight substrate in case of green roofs on old buildings.

Keywords: *Origanum vulgare* 'Aureum', culinary and ornamental herb, urban agriculture, grape marc compost, semi-arid, bee-friendly plant

P_48

Effect of substrate type and irrigation frequency on growth of the bee-friendly plant *Thymus citriodorus* on an urban extensive green roof

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The trend in recent years internationally has been to use bee-friendly plants in the urban landscape, given the large population decline of pollinators worldwide. Thus, in this study growth and flowering of *Thymus citriodorus* (lemon thyme) was investigated on a green roof in Athens, Greece, of extensive type, in respect of two irrigation frequencies and substrate types. Rooted cuttings were planted at beginning of November 2014 in experimental modules, with a green roof infrastructure (substrate moisture retention and protection of the insulation, drainage element, and filter sheet), on a fully exposed flat roof at the Agricultural University of Athens. Two types of substrate with 10 cm depth were used, grape marc compost: perlite: soil: pumice (3:3:2:2, v/v) and grape marc compost: perlite: pumice (3:3:4, v/v), and two irrigation frequencies during the dry period (May-September, every 2 to 4 days (normal, 17-20% substrate moisture) and every 4 to 6 days (sparse, 8-11% substrate moisture), depending on the month. Results presented are after 17 months of culture. Plants developed larger horizontal diameter, fresh and dry weight of canopy in the substrate with soil, while irrigation frequency did not affect plant growth. All treatments induced similar plant height and flower number. Lemon thyme developed a dense, hemispherical canopy, satisfactory soil coverage, and extending bee-attracting flowering in all treatments, and thus could be suggested for use on urban extensive green roofs in semi-arid areas, employing sparse irrigation to save water, and lightweight substrate in case of green roofs on old buildings.

Keywords: lemon thyme, culinary and ornamental herb, aromatic plant, urban agriculture, grape marc compost, semi-arid

P_49

The effects of seed coat scarification, priming, and cold stratification on seed germination of a tropical night-blooming waterlily hybrid *Nymphaea rubra* `Maeploi´

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Nymphaea rubra ‘Maeploi’ is a naturally tropical waterlily hybrid. It is discovered by Dr. Sermlarp Wasuwat and then registered to the international waterlily and water gardening society (IWGS) in 2002. This waterlily hybrid cultivar has more attractive characteristics, such as the bright to shocking pink petals and reddish-brown leaves. This research was aimed to study the effects of seed coat scarification, seed priming, and cold stratification on germination of *N. rubra* ‘Maeploi’ seeds. Clipped seeds cultured under light condition gave the better germination (41.67%) than other conditions. Seeds were investigated by hydropriming (distilled water and filtered water) and osmopriming (sucrose, glucose, maltose, and sorbitol) treatments at different concentrations (0, 1, 2, 4, 8, 16, and 32 % (w/v)). After 4 weeks of culture, the germination of primed seeds cultured in filtered water was 68.33% and then also found that the highest percentage of viable seeds (90%), compared to others. According to cold stratification, the results showed that non-clipped seeds cultured without cold stratification (at 10°C) during one week of incubation gave the highest germination (78.33%) than the seeds cultured with cold stratification (0%). These suitable preconditioning treatments would be basic information and research which were useful for ex situ conservation, propagation, and breeding experiment of tropical night-blooming waterlilies and their hybrids.

Keywords: germination, scarification, priming, stratification, *Nymphaea rubra* ‘Maeploi’

P_50
Comparative evaluation of rooting cuttings of five Mediterranean sage species (*Salvia* sp.) native to Greece

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The effect of application method and concentration of indole-3-butyric acid (IBA) on rooting stem cuttings of five Greek wild species of sage, *Salvia fruticosa*, *S. officinalis*, *S. pomifera* ssp. pomifera, *S. ringens*, and *S. tomentosa* were examined, aiming to find an effective rooting method, along with obtaining mother plants and plant-clones with desirable

characteristics for future crosses to improve wild species for potential horticultural use. Shoot-tip cuttings, 12-15 cm long, collected from native plants in April to May 2019, were treated either with dusting powder Rhizopon (0.5% w/w IBA) or their bases were dipped for 1 min in IBA solution (50% ethanol) with 0 concentration (control) or 500 or 1,000 or 2,000 or 3,000 mg L^{-1} and were placed for rooting on peat-perlite 1:1 (v/v) in a mist for 2 weeks and then remained on the greenhouse bench in a semi-shaded location for another 4 weeks. In all species, with the exception of *S. officinalis*, higher rooting percentages of cuttings were observed after treatment with dusting powder or immersion in a 2,000 or 3,000 mg L^{-1} IBA solution compared to immersion in a solution of 500 or 1,000 mg L^{-1} IBA or control. In *S. officinalis*, lower rooting percentages were generally observed compared to other species, probably because cuttings were not sufficiently lignified and at the same time they were in blooming, while immersion in a solution of 2,000 or 3,000 mg L^{-1} IBA were the best treatments for this species.

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Keywords: indole-3-butyric acid (IBA), shoot-tip cuttings, rooting, native xerophytic ornamentals

P_51

Effects of the different forms of aluminum and degree of pH in preservative solutions on the quantity of microorganism and vase life of *Dendrobium* `Ear Sakul´

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Dendrobium ‘Ear Sakul’ is one of high value exported orchid cut-flower. Prolonging vase life which is lower cost is an advantage for orchid growers. This study was to compare aluminum in the different forms: aluminum sulfate, aluminum hydroxide, aluminum nitrate, aluminum chloride, and aluminum potassium hydroxide, for extending vase life and reducing the number of microorganisms. Also to examine the different degrees of pH (3.0, 3.5, 4.0 and 4.5) to reduce the quantity of microorganism in vase solution. The results showed that the longest vase life of *Dendrobium* ‘Ear Sakul’ in 250 mg/L of aluminum sulfate and aluminum hydroxide (27 and 28 days, respectively) and were not significantly different with 8-hydroxyquinoline sulfate (250 mg/L) and silver nitrate (25 mg/L) as control. The results showed that pH 4.5 extended the vase life of *Dendrobium* ‘Ear Sakul’ for 25 days and was

not significantly different from control. The cross-section of *Dendrobium* 'Ear Sakul' peduncle in vase solution of 250 mg/L of aluminum sulfate and aluminum hydroxide also pH 4.5 exhibited no microorganism in the vascular bundle but found in parenchyma cells around the vascular bundle. The number of microorganisms were fluctuated and irrelevant with the vase life.

Keywords: aluminum, pH, vase solution, orchid

P_52
Comparative evaluation of seed germination of five Mediterranean sage species (*Salvia* spp.) native to Greece

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Salvia spp. (Lamiaceae) comprises about 900 species worldwide, many of which are used as ornamental or medicinal plants. In the present study, the effect of seed pretreatment by surface scarification (mechanical or chemical) on germination of five Mediterranean sage species, *S. fruticosa*, *S. officinalis*, *S. pomifera*, *S. ringens*, and *S. tomentosa* was examined. Seeds were harvested from native populations in August 2018 and stored in the dark, at room temperature, for 5 months. The seeds were surface sterilized with commercial bleach solution (20% for 15 min) and placed for germination in vitro, in Petri dishes, with a solid (8 g l^{-1} agar) half-strength MS medium containing 20 g l^{-1} sucrose, at 15 °C and 16 h photoperiod, either without pretreatment (control) or after scarification with sandpaper (suitable for metal surfaces) for 1 min or after dipping in dense H_2SO_4 for 15 min. In *S. fruticosa*, higher seed germination percentages were observed after mechanical or chemical scarification compared to the control; whereas, in *S. officinalis* dipping in H_2SO_4 was the most effective pretreatment. In other three species, very low germination percentages (<28%) were generally observed irrespectively of pretreatment. In all species, seeds immersed in dense H_2SO_4 reached faster T_{50} than those that received mechanical scarification or no pretreatment. In conclusion, pretreatment by mechanical or chemical scarification had a favorable effect on seed germination of *S. fruticosa* and *S. officinalis*; whereas, in *S. pomifera*, *S. tomentosa*, and *S. ringens* further investigation are required.

Project: SALVIA-BREED-GR. This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T1EDK-04923).

Keywords: seed pretreatment, scarification, in vitro seed germination, native xerophytic ornamentals

P_53

Influence of hyperthermal stress on the functional state of persimmon (*Diospyros kaki* Thunb.) leaf apparatus

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The article presents the results of evaluation of heat resistance of leaves of persimmon (*Diospyros kaki* Thunb.) by changing the kinetics of fluorescence induction of chlorophyll *a*. For comparison we took five cultivars: Zolotistaya, Mechta, Rossiyanka, Hyakume, and Yuzhnaya Krasavitsa. For temperature effects, we used two levels of elevated temperature 35 °C and 45 °C. Short-term temperature rose to 35 °C did not lead to any significant physiological changes (variation of the photoinduction curve and calculated coefficients did not differ from the control). The longer exposure to high temperature (45 °C during 4 hours) leads to photo-inhibition which is associated with a decrease in the activity of the reaction center Photosystem II (PS II). In the version of the experiment, hyperthermia with hydration, we observed a decrease in the coefficient of variable fluorescence ($F_v = F_m - F_0$) by 66.5%, the maximum photochemical quantum yield of PS II. (F_v / F_m) at 35.8%, photosynthetic activity ($PA= (F_m - F_t)/F_m$) at 18.7%, fluorescence decay coefficient (F_m/F_t.) at 26.4% and effective photochemical quantum yield PS II ($Y(II)= (F_{m'} - F_t)/F_m$) at 54.7%. At the same time, in the experiment variant, when the leaves were dehydrated, there was a more significant decrease in the effective photochemical quantum yield of PS II (by 79.4%). Thus, cultivars with high water-holding capacity and good turgor recovery ability are better adapted to high-temperature stress. The research has been carried out with the equipment of Core Facilities Center" Physiological and Biochemical Research of Plant Objects (PBR PO)" by FSFIS "NBG-NSC" (Yalta, Russia).

Keywords: hyperthermal stress, fluorescence, chlorophyll a, heat resistance, water-holding capacity, persimmon

P_54

Evaluation of persimmon drought tolerance under the simulated stress and its correlation with the anatomic structure of a leaf blade

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The results of the persimmon (*Diospyros kaki* Thunb.) leaves anatomical structure and drought resistance are presented. Five cultivars in the collection of the Nikita Botanical Gardens were taken for comparison: Zolotistaya, Mechta, Rossiyanka, Hyakume, and Yuzhnaya Krasavitsa. The plants were grown ex situ. Under a short-term exposure of a temperature 45 °C for 4 hours (along with dehydration), the following decrease in leaf tissue total water content was observed: cultivar Mechta (from 73.8 to 57.9%), Hyakume (from 72.1 to 56.7%), Zolotistaya (from 63.8 to 48.8%), Yuzhnaya Krasavitsa (from 67.3 to 53.3), and Rossiyanka (from 56.4 to 33.6%). The studied persimmon cultivars had the following histological characteristics of the leaf blades: leaf thickness was 284-360 μm, leaves were bifacial and hypostomatic, covered with cuticle (up to 9 μm); had sporadic unicellular trichomes. The mesophyll was 6-7-layer, included one layer of the palisade parenchyma and the spongy parenchyma with large intercellular spaces. Palisade index was 0.45-0.51. The size of palisade chlorenchyma cells was 98 × 12 μm. Chloroplasts were located near the cell wall, less often diffusely; their number was 36-52 plastids/cell. The high density of mesophyll, developed integumentary system and multiple (192 stomata/mm^2) small (stomatal pore length 32-41 μm) stomatal apparatuses are characteristic of the cultivar Mechta, which can be selected as the most resistant to hydrothermal stress. The research has been carried out with the equipment of Core Facilities Center "Physiological and Biochemical Research of Plant Objects (PBR PO)" by FSFIS "NBG-NSC" (Yalta, Russia).

Keywords: persimmon, drought tolerance, leaf blade, cuticle, total water content

P_55

Dissemination of experimental results in a rose trial garden through a support device

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The Rose Garden of the University of Bologna, where more than 1,000 old and new species/cultivars are collected, includes an experimental field for the evaluation of landscaping roses under low maintenance conditions, i.e. without irrigation, fertilization, phytosanitary treatments, and pruning for the first 5 years from planting, and a mechanical pruning in the sixth year, just before dormancy breaking. Since 2002, about 160 cultivars have been tested and characterized. Data concerning morpho-phenological parameters and disease incidence, the Flower-Cover Index, the Ornamental Index and the graphs of flowering trend from April to October were elaborated per year and on average over 6 years for each cv. The availability of this data and information could be very useful for nurseryman, breeders, landscapers, and all the Rose Garden visitors interested in a deeper information on the varieties in field.

The use of radio-frequency identification (RFID) techniques can be a solution for an easy spread of the experimental results and a way to update the garden as at museum level happens. The creation of datasheets started with the selection of suitable information for two types of users (professionals and amateurs) providing a privileged access to each one. Data are recorded in RFID microchips and can be viewed on mobile devices by logging in the app first, then entering the tagging code/name assigned to each cultivar in the search field of the homepage. The use of the label with the cv name, as microchip support, is cheap, practical, and compatible with the distance for reading microchip.

Keywords: radio-frequency identification (RFID), cultivars, flower-cover index, ornamental index

P_56

Chromatographical profiles and microscopical characteristics of four *Callicarpa* species leaf samples collected in Thailand

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The genus *Callicarpa* is a large and widespread genus in the family Lamiaceae. In Thailand, twelve species of *Callicarpa* have been identified with the presence of remarkable therapeutic effects, such as the treatment of abdominal troubles, amenorrhea, wounds, and asthma. Phytochemical and microscopical profiles of the leaf samples from four *Callicarpa* plants in Thailand; *C. arborea* Roxb., *C. candicans* (Burm. f.) Hochr., *C. longifolia* Lam., and *C. rubella* Lindl. were evaluated by chromatographic and microscopic techniques. Thin layer

chromatographic (TLC) and high performance liquid chromatographic (HPLC) analysis suggested that all *Callicarpa* leaf methanol extracts showed similar chromatographic patterns with the major compounds corresponded to oleanolic acid and β-sitosterol while only the leaf extract from *C. candicans* showed the presence of callicarpone, the compound that was previously reported to promote strong piscicidal effect. Microscopic analysis of plant powders showed that all selected *Callicarpa* leaf samples contained similar preliminary cells including epidermis, trichomes, fragments of lamina, and mesophyll layers. Three types of trichome; uni- and multi-cellular covering trichomes, glandular trichomes, and candelabra trichomes were found in these 4 selected *Callicarpa* leaves in different sizes and amounts. Therefore, the number, size, and type of the trichome could be used to differentiate *Callicarpa* species by microscopic technique. The information about the chromatographic fingerprints and microscopic characteristics from this study could be a guidance for quality control and setting up the specification of *Callicarpa* plant raw materials and extracts in the future.

Keywords: *Callicarpa*, *Callicarpa candicans*, HPLC, TLC, microscopic characteristics

P_57
A comparison of flooding tolerance of guava trees propagated from shoot layering and seedling

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Guava orchards in Nakhon Prathom province, Thailand were damaged by flooding in 2011 resulting in the death of guava trees. Guava trees were susceptible to flooding conditions because almost guava trees in the orchards were usually cultivated by shoot layering or shoot cutting. Using seedlings or suitable rootstocks could increase the flooding tolerance to the guava trees. However, there is no information about using guava seedlings and rootstocks for cultivation in Thailand. The objectives of this study were to study and compare potential response parameters of flooding tolerance between guava trees cultivated from shoot layering and seedlings. A factorial experiment with two forms of 'Wan Pirun' guava cultivar combined with two levels of water including submerged in water tanks (10 cm water level above soil level) and no submerged for 8 weeks was done. The results showed that propagation methods of 'Wan Pirun' guava and flooding treatments had effects on shoot and root growth. Shoot layering of 'Wan Pirun' guava showed the highest value of leaf, shoot, and root weight under no submerged condition. While, both seedlings and shoot layering trees under flooding showed the lowest value and presented leaf chlorosis and falling leaves. Bark cracking and adventitious root formation were found only in guava trees from seedlings after 5 weeks of flooding. However, guava seedling trees had a lower percentage of reduction in all parameters

than the trees from shoot layering under flooding condition. In addition, a wilting score of the seedling trees was lower under flooding condition. Leaf greenness of both seedling trees and shoot layering trees was not significantly different. Thus, the guava trees cultivated from seedlings were more tolerant than those from shoot layering trees under flooding condition.

Keywords: *Psidium guajava*, waterlogging, guava rootstock

P_58
Morphological and physiological responses of Thai commercial pummelo cultivars under salt stress

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Pummelo production in the lower central region of Thailand, especially in Nakhon Prathom provinces, has been affected by the high sea bolster during the dry season. The sea water rising of each area decreased tree growth, induced leaf burn, induced shoot dieback and death. Salt accumulation caused saline soil problems. There is no information of pummelo tolerance to salinity levels, especially in commercial pummelo cultivars including "Thongdee" and "Khaonamphueng". The objectives of this study were to evaluate morphological (shoot extension, shoot fresh and dry weights, leaf area, leaf number, leaf burn, root fresh, and dry weights) and physiological (photosynthesis rate, transpiration, leaf greenness, leaf water potential, and relative water content) parameters related to salt stress. The completely randomized design with 4 levels of salt concentrations; 2, 4, 8, and 16 ds/m were applied by using Hoagland's nutrient solution for 13 weeks to 4 months old of shoot layering of "Thongdee" and "Khaonamphueng" cultivars. In addition, orthogonal comparison was used to predict the significantly response to salinity effects of those pummelo cultivars. The results showed that salt stress caused leaf burn in both "Thongdee" (> 8 ds/m) and "Khaonamphueng" (16 ds/m) cultivars. In "Khaonamphueng" cultivar, salt stress caused quadratic decrease in shoot fresh weight, shoot dry weight, leaf area, root fresh weight, root dry weight, and leaf water potential; and linear decrease in phoyosynthesis rate. For "Thongdee" cultivar, salt stress caused quadratic decrease in all parameters. Meanwhile, leaf greenness was not significantly different. Comparing salt tolerance between two cultivars, it was found that "Khaonamphueng" cultivar was more resistant to salinity than "Thongdee" cultivar.

Keywords: *Citrus maxima*, saline stress, "Thongdee" and "Khaonamphueng" cultivars, salt tolerance

P_59

The development of female gametophyte in hermaphrodite flowers of papaya (*Carica papaya* L.) `Pluk Mai Lie´ cultivar

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Papaya (*Carica papaya* L.) is a fast-growing tropical fruit crop. It is a trioecious plant with male, female, and hermaphrodite type. Both female and hermaphrodite plants consist of female reproductive organs. The fruit shape, size, and numbers of seeds are largely influent by flower (particularly ovary) shape, fertilization, and numbers of fertile ovules. The female gametophyte was investigated during elongata type flower development. Papaya flowers at different stages were excised into thin sheets and examined immediately under the microscope 20x (Nikon YS 100). In addition, the resin-encapsulated flower specimen was also used to examined the development. The three development domains of papaya ovules were observed through 4 different stages (I-IV). The similarity to Arabidopsis female gametophyte was observed and discussed.

Keywords: papaya, female gametophyte, elongata flower

P_60

Successes in remote hybridization of cereals

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Tsitsin Main Botanical garden of RAS is one of the leading research centers carrying out researches on remote hybridization of cereals and other plant species. Remote

hybridization - crossing plants belonging to different species and genus - provides opportunities for using useful properties of wild species (ecological plasticity, resistance to adverse environmental factors, diseases and others) and allows to transfer them to cultural forms. At the same time, the more distant phylogenetic relationship between parent forms are, the more interesting the results of crosses would be. After long time of breeding and genetic researches the new crop Trititrigia (*Trititrigia cziczinii* Tsvel.), the result of hybridization of different species of wheat and wheatgrass was developed. Trititrigia has two subspecies: ssp. *perenne* and ssp. *submitans*. Both subspecies have a lot in common. Their main difference is perennialness: unlike ssp. *submitance*, with the right agrotechnology ssp. *perenne* can grow for 2-3 years. According to its morphological and biological features Trititrigia takes an intermediate position between wheat and wheatgrass, but with more resemblance to wheat. Its genome is represented by 56 chromosomes; whereas, 42 are from wheat and 14 are from wheatgrass. Selected forms promising in terms of yield, high protein content in grains, good baking qualities, fresh yield for three mowings, and pest resistance were chosen.

Keywords: remote crosses, perennial wheat, *Trititrigia cziczinii*, wheatgrass, genetics, selection, biodiversity

P_61
Expression of anthocyanin biosynthetic genes in ornamental bananas

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One of attractive tropical plants is ornamental bananas with colorful male inflorescence bracts. Anthocyanin components and combination within these bracts relate to the color variations occur in the banana family, Musaceae. Anthocyanin biosynthesis of several pigments and genes have already been studied. However, the underlining genetic background which causes color differences has not been explained. In our study, anthocyanin

biosynthetic pathway in uncommon yellow bract taxa was compared to that of other species with red, pink, and purple bracts. The results showed that the expression of *leucoanthocyanidin diaxygenase* (*LDOX*) was almost absent in the orange-and-red color-deficient taxa, such as the yellow bract *Musa rubra* var. *siamensis*, and the green bract *Ensete glaucum*. Thus, the results suggested that *LDOX* is positively be one of the factors related to anthocyanin accumulation in the banana bracts.

Keywords: anthocyanin biosynthesis pathway, Musaceae, banana, *Musa rubra* var. siamensis, *Ensete glaucum*, *Musa acuminata*, *Musa ornata*, anthocyanidin, leucoanthocyanidin diaxygenase, LDOX, gene expression

P_62
DNA barcoding and UPLC-QTOF-MS in support of folk classification of *Acorus*

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The demands of plants resource utilization and medication safety caused by unclear taxonomy of *Acorus* plants are becoming more and more urgent because of their significance as herbal medicines and ornamentals. Current taxonomic positions of *A. macrospadiceus* (Yamamoto) F. N. Wei and Y. K. Li *and A. tatarinowii* Schott are confused based on opinions from various taxonomists. People in the ethnic communities of southwest China consider *A. macrospadiceus* is different from other *Acorus* species by folk taxonomy, which conflicted with the view of Flora of China and The Plant List. The present study used DNA barcoding to evaluate two loci (*rbcL*, *trnL-trnF*) and combination barcode (*rbcL+trnL-trnF*) to identify the genetic relationships among *Acorus* by constructing phylogenetic trees (maximun parsimony tree and maximum likelihood tree). All *A. macrospadiceus* and *A. tatarinowii* simples collected from different growth location were clustered into each group, which revealed that they should be independent species. Meanwhile, multivariate statistical analysis of metabolites in different parts of *Acorus* was carried out based on UPLC-QTOF-MS data.

Three independent analysis, principal component analysis, heat-map analysis, and hierarchical cluster analysis, showed that *A. macrospadiceus* and *A. tatarinowii* are different from other *Acorus* species as well. The results of DNA barcoding and chemotaxonomy consisted of the knowledge of local people regarding *Acorus*, which supported the rationality and scientificity of folk taxonomy. Multiple evidences from morphology, ecology, folk classification, DNA barcoding, and chemical taxonomy demonstrate *A. macrospadiceus* and *A. tatarinowii* should be independent species and propose to restore the legitimacy of their names.

Keywords: *Acorus*, *Acorus macrospadiceus*, *Acorus tatarinowii*, DNA barcoding, UPLC-QTOF-MS

P_63

Elemental composition and antioxidant status of some aromatic and medicinal plants in the conditions of the southern coast of the Crimea

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A long-term conscious breeding effort to create high yielding, adaptive to difficult environments, high – performance essential oil, aromatic and medicinal plants is underway in the Nikitsky botanical gardens, which is situated in the Southern Coast of the Crimea. The set of subtropical fine climate of Mediterranean type conditions and mountain seascape in the region allows to take in environmental responsible high-quality herbal drugs. To provide evaluation of crude drugs, the biochemical study of the tops of *Melissa officinalis* L. cv. AromatnayaTavridy, *Salvia sclarea* L.cv. Ai-Todor, *Monarda fistulosa* L., *Hyssopus officinalis* L. cv. Nikitsky bely, f. rosea and f. cinerea, *Origanum vulgare* cv. Krymchanka, *Agastache toeniculum* cv. Pam'yaty Kapeleva, and *Nepeta cataria* cv. Permozshec-3. The use of atomic adsorption analysis allowed to ascertain that there are the most Fe (527 mg/kg), Cu (26.4 mg/kg), and Mn (19.9-22.1 mg/kg) in the tops of *Origanum vulgare*. It is twice more in comparison with other varieties. The crude drugs of two forms of *Hyssopus officinalis* and cv. Nikitsky bely holds a significant amount of содержит Zn (19.9-22.1 mg/kg). The phenol quantity in the crude drugs of the studied varieties ranges from 13.35 (*Hyssopus officinalis* cv. Nikitsky bely) to 26.6 мg - eq gallic acid/g d.w. (*Melissa officinalis* cv. Aromatnaya Tavridy). *Melissa officinalis* is of the highest antioxidative activity (102.2 мg - eq gallic acid/g d.w.), as well as *Agastache foeniculum* (100 мg - eq gallic acid/g d.w.), *Origanum vulgare* (93.6 мg - eq gallic acid/g d.w), and bee balm (90.35 мg - eq gallic acid/g d.w.).

Keywords: aromatic and medicinal plants, herbal drugs, micro- and macro-elements, poly-phenol, anti-oxidant status

P_64
On the tissue of plant survival in a changing environment

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The prognosis of climate change is often counted based on the use of global models of atmosphere circulation. It is assumed that in the middle latitudes, the temperature increases 1-3.5° C in the next hundred year. It will be equivalent to the displacement of isotherms at 150-550 km in latitude towards the poles, or 150-550 m in height. Accordingly, the restructuring of plant communities is expected. The rate of climate transformation is likely to be significantly higher than the rate of species adaptation to new conditions of ecotopes and a number of species will not be able to resist elimination, due to the loss of its ecological niche. It is quite difficult to predict possible changes in plant communities. The method developed by us is suitable for specific phytocenoses fixed by complete geobotanical descriptions. Its essence is as follows: 1. The geobotanical description is the basis for the estimation of species packing density on the gradients of environmental factors. Information for each species (minimum and maximum range of values on gradients) is obtained from the database "Ecodata", created in the Nikitsky Botanical Gardens. The database contains standardized 100-point scales of plant species positions on the gradients of the following environmental factors: illumination-shading, thermal mode, ombro mode, cryo regime, continentality, moisture, variability of moisture, acidity of substrate, anionic composition, contents of carbonates, nitrogen content, and aggregate-size distribution of the substrate. 2. Assessment of the packing density of species on gradients of the environmental factors is carried out using the original program "Pover", allowing to assess the capacity of habitats and to set the position of the optimum point. According to the results of calculations, the "comfort corridor" (realized part of the gradient) and the optimum line is determined. 3. For each gradient, a graphical model is constructed on which the vectors of fundamental values of the analyzed factors are placed along the obtained "comfort corridor" with the optimum line. The received model demonstrates the current state of the community species and indicates possible ways of behavior of taxa in the transformation of environmental indicators. The inclusion in the model of an additional axis with specific values of the factor makes it possible to predict the future composition of the phytocenosis and to take measures to preserve biodiversity.

Keywords: biodiversity, climate transformation, gradients of the environment, graphical model

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The Department of Plant Science within Mahidol University's Faculty of Science was established with the objective of providing a broader range of botanical education and research. We aim to instruct and guide students to become graduates with specialized expertise in plants, which is much needed given that Thailand benefits from both its bountiful agricultural crops and vast plant diversity. A core group of botanical educators – namely, Asst. Prof. Warunee Lertsiri, Asst. Prof. Waree Prasomsuk, Assoc. Prof. Dr. Siriporn Nittayangkun and Mr. Prasit Srijamnong – worked together to establish the Department, which was officially approved on September 18, 1992 with Assoc. Prof. Dr. Siriporn Nittayangkun serving as the first Head of the Department. The second Department Head was Assoc. Prof. Dr. Kanchit Thammasiri, who is still active in the Department, and currently the position is held by Assoc. Prof. Dr. Puangpaka Umpunjun.

The Department has three academic programs: Bachelor of Science in Plant Science (Thai program), Master of Science in Plant Science (international program), and Doctor of Philosophy in Botany (international program). The B.Sc. program is the oldest of the three, having been opened with the founding of the Department. The M.Sc. program was initiated in 2005 as a joint program with the Department of Pharmaceutical Botany (within Mahidol University's Faculty of Pharmacy), and in 2017, an MOU between Mahidol University and Chiba University, Japan, allowed M.Sc. students to study with Chiba University's Department of Horticulture and receive a double degree. The Ph.D. program was recently established in 2016 and continues to grow yearly. The Department continues to produce graduates that further their studies both in Thailand and abroad, as well as applying their botanical expertise in positions in private and government organizations e.g. at NSTDA, the Royal Chitralada Projects, the Department of Agriculture, universities, primary schools, fruit and export farms, start-up businesses, and others.

In addition to teaching, faculty members within the Department are also heavily involved in research. Areas of expertise within the Department include plant systematics, physiology, tissue culture, molecular biology, cytology, anatomy, ecology, and applied plant science. Ongoing research projects include studying food plants, herbs, ornamental flowers, rare and endangered, and poisonous, addictive, and allergenic plants. Moreover, many faculty members conduct research on plant species that are economically important in Thailand, such as durian, banana, longan, rubber and cassava. Another key area of the Department's research focuses on exploring and describing Thailand's abundant biodiversity, much of which is still understudied or even undiscovered. Most research within the Department is conducted collaboratively with both Thai and international researchers. The Department is active in sharing novel research findings through published articles and books, conference presentations, and workshops.

Through education and research, the Department of Plant Science is passionate about sharing and expanding our borders of botanical knowledge, which is vitally important to our green world.

Kan Phai Mahidol, the Symbolic Plant of Mahidol University

Kan Phai Mahidol, the symbolic plants of Mahidol University, was named to commemorate the late Princess Mother, Somdej Phra Sri Nakarindra Boromarajajon nani (then Princess Srisangwan Mahidol). It is a rare tropical plant found in limestone mountains in the western side of Thailand. One among only three known species in the genus, *A. mahidoliae* is a climber in the pea family (Fabaceae). The plant possesses purplish and whitish pea-like florets in inflorescences which are usually in blooms during August to November. The plant was found in Sai Yok, Kanchanaburi in 1967 by a Thai botanist, Kasem Chandraprasong and the named was published in *Notes from the Botanic Garden Edinburgh* Vol. 31 No. 1 July 1971 by a Scotish, Mr. B.L. Burtt and Assistant Professor Dr. Jirayupin (Chermsirivathana) Chandraprasong. The Thai name 'Kan Phai Mahidol' was suggested by the late Professor Tem Smitinand, the former Director of the Flora of Thailand Project, because it belongs to the same genus as 'Kan Phai' (*Afgekia sericea* Craib). The Thai word for the plant 'Kan Phai' (กันภัย), means 'protecting from threat', appeared in the famous Thai epic 'Khun Chang Khun Phan', as a captivating vine in a sacrament. Kan Phai Mahidol was named the symbolic plant of Mahidol University in the 30th Anniversary of the university in 1999. Recently, the specific epithet "*mahidolae*" was corrected to "*mahidoliae*" following the International Code of Botanical Nomencla- ture (Vienna code), under Recommendation 60C.1.b.

Thai name: Kan Phai Mahidol
Scientific name: *Afgekia mahidoliae* B. L. Burtt & Chermsir.)
Family: FABACEAE (LEGUMINOSAE)

Watercolor: Sunitsorn Pimpasalee

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