XIV International Symposium on Flower Bulbs and Herbaceous Perennials

April 14–19, Warsaw, Poland

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Book of Abstracts

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organized by Warsaw University of Life Sciences and the National Institute of Horticultural Research, Skierniewice

WARSAW UNIVERSITY OF LIFE SCIENCES

InHort INSTYTUT OGRODNICTWA

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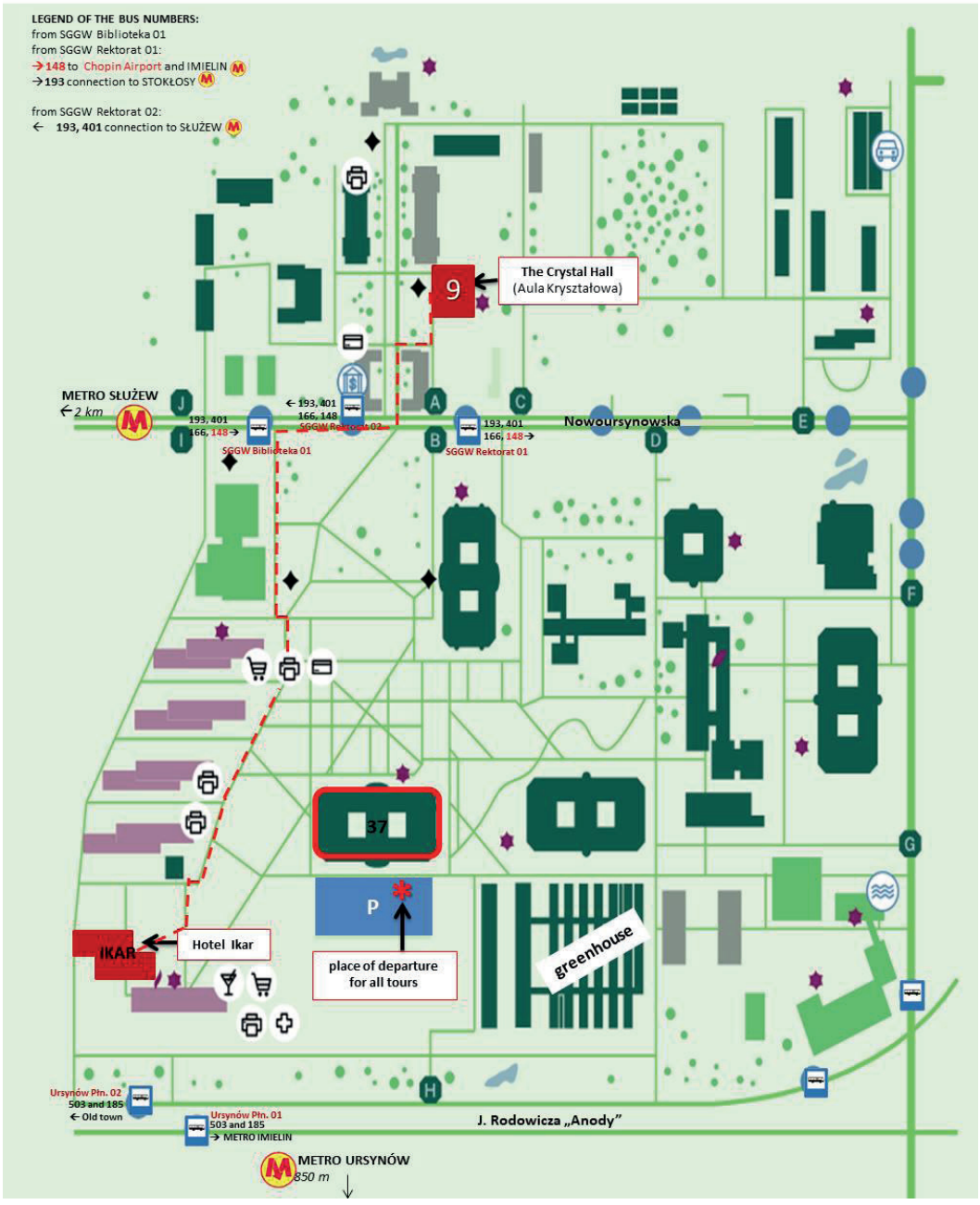

Programme of the XIV International Symposium on Flower Bulbs and Herbaceous Perennials
14–19 April 2024, Warsaw, Poland

Venue: Warsaw University of Life Sciences, Crystal Hall
166 Nowoursynowska St., 02-787 Warsaw

Sunday, April 14th, 2024	**17.00-20.00**	**WELCOME RECEPTION**
Monday, April 15th, 2024	**8.30-9.30**	**REGISTRATION**
	9.30-10.15	**OPENING CEREMONY**
	10.15-12.00	**GENERAL SESSION** **Chairperson: *Margherita Beruto***
	10.15-10.40	30 years for geophyte production in changing climate – where science meets technology *by Rina Kamenetsky-Goldstein* (ARO, The Volcani Center, Bet-Dagan, Israel)
	10.40-11.05	Biotechnology in the breeding of ornamental geophytes *by Ki-Byung Lim* (Kyungpook National University, Daegu, Korea)
	11.05-11.30	Production and breeding of bulbous plants and herbaceous perennials in Poland *by Dariusz Sochacki* (Warsaw University of Life Sciences, Poland) *and Tomasz Michalik* (Vitroflora, Poland) co-author: Jadwiga Treder
	11.30-11.55	How can we plant more flower bulbs into the landscape? *by William B. Miller* (Cornell University, Ithaca, NY, USA)
	12.00-12.45	**COFFEE BREAK**
	12.45-14.30	**SESSION 1 – Propagation, cultivation and forcing** **Chairperson: *William B. Miller***
	12.45-13.10	**Keynote lecture:** Micropropagation of ornamental geophytes: a useful approach for development and valorization *by Margherita Beruto* (Chair ISHS Division Ornamental Plants, Italy) co-authors: Sara Yasemin, Serena Viglione, Basar Sevindik

	13.10-13.25	*In vitro* techniques for tulip micropropagation, virus eradication and tetraploid induction *by Małgorzata Podwyszyńska* (The National Institute of Horticultural Research, Skierniewice, Poland) co-author: Dariusz Sochacki
	13.25-13.40	A new nursery system for the production of high-quality propagating tubers of *Zantedeschia* in the Netherlands *by Natalia Moreno-Pachon* (Wageningen University and Research, Horticulture and Flowerbulbs, Bleiswijk, Netherlands) co-authors: Paul van Leeuwen, Arca Kromwijk, Paul Ruigrok
	13.40-13.55	An indoor cultivation system for the production of virus free lilies in the Netherlands. Turning lily cultivation outside in *by Paul Ruigrok* (Wageningen University and Research, Horticulture and Flowerbulbs, Bleiswijk, Netherlands) co-authors: Casper Slootweg, Natalia Moreno-Pachon
	13.55-14.10	Herbaceous perennial trials at Colorado State University *by Chad Miller* (Colorado State University, Fort Collins, USA) co-author: David Staats
	14.10-14.25	Effects of supplemental lighting using LED's on the quality of tulips forced hydroponically *by Jadwiga Treder* (The National Institute of Horticultural Research, Skierniewice, Poland) co-authors: Waldemar Kowalczyk, Dariusz Sochacki, Ewa Skutnik, Julita Rabiza-Świder, Aleksandra Staniuk, Agnieszka Połeć
	14.30-15.30	**LUNCH**
	15.30-16.40	**SESSION 2 – Biodiversity, genetics, biotechnology and breeding** **Chairperson: *Małgorzata Podwyszyńska***
	15.30-15.55	**Keynote lecture:** Developments in breeding of bulbous crops from a genetics and genomics perspective *by Paul Arens* (Wageningen University and Research, Wageningen, Netherlands) co-authors: Giorgio Tumino, Danny Esselink, Jan van Kan, Richard Immink

	15.55-16.10	Distant hybridization of *Hemerocallis* with *Eremurus* and *Lycoris by Yi Lv* (Beijing Forestry University, Beijing, China) co-authors: Yike Gao, Yuxuan Zhou, Ying Wang, Yuxuan Cui, Jing Zhou
	16.10-16.25	Intergeneric hybridization and endosperm culture of *Lycoris by Yike Gao* (Beijing Forestry University, Beijing, China) co-authors: Yuxuan Zhou, Yi Lv
	16.25-16.40	Breeding *Impatiens* for resistance to the fungal disease impatiens downy mildew (*Plasmopara obducens*) *by Mark P. Bridgen* (Cornell University, Ithaca, NY, USA) co-authors: Victor Zayas, James Keach
	16.40-17.10	**COFFEE BREAK**
	17.10-18.10	**ISHS BUSINESS MEETING**
Tuesday, April 16th, 2024	**8.30-17.00**	**TECHNICAL TOURS (tours A, B, C)**
	19.00-23.00	**GALA DINNER (Villa Intrata by the Royal Palace in Wilanów)**
Wednesday, April 17th, 2024	**9.30-11.10**	**SESSION 3 – Flowering, postharvest and storage physiology** **Chairperson: *Rina Kamenetsky-Goldstein***
	9.30-9.55	**Keynote lecture:** Long term storage of cut flowers *by John M. Dole* (North Carolina State University, Raleigh, NC, USA) co-authors: Nathan Jahnke, Jennifer Kalinowski
	9.55-10.10	Balancing of some endogenous phytohormone on growth and development of sacred lotus (*Nelumbo nucifera* Gaertn.) after spraying of GA_3 application *by Panupon Hongpakdee* (Khon Kaen University, Khon Kaen, Thailand) co-authors: Sornnarin Suangto, Chaiartid Inkham, Soraya Ruamrungsri
	10.10-10.25	Reblooming in perennials: bearded iris (*Iris germanica*) as a model *by Zhuping Fan* (Leibniz Institute of Vegetable and Ornamental Crops, Grossbeeren, Germany and Beijing Forestry University, Beijing, China) co-authors: Yike Gao, Rong Liu, Chunjing Guan

	10.25-10.40	De-vernalization – when heat erases flower induction *by Michele Zaccai* (Ben Gurion University, Beer Sheva, Israel) co-authors: Hagai Yasuor, Ran Bar, Yair Nishri, Silit Lazare
	10.40-10.55	Simulated spring freezes cause bud abortion and receptacle necrosis in *Paeonia lactiflora* 'Festiva Maxima' *by John M. Dole* (North Carolina State University, Raleigh, NC, USA) co-authors: Nathan Jahnke, David Livingston III, Tan Tuong
	10.55-11.10	Identification of below-ground phenotypic markers for early flowering (Cycle 1) *Gladiolus hybridus*: daughter corm and cormel production, cormel types *by Neil O. Anderson* (University of Minnesota, St. Paul, MN, USA)
	11.10-11.40	**COFFEE BREAK**
	11.40-13.10	**POSTER SESSION**
	13.10-14.20	**SESSION 4 – Plant protection** **Chairperson: *Paul Arens***
	13.10-13.35	**Keynote lecture:** Integrated management of diseases on ornamental geophytes and herbaceous perennials *by Gary A. Chastagner* (Washington State University, Puyallup, WA, USA) co-author: Hanu Pappu
	13.35-13.50	Advances in powdery mildew and rust control for ornamental perennial crops *by Mary Hausbeck* (Michigan State University, East Lansing, MI, USA) co-authors: Ethan Tippett, Carmen Medina-Mora, Cheryl Engfehr, Blair Harlan
	13.50-14.05	How to deal with non-persistently aphid-transmitted bulb flower viruses? *by Martin Verbeek* (Wageningen University and Research, Wageningen, Netherlands) co-authors: Ineke Stijger, Iris Stulemeijer, Frank Kreuk
	14.05-14.20	Characterization of biological and synthetic microstructures of *Zantedeschia* leaf surface, and their interaction with *Pectobacterium by Iris Yedidia* (ARO, The Volcani Center, Bet-Dagan, Israel) co-authors: Nofar Hod, Preeti Patel, Maya Kleiman

	14.30-15.30	**LUNCH**
	15.30-16.25	**SESSION 5 – Using in landscape and for other purposes** **Chairperson: *Gitana Stukeniene***
	15.30-15.55	**Keynote lecture:** Perennials and geophytes selection for therapeutic horticulture *by Bożena Szewczyk-Taranek* (University of Agriculture in Krakow, Poland)
	15.55-16.10	Evaluation of growth and flowering of ornamental grasses and other perennials planted in a city parks, the case of Rabka-Zdrój *by Anna Kapczyńska* (University of Agriculture in Krakow, Poland)
	16.10-16.25	Analysis of decorativeness and variability of species in "perennial meadows" of a revitalized Park Krakowski *by Monika Cioć* (University of Agriculture in Krakow, Poland) co-author: Przemysław Gołębiowski, Marcin Gajda, Bożena Pawłowska
	16.30-17.00	**CLOSING CEREMONY**
Thursday, April 18th, 2024 **Friday, April 19th, 2024**		**POST-SYMPOSIUM TOUR** 1. Vitroflora – close to Bydgoszcz (herbaceous perennials – young plants, tissue culture and breeding) 2. Królik – close to Poznań (reproduction of ornamental geophytes in the field plantations and forcing for cut flowers under covers) 3. Tulipany Polskie (Polish Tulips) Orłowscy – close to Kalisz (tulips forcing for cut flowers hydroponically)

Posters

P-1 Use of *Solidago rugosa* 'Fireworks' in ground cultivation in Poland **(Bąbelewski P. and Lewandowki M.)**

P-2 Do new cultivars of *Ranunculus* and *Anemone* need vernalization? **(Benchaa S. and Lapointe L.)**

P-3 Impact of *Tobacco rattle virus* on the vase life of 'Sarah Bernhardt' peonies **(Chastagner G.)**

P-4 Changes in biomass partitioning based on phenological observation in *Lilium* hybrids **(Choi H. *et al.*)**

P-5 Flower bulbs in Mexico in relation to world production **(Espinosa-Flores A. *et al.*)**

P-6 The effect of varying greenhouse conditions for forcing *Cymbidium* orchids growth in a tropical climate region **(Inkham C. *et al.*)**

P-7 Longevity of *Lachenalia* cut flowers **(Kapczyńska A. *et al.*)**

P-8 Breeding of *Rudbeckia hirta* L. using mutation techniques **(Kisvarga S. *et al.*)**

P-9 Use of miscanthus-based substrate in nursery production of *Rudbeckia fulgida* 'Goldsturm' **(Lewandowki M. and Bąbelewski P.)**

P-10 Phenotypic and cytogenetic characteristics study of winter hardy woody and herbaceous *Hibiscus* **(Lim K.B. *et al.*)**

P-11 Effect of aeration and volume of medium on biomass growth and shoot propagation in bioreactor cultures of *Heuchera*, *Hosta* and *Echinacea* **(Malik M. *et al.*)**

P-12 Effect of fluridone on the growth and some physiological features in leaves and roots of uncooled *Muscari armeniacum* bulbs **(Marasek-Ciołakowska A. *et al.*)**

P-13 Effect of biostimulant Kelpak SL on growth, flowering and tuber yield of *Dahlia* **(Marcinek B.)**

P-14 Effect of gibberellic acid on growth, flowering and tuber yield of *Dahlia* **(Marcinek B. and Parzymies M.)**

P-15 Micropropagation, acclimatization and *in vitro* mutation breeding of ornamental perennial *Veronica* hybrid **(Miler N. *et al.*)**

P-16 Bioactive compounds analysis in inflorescences of Polish winterhardy hybrids of chrysanthemum: the preliminary evaluation of possible herbal applications **(Miler N. *et al.*)**

P-17 Controlling plant height in three oxalis (*Oxalis* spp.) using plant growth regulators **(Miller C.)**

P-18 Performance of *Achimenes* in landscape trials **(Miller C. *et al.*)**

P-19 Effects of exogenous plant growth regulators on rhizome coloration in red rhizome lotus **(Miura R. *et al.*)**

P-20 Dynamic climate changes determine the new directions in ornamental perennials introduction in Poland **(Monder M.J. and Pacholczak A.)**

P-21 Hotspot geophytes may support biodiversity in green areas in Poland under changing climate conditions **(Monder M.J. and Pacholczak A.)**

P-22 The effect of treatment of ornamental bulb plants on the settlement of bulbs and the substrate by fungi during the period of rooting and on the growth and development of plants **(Nowak J. *et al.*)**

P-23 *In vitro* effect of some compounds on fungi developing on bulbs during their rooting **(Nowak J. *et al.*)**

P-24 Nutrient deficiencies affect growth and development of *Curcuma* 'Golden Reign' **(Panjama K. *et al.*)**

P-25 Parks and gardens as a contributor to older people's perceived well-being and health **(Pawłowska B. *et al.*)**

P-26 LED light affects the biochemical composition of *Lilium candidum* adventitious bulbs formed *in vitro* on a cytokinin medium **(Pawłowska B. *et al.*)**

P-27 Single-node cuttings constitute a highly efficient *Pennisetum* 'Vertigo®' propagation material **(Pawłowska B. *et al.*)**

P-28 The senescence of perianth and corona in cut daffodil 'Dutch Master' flowers **(Rabiza-Świder J. *et al.*)**

P-29 Organic and conventional agriculture in tulip flower greenhouse production **(Rodríguez Elizalde M.A. *et al.*)**

P-30 Light emitting diode for off-season flowering of *Curcuma alismatifolia* Gagnep **(Ruamrungsri S. *et al.*)**

P-31 The effect of postharvest treatments with commercial preservatives on keeping qualities of cut peony flowers **(Skutnik E. *et al.*)**

P-32 The possibility of using new plant growth regulators in micropropagation of Polish tulip (*Tulipa* L.) cultivar 'Heart of Warsaw' **(Sochacki D. *et al.*)**

P-33 Evaluation of ploidy level and genome size of *Hippeastrum* **(Sochacki D. *et al.*)**

P-34 Ecological aspects of tulip virus X in the Netherlands **(Stijger I. *et al.*)**

P-35 Conservation of plant genetic resources in Lithuania **(Stukeniene G. and Skridaila A.)**

P-36 Interspecific hybridization between *Cyclamen hederifolium* Aiton and *C. purpurascens* Mill. **(Takamura T. *et al.*)**

P-37 Effect of foliar fertilization on bulblet formation from leaf cuttings of *Lachenalia* **(Treder J. *et al.*)**

P-38 Effect of elicitors on *Fusarium* development in tulip bulbs **(van Vilsteren S. *et al.*)**

P-39 Wood fibre as a component of sustainable substrates for pot plant production of *Helenium hybridum* **(Zawadzińska A. *et al.*)**

O-1

30 years for geophyte production in changing climate – where science meets technology

Rina Kamenetsky-Goldstein (vhrkamen@volcani.agri.gov.il)
Agricultural Research Organization, The Volcani Center, Bet-Dagan, Israel

Efficient horticulture, based on the quality of plant material, new and improved varieties and technological innovations, is the most active sector of agriculture. New insights and evolving production technologies are needed to increase revenue, reduce costs and conquer new market niches. Climate and electric solutions in greenhouses, systems for heating and cooling, soilless production, automation and robotics – this is just a short list of new technological developments in horticulture that can be and are already in use in various countries. In geophytes, the contribution of research in plant physiology and developmental mechanisms for the advancement of new technologies is especially important due to the complicated life cycle and environmental requirements. Flowering programming for cut flowers and potted plants requires in-depth understanding and precise regulation of all stages of florogenesis. For bulb production, precision agriculture and biocontrol are essential. Recent developments in the global industry of peony cut flowers production and flowering advancement in warm regions present an example of strong collaboration between science and technological innovations. Despite the popularity of cut peonies, several factors restrict their production: complicated flowering physiology, challenges of mass propagation, and postharvest handling. Implementing the expanded knowledge in peony biology, we are able to produce quality flowers off-season for special market niches.

Keywords: bulb production, flower bulbs, flowering, innovations, ornamental perennials

O-2

Biotechnology in the breeding of ornamental geophytes

Ki-Byung Lim (kblim@knu.ac.kr)

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Plant breeding of ornamental plants – including ornamental geophytes – has grown into an important field for the last decades. Modern ornamental geophyte breeding approaches such as intra- and interspecific cross-breeding or polyploidization breeding are pivotal and understanding the inheritance of genetic traits has significantly accelerated the pace of it. As a result, it is estimated that about 85,000 to 99,000 ornamental plant species are existing throughout the world currently and these include both wild and cultivated species. One of the main approaches, interspecific cross (hybridization) breeding is ideal for ornamental geophytes that have high heterozygosity compared to other geophytes, enabling the introduction of novel genes into a breeding gene pool and increasing genetic variation. Entirely new traits can be achieved when distant species are crossed, and this approach has substantially improved breeding programs of lily, *Marantaceae*, *Asclepias* sp., *Pavonia*, etc. along with deep comprehension of overcoming crossing barriers and their mechanism. The majority of interspecific crosses present difficulties due to these crossing barriers (postzygotic), e.g. embryo abortion, reduced vigor, or endosperm degeneration. However, these challenges can be overcome by tissue culture techniques such as embryo rescue, ovary culture, or ovule culture that are widely applied for interspecific crosses. In addition to these challenges, interspecific F_1 hybrids can be sterile due to the barrier, therefore, restricting further usage of these hybrids in breeding programs. However, polyploidization via chromosome doubling can restore fertility in F_1 hybrids by generating 'unreduced gametes (2n)', where the male or female gametes (meiotic cells) have the same number of chromosomes as somatic cells and they can be induced under stresses e.g. temperature or by chemical treatment e.g. colchicine. The application of unreduced gametes provides great potential for ornamental geophyte breeding since they can shorten the amount of time to produce triploid progenies. Since these understandings on the inheritance of traits and hybridization of distantly related species have accelerated ornamental geophyte breeding, the application of molecular markers has greatly improved the efficiency by ensuring the plants possess certain traits such as flower color and flower longevity or disease resistance. Development and use of molecular markers are limited to certain crops such as rose, carnation, chrysanthemum, and lily, since the availability of genetic and genomic resources of highly heterogenic ornamental crops with large and complex genomes. Nevertheless, together with developing sequencing techniques, novel molecular markers to identify specific traits are developing expeditiously. Lastly, together with mutation breeding and genetic transformation, the Cluster Regularly Interspaced Short Palindromic Repeats (CRISPR)-Cas9 system is one of the biotechnological tools that has been introduced to modern ornamental geophytes breeding. It has successfully modified the flower color in Petunia from purple violet to pale purplish pink by targeting specific genes. CRISPR system has its strength where it can precisely target specific genome sequences to obtain desired traits. Ornamental geophytes breeding today can be complex and facing several challenges due to their characteristics, however, constant development and application of diverse breeding tools can secure sustainable breeding of a wide range of ornamental crops.

Keywords: breeding, cytogenetics, embryo rescue, molecular marker, ornamental plants

O-3

Production and breeding of bulbous plants and herbaceous perennials in Poland

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Poland has a decades-long tradition in the production, research and breeding of ornamental geophytes and herbaceous perennials, with modest gene resources of its own, especially geophytes, in nature. Regarding bulbs production, tulips (*Tulipa*), narcissus (*Narcissus*), lilies (*Lilium*) and gladioli (*Gladiolus*) are the most important crops. However, the total area devoted to ornamental geophytes, estimated at 1,200 ha in 2010, is on a downward trend. The total area for all ornamental crops in the ground including geophytes, but excluding tree and shrub nursery production also records a slight decrease from 3,833 ha in 2011 to 3,801 ha in 2022. Despite the decrease in the area of bulb reproduction, the acreage occupied by forcing geophytes for cut flowers has increased in Poland. Currently, it is estimated that tulips for cut flowers are grown on an area of 5 5 ha, which allows us to speak of a production volume of approximately 180 million stems per year. Small farms still grow tulips in traditional peat substrates in boxes or even in beds, but large farms have changed to the modern and automated hydroponic method in recent years. In Poland, there is a growing market interest in both bulbous cut flowers and flower bulbs and perennials for planting in gardens and urban green areas. A new and rapidly growing trend is the production of visually attractive perennials in containers for seasonal sale. With the rapid development of online shopping in recent years, this distribution channel is also becoming increasingly important for bulbs and herbaceous perennials and is growing continuously. The Polish market of geophytes and perennials is dominated by cultivars from breeding companies in Western Europe (mostly Dutch for bulbous crops) and the USA. Own breeding of ornamental geophytes and herbaceous perennials is very limited. The creation of new cultivars currently concerns lilies (*Lilium*), daylilies (*Hemerocallis*), tulips (*Tulipa*), hipeastrum (*Hippeastrum*) and ornamental grasses, although in the past breeding was also carried out for dahlias (*Dahlia*), gladioli (*Gladiolus*), peonies (*Paeonia*), irises (*Iris*) and narcissus (*Narcissus*). Poland is the clear leader in Europe in plant propagation by *in vitro* method. At least five major laboratories produce perennials for the European market, the USA and Japan. Vitroflora (near Bydgoszcz) is one of the European leaders in the production of starting material – rooted cuttings – including perennial cuttings obtained from its own in vitro laboratory and from mother plants. The Poland's second largest producer of young plants of perennials is the Kock Nursery (near Rypin), produces exclusively rooted cuttings obtained from mother plants and also sends them to the West European market. On the domestic market, novelties of perennials come through companies selling young plants. These include Polish Vitroflora and giant global organisations such as Syngenta, Florensis, Volmary, and Selecta One.

Keywords: flower bulbs, geophytes, *in vitro* laboratory, ornamental grasses, reproduction area

O-4

How can we plant more flower bulbs into the landscape?

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Most flower bulbs used in the world originate from production fields and facilities in the Netherlands. Many fewer come from production facilities in other countries, often overseen by Dutch firms. We typically divide the bulb market into two categories: forcing and landscape-"drysale". Forcing bulbs are used by greenhouse and nursery professionals to produce cut flowers or potted plants for sale to consumers. Drysale bubs have two outlets. Some are sold directly to consumers through mail order, garden center or "big box" home stores and a large number are sold to professional landscape firms who plant them in various settings in residential, public or commercial properties. A major limitation for the drysale category is delayed gratification (effort at fall planting does not show a payoff until spring bloom) and also the work (physical labor and cost) involved. Many conversations with bulb firms over the last 25 years suggests a solution to these two issues would be revolutionary. It would be easy enough to plant pre-cooled bulbs to reduce the time from planting to flowering, and such techniques are already in the industry. To reduce labor, at least one company in the Netherlands has developed a simple machine that can plant bulbs (monocultures or species/cultivar mixtures) within existing turfgrass. The machine slices the sod, briefly lifts it and drops bulbs below the grass rootzone, finally replating the sod. Such machines can plant at least 25,000–75,000 bulbs per hour without hand labor. Rather than clumps of a few flowering bulbs, the result is expansive swaths and sweeps of color, not unlike the sense of seeing an entire field in bloom. These bulbs emerge directly through the grass, eliminating most weed problems. Such an obvious and large shift in the landscape aesthetic result of bulb planting, as well as the numbers of bulbs, involved leads to many questions about the use and performance of flower bulbs in the landscape. Unlike forcing, detailed information on landscape uses is lacking and difficult to obtain. We obtained such a machine in the fall of 2017 and have used it in a number of studies to obtain answers to questions from the industry, such as: 1) Given the bulbs are growing through turfgrass, and most landscapers want a well-manicured turf, do you need to wait until the bulb foliage totally dies back prior to mowing? Industry information would suggest "yes". 2) How deep should they be planted? Industry information would suggest "deep"… 15–20 cm. 3) What are the best cultivars to use in this application? There is nearly no published information on this. This presentation will address these and other questions related to adapting this technology to expand the use of flower bulbs in large scale commercial, municipal and private landscapes. In most cases, our results are contrary to long-standing industry practice.

Keywords: ecosystem services, human health, perennialization

O-5

Micropropagation of ornamental geophytes: a useful approach for development and valorization

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The floriculture industry is experiencing substantial growth in production and trade rates, with bulbous and perennial flowers playing a vital role in the ornamental flower market. However, many flower bulb species are currently facing endangerment due to their attractive properties and medicinal values. Conventional cultivation of flower bulbs is hindered by challenges such as long juvenile periods, contamination of bulb structure, and limited multiplication rates. To overcome these limitations, researchers have turned their attention toward the micropropagation of flower bulbs. This method offers significant advantages, including the conservation of endangered species, mitigation of *in vivo* cultivation challenges, mass reproduction of high-quality plants free from viruses and diseases, and shortening of the juvenile period. Various explant sources, such as bulb scales, bulb shoot apices, roots, leaves, floral tissues, vegetative buds from tubers, rhizomes or corms, young stems, and seeds, have been used in geophytes. In most cases, culture media such as MS, B5, White, Nitsch, and Nitsch have been employed with different types and concentrations of plant growth regulators, sucrose, etc. Successful application of tissue culture methods has been demonstrated in flower bulbs such as *Anemone*, *Colchicum*, *Crocus*, *Cyclamen*, *Fritillaria*, *Galanthus*, *Gladiolus*, *Helleborus*, *Hippeastrum*, *Iris*, *Leucojum*, *Lilium*, *Muscari*, *Narcissus*, *Pancratium*, *Ranunculus*, *Sternbergia* and *Tulipa*. Both organogenesis and somatic embryogenesis have been explored for these flower bulbs. Enhancing the *in vitro* cultivation of flower bulbs holds great potential for preserving their species and increasing their trade value through mass reproduction. In this review, we will provide some case studies aimed to highlight the use of micropropagation for the valorization of some ornamental geophytes.

Keywords: floriculture, *in vitro* conservation, organogenesis, ornamental geophytes, tissue culture

O-6

In vitro techniques for tulip micropropagation, virus eradication and tetraploid induction

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In Poland, there are many valuable cultivars of tulip deserve wider dissemination due to high decorative qualities and adaptability to our climate. Improvement of biotechnological methods such as *in vitro* propagation can speed up breeding and provides new genotypes for the market. Therefore, studies have been undertaken on the improvement of micropropagation method of tulip. As a result of our research the cyclic multiplication of adventitious shoots of this geophyte was obtain by using 1-naphthaleneacetic acid (NAA) combined with cytokinins such as isopentenyladenine (iP) with addition of thidiazuron (TDZ) or meta-Topolin (mT). Moreover, the last micropropagation stage, formation of microbulbs was also significantly improved, that is very important because only bulbs are capable of rooting and further growth in soil. It was found that modification (by replacement of TDZ with iP in a medium) and prolongation to 12 weeks of the last multiplication subculture, prior to cooling combined with the application of growth retardant enhanced shoot's bulbing capacity. Bulbing efficiency was markedly increased by treatment with MeJA at the last phase of this process, 6 weeks after the end of cooling shoots. Due to the sever virus infection of several tulip cultivars, one of the aim of our research was to develop the *in vitro* method of virus eradication from plant material. Virus elimination from the totally infected tulip genotypes was possible due to application of ribavirin for *in vitro* chemotherapy. Currently in tulip, the polypoid cultivars are in high demand. Therefore, during our study we developed *in vitro* method of tetraploid induction using herbicidal antimitotic agents such as oryzalin, amiprophos methyl (APM) and trifluralin as alternative to colchicine.

Keywords: micropropagation, ribavirin, tetraploids, *Tulipa*, virus-free plants

O-7

A new nursery system for the production of high-quality propagating tubers of *Zantedeschia* in the Netherlands

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The cultivation of *Zantedeschia* (calla lily) in the Netherlands takes place from March to October. *In vitro* culture plantlets are used as the starting material for tuber production. This material is grown aseptically indoors only during the first year. Thereafter, it is grown for 1–2 years in the open field into propagating tubers. A high-quality propagating tuber should be healthy, have many eyes (shoot meristems), have a circumference larger than 6 cm, and have high dry matter content. The goal of this study was to develop a new nursery cultivation system for the production of high-quality and virus-free propagating tubers in half of the current timeframe. Plantlets produced *in vitro* were used as the starting material. The experiments took place from 2020 to 2023 at the Wageningen Plant Research – Greenhouse Horticulture & Flower Bulbs Center. Several greenhouse parameters were investigated to maximize tuber growth, such as light intensity, light spectrum and temperature. Photosynthetic activity and tuber yield were assessed. The results demonstrate the feasibility of producing clean propagating-size tubers within a year using two greenhouse cycles: a short winter cycle (November–March) at 17°C and a regular summer cycle at 22°C. The winter cycle requires a minimum of 7.8 mol/m^2/day (PAR sum) for optimal tuber growth. These tubers are stored at 20°C for two months, multiplied in May and planted. During the second cycle, natural sunlight is primarily used, except when the minimum PAR sum is not reached. This nursery system could reduce dramatically the amount of chemical crop protection currently used in the Netherlands for the production of commercial *Zantedeschia* tubers.

Keywords: calla lily, photosynthesis, tuber biomass, tuber buds

O-8

An indoor cultivation system for the production of virus free lilies in the Netherlands. Turning lily cultivation outside in

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The traditional outdoor lily cultivation requires the use of multiple chemical protection products given the high disease pressure. However, the reduction in allowed products and the increasing societal demands, requires a new and sustainable cultivation system. In the project Vital Lily Cultivation a "one way cultivation system" was developed to produce healthy commercial-size bulbs (for forcing) with minimum crop protection residue. The starting material is clean and virus-free bulblets from tissue culture and these are cultivated and multiplied in the greenhouse. The resulting planting material requires only one or two outdoor cultivation cycles to reach the commercial size. Wageningen University and Research conducted trials to optimize lily bulb growth under greenhouse conditions. Aspects that have been studied are light intensity, light spectrum, planting density, fertigation, senescence, successive cultivation and the economical aspects. The results indicate that it is possible to grow to size 14 from size 4 in one greenhouse cycle of nine months. Those can be multiplied and re-grown to size 14 in nine months, or to planting material (size 8) in just four months, which makes it possible to have a fast propagation indoors. In the indoors cultivation no pesticides have been used and no problem with diseases have occurred. The research was done with an LA, OR and OT cultivar. An issue to tackle in this system is the senescence and the preparation of bulbs for the next season. If this is not done correctly, sprouting is reduced to 50% and plants with only leaves and no stems are formed, and more bulbs with double noses were harvested. In a pilot experiment, a period of 50 days of below 13°C improved the sprouting. However, plants were not completely senesced yet and afterwards still formed double noses. A better understanding of the senescence process is needed to overcome these physiological abnormalities.

Keywords: cultivation, *Lilium*, propagation, senescence

O-9

Herbaceous perennial trials at Colorado State University

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Public and private plant trials are critical for the horticulture industry, providing valuable feedback about plant performance. The Colorado State University (CSU) trial gardens attract thousands of visitors each year. The trial gardens evaluate both annual and perennial species marketed in the United States (US) horticulture industry. The perennial trials were established in 1997, as there was increased interest in evaluating new perennial plant species and cultivars, and how their adaptation to the Rocky Mountain environment, which is classified as a steppe region. The trial gardens do not receive any direct state or public funding and are supported wholly through trial entry fees. The gardens do also receive donations and support from horticulture industry, associations, foundations, and other green industry affiliates. Perennial plants are evaluated for a period of three years to include three summer growing seasons and two winter seasons. Perennials are received from plant breeding companies and plant brokers early in the season, grown in the greenhouse until planting in mid-spring. Plants are evaluated for plant vigor, uniformity, flowering, and overall tolerance to environmental stresses. In the 26 years of perennial trialing, over 125 different genera have been trialed. The top 10 most trialed genera have been *Dianthus*, *Echinacea*, *Coreopsis*, *Phlox*, *Salvia*, *Heuchera*, *Penstemon*, *Leucanthemum*, *Lavandula* and *Veronica*. Plant trials will continue to be important for plant breeding companies and marketers to identify ideal and plants that perform well in specific environmental conditions.

Keywords: *Dianthus*, *Echinacea*, floriculture, horticulture, plant evaluations

O-10

Effects of supplemental lighting using LED's on the quality of tulips forced hydroponically

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Tulip (*Tulipa* sp.) is one of the most popular bulbous plant grown for cut flowers during winter time. In Poland forcing technology in mostly based on traditional cultivation on soil beds or in containers filled with peat/sand substrates. However, in recent years the biggest farms are changing their technology to a modern, very efficient hydroponic method with automatic control of the movement of cultivation tables. Tulips do not have high light requirements during forcing and usually they are grown in natural light conditions. However, for early flowering period the lack of natural light, from November up to mid-January, can negatively influenced flowers quality and extend cultivation period. The aim of the study was to determine the effect of supplemental LED lighting on the forcing duration and quality of cut tulip flowers in hydroponics. Four commonly grown cultivars: 'Kung Fu', 'Strong Gold', 'Strong Love' and 'Surrender' were evaluated. Control plants were forced in natural light conditions. As a source of light supplementation the full spectrum LED lamps, with a power of 300 and 240 W, applied for 8 or 4 hours daily were used. The effect of LED lighting on the tulip growth dynamics and the date of flowering as well as selected biometric parameters of cut flowers (the length of the flower stem, flower bud and the last internode, the thickness of the stem, and the flower stem fresh mass) were determined. The studies showed that supplementing natural light during tulip forcing using LED lamps has an positive effect on shortening the forcing period and thus obtaining flowers earlier by 1 to 6 days, depending on the cultivar and the intensity of lighting. Flower buds of tulips grown with LED lamps usually showed color faster and were harvested earlier than control plants. However, control plants (without lighting) were ready to harvest for an additional few days later so, they gained more time for growth, which resulted sometimes in higher fresh weight. The obtained results showed that 3 out of 4 examined cultivars are did not increase the fresh mass of flower stems, which indicates positive effect of light supplementation with LED lamps on the mass of cut flowers. Depending on the cultivar, the supplemental lighting did not affect the total height of the plant ('Kung Fu' and 'Strong Love') or influenced the achievement of higher plants ('Strong Gold' and 'Surrender'). The LED lighting also did not influenced the thickness of the tulip stems just below the bud in the 'Kung Fu', 'Strong Love' and 'Strong Gold' cultivars, only 'Surrender' grown with 240 W LEDs for 8 h increased the diameter of the stem by 0.3 cm compared to the diameter of the shoot in control, non-lighted plants. Supplemental lighting affects positively also vase life, leaf chlorophyll content and nutrient uptake of tulips forced hydroponically.

Keywords: 'Kung Fu', nutrient content, 'Strong Gold', 'Strong Love', 'Surrender'

O-11

Developments in breeding of bulbous crops from a genetics and genomics perspective

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Breeding of bulbous crops is challenging because of the crop specific characteristics in most important geophytes like tulip and lily that need more time and effort to deal with. In this overview we will go into some of the new developments and research in the Netherlands in attempting to overcome or deal with such problems in generation time, reproduction, genome size and phenotyping for disease resistance. The focus will be on genetic and genomics aspects of these bulb specific characteristics rather than recent developments into bulb production.

Keywords: bait-seq, effector screening, genome assembly, RNA-seq

O-12

Distant hybridization of *Hemerocallis* with *Eremurus* and *Lycoris*

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Hemerocallis spp. is a perennial plant with high ornamental and economic value. However, long-term hybridization between closely related species has made it difficult to obtain innovative *Hemerocallis* germplasm. Distant hybridization can greatly enrich genetic diversity. Consequently, a four-year hybridization study was carried out with *Hemerocallis*, *Eremurus*, and *Lycoris*. Artificial pollination was conducted to overcome the pre-zygotic reproductive barrier; embryo rescue was carried out to overcome the post-zygotic barrier. The interfamily hybrid was identified, cytological and phenotypic observations were performed. Analysis of cross-compatibility revealed that reproductive isolation strongly hinders distant hybridization. For the hybridization between *Hemerocallis* and *Eremurus*, a total of 752 *Hemerocallis* flowers were pollinated, the fruit set rate is 0–5.26%, and only obtained 1 hybrid embryo. And 378 *Eremurus* flowers were pollinated, no fruit was acquired. For the hybridization between *Hemerocallis* and *Lycoris*, a total of 1597 *Hemerocallis* flowers were pollinated. The fruit set rate was 0.41% and 1 hybrid embryo was obtained. And 1446 *Lycoris* flowers were pollinated, the fruit set rate is 0–61.82%, 121 hybrid embryos were obtained. The pre-zygotic isolation between *Hemerocallis* and *Eremurus* was more severe than *Hemerocallis* and *Lycoris*. After 7 months of embryo rescue, an interfamily hybrid seedling was obtained. The hybrid was identified by inter-simple sequence repeat (ISSR). The growth rate of interfamily hybrid seedlings was at least five weeks slower than that of *Lycoris* interspecific hybrid seedlings. The hybrid owned the same chromosome number as the paternal plants (2n = 22) and showed maternal overall phenotypic characteristics. Distant hybridization between *Hemerocallis* and *Lycoris* exhibits severe reproductive isolation, but the hybrid seedlings can still be obtained. This research lays the foundation for the future development of *Hemerocallis* breeding and distant hybridization.

Keywords: daylily, embryo rescue, foxtail lily, interfamily hybridization, intergeneric hybridization, lycoris, reproductive isolation

O-13

Intergeneric hybridization and endosperm culture of *Lycoris*

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Lycoris (*Amaryllidaceae*) is an important bulb flower, which has great potential in both landscaping and cut flower applications. It is difficult to obtain innovative *Lycoris* germplasm by conventional crossbreeding. To enrich the ornamental characteristics of *Lycoris* plants, intergeneric hybridization between *Lycoris* and *Hippeastrum* was conducted. Further, endosperm culture was adopted in this study for improving the ploidy level of *Lycoris*. During this experiment, 298 Lycoris and 276 *Hippeastrum* were pollinated. The results showed that the fruit setting rates of *Lycoris* × *Hippeastrum* and *Hippeastrum* × *Lycoris* were both high, 65.8% and 64.9% respectively. But *Lycoris* × *Hippeastrum* obtained much more ovules than *Hippeastrum* × *Lycoris*, with 347 and 19 ovules respectively. The endosperm culture was unsuccessful in the two intergeneric hybrid combinations, but two seedlings were obtained in the interspecific hybrid *Lycoris aurea* × *Lycoris tsinlingensis* four months after pollination. During this presentation, as the background and reference of this study, the successful cases of intergeneric hybridization and endosperm culture of monocotyledon plants will be reviewed, as well as the research progress of methods to overcome the barriers of intergeneric hybridization of monocotyledon plants. Also, the types of barriers to intergeneric hybridization of *Lycoris* as a parent and the suitable conditions for endosperm culture of *Lycoris* will be discussed.

Keywords: distant hybridization, embryo rescue, hippeastrum, ploidy breeding, postzygotic disorder

O-14

Breeding *Impatiens* for resistance to the fungal disease impatiens downy mildew (*Plasmopara obducens*)

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Impatiens walleriana, commonly known as impatiens, is one of the most popular annual bedding plants and an important source of income for many greenhouse growers and landscapers in the United States and Europe. However, the advent of Impatiens Downy Mildew (IDM), *Plasmopara obducens*, changed the plant's status and economic value. IDM is a pathogen that has become virulent against this species of Impatiens; it leaves plants defoliated and commercially unviable. IDM is a disease that is very difficult to manage. Fungal oospores allow reinfection to occur and it is theorized that the oospores can remain in soil for up to 10 years. Commercial fungicides are ineffective at eradicating the disease and only temporarily prolong the health of the plant. Consumers who are not able to use these fungicides still see the impact of the disease in their gardens. By 2011, the pathogen had spread worldwide and become a significant problem in the landscape. This disease results in wilting, leaf and flower drop and ultimately death of this important bedding plant. In the past 10 years, sales of *Impatiens walleriana* have plunged because of this devastating disease. There was a critical need for breeding research with Impatiens to develop resistance to IDM; we began a breeding program at Cornell University to accomplish this. In 2015, we successfully confirmed that IDM-resistance is genetically inherited with impatiens. A traditional breeding program was begun to hybridize *Impatiens walleriana* plants with resistant Impatiens species. We demonstrated that the popular *Impatiens walleriana* is compatible for cross-fertilization with other impatiens species that are resistant to IDM and that the ornamental qualities of the common impatiens can be combined with the disease resistance of the wild relatives to produce improved plants. By 2016, two hybrid plants were developed that were resistant to the disease. These two plants were used for further breeding with the ultimate goal of developing seed-propagated lines of Impatiens that are resistant to IDM. Hybrid plants that are produced from our breeding program are grown in the field and challenged with natural IDM inoculations to identify resistant plants. Impatiens plants are selected that have little or no infection, no defoliation, and are able to complete their life cycle throughout the growing season. Our breeding uses inbred lines to generate hybrid plants that are resistant to IDM. Good ornamental traits, in addition to IDM resistance, are our breeding objectives. The new plant products that will be generated from this research will have great potential for the ornamental horticulture industry.

Keywords: disease resistance, *Impatiens*, plant breeding

O-15

Long term storage of cut flowers

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Cut flower producers often need to cold store cut flowers to build up inventory for events, markets and holidays or to hold excessive production. Cut flower species are grouped into three categories based on chilling sensitivity: tropicals (12 to 16°C), sub-tropicals (2 to 8°C) and chilling tolerant species (0 to 2°C). Successful long term storage of cut flowers requires that the stems be high quality, disease free, properly treated prior to storage, properly packaged, and held at the coldest temperature possible for each species. For chilling-tolerant species, subzero storage shows promise for increasing the storage duration while maintaining quality. Cut *Paeonia* flowers stored for 16 weeks at −0.6°C showed no freezing injury and were higher quality (reduced percentage of flowers that failed to open and fewer deformed flowers) than those stored at 0.6°C. Pre-storage pulses using a commercial hydration solution for 2 hours at 4°C and 200 $g \cdot L^{-1}$ had no effect. *Tulipa* stems could be stored for up to six weeks with no reduction in vase life if held at −0.6°C with the bulb attached and then treated with floral solutions after storage. *Iris* × *hollandica* stems lasted longer and more fully opened when pre-pulsed with floral solution prior to six weeks of storage at −0.6°C. Subzero storage may also be effective for long-term storage of other perennial and bulbous cut flowers including *Alstroemeria* hybrids, *Anemone coronaria*, *Campanula medium*, *Chrysanthemum* hybrids, *Dianthus caryophyllus*, *Lilium* hybrids, *Ranunculus* hybrids and *Rosa* hybrids.

Keywords: acclimation, cold storage, pretreatment

O-16

Balancing of some endogenous phytohormone on growth and development of sacred lotus (*Nelumbo nucifera* Gaertn.) after spraying of GA_3 application

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Sacred lotus is an important cut floricultural crop in Thailand, which became dormant in mild winter and caused to non-year-round production. The poor growth in low-temperature conditions resulted in not enough flower market demand. The experiment aimed to clarify some strategies for improving quantity and quality of flowering in sacred lotus off-season production. The influence of gibberellic acid (GA_3) application on the changes in contents of some endogenous phytohormones such as trans-Zeatin riboside (t-ZR), abscisic acid (ABA) and gibberellin-like substances (GLS), as well as on the growth and development of lotus was examined in complete randomized design (CRD). One-month old plants were treated with GA_3 at 200 and 400 ppm. GA_3 treatment, regardless of the concentration, increased leaf number, leaf stalk length, and stolon length. Nevertheless, no effects of GA_3 application on flower quality and number were observed. Plants treated with 400 ppm of GA_3 showed the highest t-ZR content in stolon and trend to reduce GLS in plant parts compared to control plants. Increasing GA_3 concentration reduced ABA content in leaves, but not in nodes. These findings on balancing of endogenous phytohormone might be beneficial for applying the PGRs to control flowering in further aspects.

Keywords: ABA, flowering, gibberellin-like substances, off-season sacred lotus, t-ZR

O-17

Reblooming in perennials: bearded iris (*Iris germanica*) as a model

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Reblooming, also known as continuous flowering, is common in the genus of *Rosa*, *Fragaria* and *Iris*. The reblooming perennials could bloom out of season, giving them more reproduction chances and extended ornamental stages. Bearded iris (*Iris germanica*) is a widely-used ornamental perennial, and the reblooming ones could annually bloom in spring and autumn. To reveal its molecular mechanisms of reblooming could provide important reference to the continuous flowering research in other perennials. In this presentation, our recent research results on reblooming bearded iris will be discussed. Specifically, through hybridization and phenotypic character analysis, transcriptome sequencing, transgenic analysis and genome editing, we analyzed the genetic law of ornamental characters in reblooming populations, and characterized the functions of flowering-related genes, thereby laying the theoretical foundation for the breeding of reblooming perennials.

Keywords: bearded iris, continuous flowering, genetic law, reblooming

O-18

De-vernalization – when heat erases flower induction

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De-vernalization is the process leading to the delay or total inhibition of flowering in vernalized plants. This phenomenon takes place after planting under high temperatures and its meaning is the actual reversion of flower induction acquired by the plant during cold exposure. De-vernalization occurs in both annual and perennial plant species and can even be used a means to avoid flowering, like in onion. How can this happen? The mechanism of de-vernalization has been elucidated in only a small number of plants, like wheat and *Arabidopsis*, revealing differential expression of master flowering inhibitors achieved by epigenetic modifications. Typically, bulbs and corms grown for flower production undergo appropriate forcing and vernalization treatments in the summer and are planted in autumn. In these crops, the occurrence of de-vernalization generating a delay or complete revocation of flowering is increasing, due to the constant rise in autumn temperatures. These features have a major detrimental effect on flower production, yet the regulation of de-vernalization in flowering bulbs is far from being elucidated. In bulbs and corms, higher temperatures at planting severely reduce germination and sprouting rate. In corms, such as anemone and buttercup, de-vernalization can lead to a total arrest of meristem development. In lily, de-vernalization is linked with an increase in glycerol content in the bulb. Glycerol and/or its metabolites also induce the upregulation of genes linked to dormancy and to the down-regulation of flowering-promoting genes. In the context of climate changes and in view of the damaging interactions of higher temperatures with flowering-promoting pathways, it is important to further explore the regulation of de-vernalization in bulbs and corms.

Keywords: climate, flower induction, metabolites

O-19

Simulated spring freezes cause bud abortion and receptacle necrosis in *Paeonia lactiflora* 'Festiva Maxima'

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Sub-zero temperatures during spring freeze events can cause significant losses in North Carolina (NC) cut peony (*Paeonia lactiflora* Pall.) production fields. Damaged buds fail to open and internal necrosis is visible in the receptacle. Two protocols were developed to simulate spring freezes using data from three weather stations surrounding two of the largest NC cut peony producers. The cultivar Festiva Maxima was subjected to simulated spring freezes as potted plants at two growth stages prior to flowering where the minimum temperatures were either −3 or −6°C for 1 hr. Bud abortion was only observed on peonies at the second growth stage and the highest percentage of buds aborted when simulated freezes had a minimum temperature of −6°C. If freezing occurred, peony shoots always froze from the root system upwards, which was confirmed and visualized using an infrared camera. Some shoots at both growth stages 2 and 3 remained supercooled (the ability of water to remain below 0°C without ice nucleation) throughout both simulated freezes of −3 and −6°C. Histological sections of a necrotic receptacle depicted air pockets in the receptacle tissue characteristic of ice damage.

Keywords: cut flowers, perennials

O-20

Identification of below-ground phenotypic markers for early flowering (Cycle 1) *Gladiolus hybridus*: daughter corm and cormel production, cormel types

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Gladiolus hybridus (*Iridaceae*) is an important herbaceous perennial and cut flower crop. As a geophyte, it produces corms and cormels for perennial survival and cloning. The life cycle of gladiolus (seed to flower) is typically 3–5 years, which slows the rate of breeding progress. We have developed rapid generation cycling (RGC) lines that flower in ≤ 1 year from sowing (Cycle 1). After the first year ends, it is impossible to phenotypically distinguish Cycle 1 RGCs from seedlings flowering in years 2–5 (Cycles 2–5) using above-ground traits. The objective of this study was to screen below-ground structures to determine if unique phenotypic traits(s) could be found for Cycle 1s. Two experiments were conducted (2021; 2022): Expt. 1 screened traits across Cycles 1–5 genotypes (n=1 clone/genotypes); Expt. 2 expanded replications/genotype (n=5). Expt. 1 had n=140 genotypes (categories: 22-Cycle 1s; 3-cultivars, 'Manhattan', 'Fordhook', 'White Prosperity'–potential Cycle 1s; 94-UMN cycles 2–5; 20-cvs. Cycles 2–5; 1-wild spp.) whereas Expt. 2 tested n=88 in categories: 18-Cycle 1s; 3-cultivars potential Cycle 1s, 'Manhattan', 'Fordhook', 'White Prosperity'; 34-Cycle 2s; 34-Cycles 2–5, including wild spp.). Gladioli were field-grown and harvested post-flowering in late fall. Traits examined in Expt. 1 included: no. daughter corms, no. cormels/quadrant/corm, no. cormels, no. UCT (unbranched cormel type), no. BsCT (branched, simple cormel type), no. BfCT (branched, fasciated cormel type), cormel production/quadrant/corm. Cormel production/quadrant/corm was not significantly different among cycle categories and was eliminated in Expt. 2. In both experiments, three below-ground traits were either significantly higher (no. daughter corms, unbranched cormel counts) or lower (no. of cormels/fasciation) for Cycle 1 genotypes than Cycles 2–5. All other traits overlapped among Cycles. These three traits can be used to distinguish Cycle 1 vs. Cycles 2–5, regardless of age. Future research will focus on identifying molecular markers linked with one or more of these traits.

Keywords: cormels, corms, geophyte, *Gladiolus*

O-21

Integrated management of diseases on ornamental geophytes and herbaceous perennials

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The development and implementation of cost-effective, long-term production practices that rely on an integrated approach to managing diseases is important to enhancing the efficiency of producing field and greenhouse grown ornamental geophytes and herbaceous perennials. While there are numerous economically important diseases that can impact the production of high-quality bulbs, cut flowers, and potted plants, this presentation will focus on approaches that are being used to manage *Botrytis* diseases on a number of crops, and approaches that are being used to enhance the management of virus diseases on dahlias. Approximately half of the 40 species of *Botrytis* that have been described cause diseases on ornamental geophytes and flowering herbaceous perennials. These include the generalist *B. cinerea*, which has been reported on > 1,400 plant species spanning nearly 600 genera, as well as species that have narrow host ranges and are often highly virulent on their host. Fungicides have historically been used extensively in disease management programs to limit the pre- and post-harvest impact of *Botrytis* diseases. An overview of the effectiveness of new reduced-risk fungicides and biological-based products and approaches, such as the use of environmental-based decision support systems and crop phenology-based application strategies, that are being used to significantly reduce fungicide use will be discussed. Fresh-cut dahlia flowers are an important crop, especially to small specialty cut flower growers that sell flowers to local markets. More than 10 viruses are known to infect dahlias and U.S. stakeholders have identified viruses as their number one plant health concern. A combination of improved diagnostic tools to detect multiple viruses in a single test and the production and strategies for use of virus-free planting material to reduce the impact dahlia viruses will be discussed.

Keywords: *Botrytis*, dahlias, disease management, viruses

O-22

Advances in powdery mildew and rust control for ornamental perennial crops

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Ornamental perennial crops are threatened by obligate fungal pathogens that cause unsightly disease and impact plant vigor. The powdery mildew fungus (*Golovinomyces* (syn. *Erysiphe*) *cichoracearum* DC.; *Podosphaera* sp.; *Oidium* sp.) forms a hyphal network across the leaves, flowers, and stems resulting in white, talcum-like colonies. As the disease progresses, lower leaves drop and the plant ceases to produce flowers, becoming unmarketable. Powdery mildew is a common and destructive foliar disease of gerbera daisy (*Gerbera jamesonii*), dahlia (*Dahlia hortensis*), aster (*Aster* sp.), and phlox (*Phlox paniculata*). The rust pathogen, *Puccinia malvacearum,* infects hollyhock (*Alcea rosea*) and mallow (*Malva sylvestris*) causing light yellow-orange spots on the leaves which then progress to brown pustules; severe disease causes leaf death. This study investigated plant protection products for their ability to limit these diseases under greenhouse or growth chamber conditions. Floral crops known to be susceptible to powdery mildew or rust were inoculated by exposing them to naturally infected plants of the same type. Plants were incubated under high relative humidity conditions. Prior to inoculation, plant protection products were applied as a foliar spray using a hand-pump compressed-air sprayer and reapplied at specific intervals. Assessment included the number of powdery mildew colonies or rust pustules and/or a disease severity rating. Data were analyzed using SAS PROC GLM and statistical differences were compared using the Fisher's Protected Least Significant Differences or Student-Newman-Keuls test (P=0.05). Experimental trial results indicate that the following plant protection products effectively limited powdery mildew compared to the control: azoxystrobin + benzovindiflupyr, metconazole, myclobutanil, boscalid, trifloxystrobin, pyraclostrobin + boscalid, triflumizole, fludioxonil + cyprodinil, and azoxystrobin. Effective products for rust protection included pyraclostrobin + boscalid, triticonazole + pyraclostrobin, mefentrifluconazole, and myclobutanil. Successful management of powdery mildew and rust in ornamental perennial crops requires integration of this latest research with sanitation and environmental control strategies.

Keywords: disease control, fungicide, pest management

O-23

How to deal with non-persistently aphid-transmitted bulb flower viruses?

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Plant viruses which are transmitted by aphids in a non-persistent manner are of high importance to vegetatively propagated crops such as flower b ulbs. I n the N etherlands, a comprehensive quality system is in place consisting of field inspections and laboratory tests on leaves and bulbs, carried out by the Dutch Flower Bulb Certification Agency (Bloembollenkeuringsdienst, BKD). In recent years, infections with viruses which are non-persistently transmitted by aphids, such as the potyviruses *Tulip breaking virus* (TBV) and *Lily mottle virus* (LMoV), increased considerably. Growers intend to keep the number of virus sources, which are present in their bulb stocks, as low as possible. Besides virus sources, the other key role players in virus infections are the virus vectors: for potyviruses these are aphids. In the Netherlands, we observed an increase in numbers of flying aphids after mild winters. Moreover, the aphids tend to fly earlier in the year. Chemical crop protection is difficult to use for prevention of non-persistent virus transmission. Moreover, there is a tendency to abolish chemical crop protection products, resulting in a need for alternative measures for aphid and virus control. Our research is focusing on the factors influencing the shift of aphid flights towards early spring, monitoring techniques for aphids and the viruses they are carrying, and the development of environmental-friendly control measures.

Keywords: aphids, non-persistent transmission, plant viruses

O-24

Characterization of biological and synthetic microstructures of *Zantedeschia* leaf surface, and their interaction with *Pectobacterium*

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Surface architecture and its effect on bacterial attachment, colonization, and micro-environment, are a subject of clinical as well as agricultural interest. The surface microstructure is an essential component of the complex interaction between leaf surfaces and bacterial cells. Our hypothesis proposes that leaf microstructure plays an important role in bacterial behavior, and may strongly affect the outcome of bacterial leaf interactions. To answer this question, two closely related ornamental species of the genus *Zantedeschia* were chosen as model plants. These natural hosts of *Pectobacterium*, the agent of soft rot disease, differ in their innate susceptibility to the bacterial pathogen. While *Z. aethiopica* (ZA) is fairly resistant, the colored hybrid cultivar 'Captain Romance' (CR) is highly sensitive. ZA holds a relatively smooth abaxial leaf surface, while CR has a rougher lower surface, which is more competent for bacterial attachment. In order to isolate the effect of the surface microstructure, we produced biomimetic replicas of the differing *Zantedeschia* surfaces and exposed them to bacterial cells. This allowed us to associate the attachment patterns and the leaf microstructure, and establish a direct linkage between bacterial behavior and the leaf topography. The effect of the microstructure on the microenvironment will also be discussed. Our research combines multidisciplinary approaches such as biomimetics, microscopy, and molecular microbiology to study the events that affect microbes' interaction with natural and artificial surfaces.

Keywords: biomimetic, leaf surface, microstructure, *Pectobacterium*, *Zantedeschia* spp.

O-25

Perennials and geophytes selection for therapeutic horticulture

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Plants play a significant role in horticultural therapy – a form of therapy that uses gardening and plant-related activities to improve the physical, mental, and emotional well-being of individuals. Plants are essential therapeutic tools that facilitate the recovery process and should be selected according to the client's needs. Due to the diversity of possible vegetation, environmental and cultural differences, there is no single set of suitable plants. Attraction to wildlife and biodiversity enhancement are also important criteria. Plants can serve as metaphors to promote personal growth as clients draw parallels between the growth of plants and their healing journey. Qualities of flora should highlight a seasonal interest in the garden to facilitate the user's interaction with plants, promoting "flow", soft fascination and mindfulness. Plants are a source of "positive distraction" reducing stress and supporting relaxation, achieved by planting seasonally significant perennials, for example, spring bulbs, summer lilies, autumn asters, etc. These are all intertwined with the sensory experience. Plants with distinctive features that stimulate sight, smell, touch, hearing and taste are preferred in therapeutic horticulture. Scents of plants cause therapeutic modality in reminiscent therapy which is used for the elderly with dementia. This uses sensory stimuli to trigger memories and facilitate conversation and emotional connections in individuals with memory-related issues. In our survey, we aimed to determine the plant preferences of the aged population in Poland to facilitate their use in therapeutic gardens. Results indicate that for people over 60, the most remembered ornamental plants are: roses (67.7%), tulips (65%), daffodils (63.6%), and peonies (62%). For that reason, those species should be included in the plant selection in therapeutic gardens. A questionnaire type of research could be a standard procedure used before designing a garden that serves diverse therapeutic purposes.

Keywords: healing landscape, horticultural therapy, ornamental plants, people-plant interactions, sensory gardens

O-26

Evaluation of growth and flowering of ornamental grasses and other perennials planted in a city parks, the case of Rabka-Zdrój

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Ornamental perennials are the basic plant material used in modern garden art. They give natural beauty, which is changing over time, constituting a dynamic element of the arranged space, additionally supporting the biodiversity of the place. The basis for the proper development of plants is the right selection of species to the habitat conditions. In this work, the growth and flowering of several species of ornamental grasses and other perennials planted in various locations of park in the resort town Rabka-Zdrój (Poland) were observed. In order to determine the stages of growth, development, flowering and decline, the measurements of morphological parameters were carried out throughout the growing season at two-week intervals. Each time photographic documentation was prepared to visually follow the dynamics of plant development. The observed perennials were resistant or moderately sensitive to park environmental conditions. They differed in growth and flowering dynamics, habit and height, making a different impression every week and reflecting the everchanging nature of plants from one season to another. Most of the analyzed perennials were planted at the appropriate spacing and properly selected for the cultivation place. As a result, they constituted an important aesthetic accent diversifying the park greenery throughout the vegetation season.

Keywords: herbaceous ornamentals, observation trial, *Poaceae*, public spaces, seasons

O-27

Analysis of decorativeness and variability of species in "perennial meadows" of a revitalized Park Krakowski

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Green areas are important in the lives of residents of large cities, and public parks are a popular place for rest and recreation. In 2018, during the revitalization of the Marek Grechuta Park Krakowski in Krakow, so-called "perennial meadows" were introduced into the park undergrowth for the first time, referring to the communities of wild vegetation. 6 modern, naturalistic perennial plantations were designed, diversified in terms of plant selection, according to the system of the German designer Heiner Luz. In this project, these plantations, in the fifth year after planting, were subjected to observations, conducting year-round monitoring. The decorativeness of plantings was assessed according to the developed bonitation scale, the structure and the growth strength of individual plants was evaluated, referring to the project. The observations and analyses carried out indicate that the modern way of designing perennial meadows in the park undergrowth has proven successful. Although there are unfavorable conditions for the growth of herbaceous plants (high soil and air pollution, the presence of strongly overgrown old trees that create shade and also limit the space for root growth), planted compositions look aesthetic throughout the growing season and change throughout the year. Before typical perennials develop, bulbous plants are decorative in early spring: *Galanthus nivalis*, *Crocus vernus*, *Scilla siberica*. In the second half of summer and winter, ornamental grasses participate in decoration, including *Calamagrostis brachytricha* and *Miscanthus sinensis*, which grow well here. It was observed that perennials have greater growth strength and were more vigorous and healthier on better-lit sites of park. Perennials developed less in shade and near tree trunks. *Astrantia major*, *Kamilemris incisa* and *Cimicifuga acerina* are characterized by worse adaptation on perennial meadows. High expansiveness was observed in *Geranium* × *magnificum*, *G. pratense*, *G. oxonianum*, *Myrrhis odorata*, *Polygonum amplexicaule* and *Symphytum caucasicum*.

Keywords: blooming, flowerbeds, herbaceous perennials, plantings, urban greenery

P-1

Use of *Solidago rugosa* 'Fireworks' in ground cultivation in Poland

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Solidago rugosa 'Fireworks' is a tall perennial with rigid stems covered with hairs and wrinkled egg-shaped and lanceolate, crimson-edged or sharply toothed leaves. During flowering it is characterized by yellow effective panicles of flowers developing from late summer to autumn, i.e., in Polish conditions, from September to the first decade of November. The 'Fireworks' cultivar is distinguished by small, bright yellow flowers gathered in dense, plume-like panicles at the ends of stiff, leafy stems, usually reaching 60 to 90 cm in height. Our aim was to develop a technology for the propagation and production of wrinkled goldenrod in a perennial nursery. The propagation technology was developed from herbaceous shoot cuttings made from May to June. The cuttings were 4–5 cm in size and rooted in a substrate based on high peat and sand mixed to a 1 : 0,5 ratio. The pallets with the cuttings were placed in an unheated plastic tunnel, where a high humidity of 90% was maintained throughout this phase. The tunnel was also shaded from excessive sunlight. The cuttings rooted to 80% in 40 days. Young plants were then transplanted into 2l pots in a green compost-based substrate. Observations were also made phenologically in ground cultivation, distinguishing between the vegetative and generative phases of the plants. We established that the vegetative phase ends in the second decade of July, when individual stems begin to branch into generative shoots on which inflorescences will form. The first flowers appear in the first decade of September and flowering continues until the first decade of November. Cultivation of goldenrod was then carried out in an unheated plastic tunnel, in ground beds. The flower harvest started in the last decade of August and continued until the end of November.

Keywords: young plants, perennial, propagation

P-2

Do recently released cultivars of *Ranunculus* and *Anemone* still need vernalization?

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It is well known that spring bulb species require a vernalization period to flower. For some species, such as *Ranunculus asiaticus* and *Anemone coronaria*, vernalization is facultative but does improve and/or hasten flowering. However, these observations are mainly based on cultivars that are no longer very popular. We thus initiated a study to identify the best combination of temperature (5, 7 and 10°C) and duration (15, 30, 45 and 60) of vernalization for different Italian cultivars of *Ranunculus* ('Elegance') and *Anemone* ('Mistral'), to optimize the timing of flowering but also total flower yield. A second series of tests with a subset of 3 vernalization treatments was run the second year. *Ranunculus* cultivars initiated growth during vernalization, and lower temperature did not affect their emergence rate. In contrast, the emergence of both *Anemone* cultivars was negatively affected by the lower vernalization temperatures. The tested vernalization temperatures did not hasten flowering in either *Anemone* or *Ranunculus* cultivars. However, a slight advancement in flowering was observed with the longer vernalization durations, albeit resulting in a reduced number of flowers and flowers of lower quality. As both species can grow under cool temperature, one can wonder if vernalization is really required prior to planting. More thorough studies are needed to improve our understanding of the environmental cues that trigger flowering in *Ranunculus* and especially in *Anemone* for which very little scientific information is currently available.

Keywords: cold exposure, flowering, geophytes, marketable flowers, *Ranunculaceae*, temperature

P-3

Impact of *Tobacco rattle virus* on the vase life of 'Sarah Bernhardt' peonies

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Tobacco rattle virus (TRV) is the most widespread virus of peonies. It can infect both herbaceous (*Paeonia lactiflora*) and tree (*Paeonia suffruticosa*) peonies. TRV symptoms most commonly consist of ringspots of alternating green and yellow concentric circles or a yellow-green mottle or mosaic. The impact of TRV on peonies is unclear. Symptoms are not expressed in flowers and observations suggest there is no marked reduction in the vigor of infected plants. To determine TRV's impact on the postharvest quality and vase life of flowers, a display trial was conducted with 'Sarah Bernhardt' flower stems harvested from PCR-tested TRV+ and TRV– plants. Stems were placed in jars containing water and displayed in a lighted display room maintained at 20°C. A total of seven pairs of jars containing either three TRV+ or three TRV– stems were included in this trial. Changes in the condition of the flowers were monitored daily. The diameter of the open flowers was measured on day 5, and the vase life was based on the number of days before flower petals exhibited any symptoms of wilting and/or loss of petals when the flower was gently shaken. Statistically, there was no difference in the flower size or vase life of the flowers from TRV+ and TRV– plants. All the flower buds opened within the first day and the average size of the TRV+ and TRV– flowers was 13.2 cm and 13.0 cm, respectively. The TRV+ and TRV– flowers had an average vase life of 6.8 and 7.0 days, respectively. While no difference in flower quality and vase life was observed in this trial, additional studies are needed to determine if TRV infections have any impact on flowers from other cultivars. Studies are also needed to determine, what if any impact TRV has on the vigor and productivity of peonies.

Keywords: herbaceous peony, *Paeonia lactiflora*, *Paeonia suffruticosa*, tree peony

P-4

Changes in biomass partitioning based on phenological observation in *Lilium* hybrids

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Phenology is an indicator of life development in biological events through cyclical or seasonal changes. Biomass partitioning is important for characterizing plant developmental processes and an indicator of crop growth status. This study was conducted to determine changes in biomass partitioning across developmental stages in *Lilium* hybrids. The developmental stages were defined by phenological observation based on the BBCH-scale in two *Lilium* cultivars. Growing degree days (GDD) in developmental stages were calculated for each cultivar. Fresh and dry weights of bulblets, bulb roots, stem roots, stem, leaves, and floral organs were measured and applied to the phenological scale. Leaf chlorophyll content (SPAD value), the number of leaves, and leaf area were also monitored during the growing period. The total biomass continued to increase until leaf senescence, although it slightly decreased at the shoot emergence stage. Stem roots were developed at the visible flower bud stage. However, the bulb biomass gradually decreased from shoot emergence to full blooming regardless of cultivars and then started to increase from 50% flower opening stage. Leaf numbers and area increased during the leaf development stage and maintained from the visible flower bud stage to leaf senescence, and a similar trend was observed in the stem and leaf biomasses. SPAD value began to decrease at the end of the flowering stage, and this change allowed the identification of the shift in the developmental stage towards senescence. These results demonstrated biomass allocation change in accordance with developmental stages. The findings will be applied to developing a crop growth model in *Lilium* hybrids.

Keywords: biomass partitioning, developmental stage, GDD, *Lilium*, phenology

P-5

Flower bulbs in Mexico in relation to world production

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The international trade of flowers is a very dynamic activity of the world economy, which generates more than 35,000 million dollars, with annual growth rates of 6%. Within this sector, the world production and trade of flower bulbs is also important with more tan 31,000 hectares of which the Netherlands represents 65% (20,150 in 2008 and 21,400 in season 2020/21) of the world production with 10,000 million bulbs that include tulip, lily, hyacinth and daffodil species. Regarding Mexico, 5,168 hectares of bulb flowers are cultivated with a production value of 152 million dollars, Gladiola being the one that represents 87% of its surface, lilium, tulip and dahlia cover only 13%. The states of Mexico and Puebla represent 63.3% of its total surface. While Mexico City, Morelos, Michoacán, Guerrero, Veracruz and Oaxaca cover 36.7%. Mexico depends on bulbs from the Netherlands to obtain quality flowers. 100% of the producers import lilies and tulips. And in gladiola 72.3%. Bulbs are grown in 145 countries, with the Netherlands, Canada, USA, Belgium, Israel, England, New Zealand, Germany and Chile being the main exporters. In Mexico, for 20 years, international participation in the flower and vegetative material markets has reached only 3% and during this period the trade balance of all flower products in some years has shown a deficit. The free trade agreements TLC (1994) and T-MEC (2020) has had little impact on the flower sector, since of the 3,300 producers of bulb flowers, only 3.7% are dedicated to exporting to the United States and Canada. Given this scenario, the production of quality vegetative material, the search for international markets, post-harvest handling and packaging of products must be improved, as Colombia, Chile, the Netherlands, Israel and China have done.

Keywords: countries, technology change, trade agreements

P-6

The effect of varying greenhouse conditions for forcing *Cymbidium* orchids growth in a tropical climate region

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Cymbidium is a popular orchid in the world market. The demand in the Flora Holland auction was approximately 22.8 million stems in 2015 (AIPH, 2016). Thailand imported *Cymbidium* from China because the production area is too limited to only in highlands at an altitude of 1,000 meters above sea level. Therefore, growing *Cymbidium* in a controlled environmental greenhouse was the way to solve the problem. This research aimed to study the effect of greenhouse temperatures on controlling the flowering of *Cymbidium*. Three years, *Cymbidium* 'Fuku Musume' was selected and grown in a 50% shading greenhouse (with avg. light intensity of 260 μmol m^{-2} s^{-1}, relative humidity (RH) of 70%, and temperature 26–30°C) for 3 months before moving to different greenhouse condition treatments. The experimental design was completely randomized design (CRD) with 3 treatments, 8 replications (pots) i.e., T1) plants were continuously grown in 50% shading greenhouse for 5 months, T2) plants were moved to evaporative greenhouse (with avg. 200 μmol m^{-2} s^{-1} light intensity, 85% RH and temperature being 20–25°C for 5 months and T3) plants were moved to glasshouse (with avg. 100 μmol m^{-2} s^{-1} light intensity, 80% RH and temperature being 18–20°C). Liquid fertilizer was supplied every week with 500 ml/pot. The number of leaves per plant and leaf length were measured monthly for 5 months. Flowering percentage, flower quality, leaf color intensity, photosynthesis rate, transpiration rate, and stomatal conductance were recorded. The results found that different greenhouse conditions did not affect leaf length. Hɔwever, growing *Cymbidium* in the glasshouse (T3) increased leaf color intensity. The flowering percentage was the highest, about 87% in T3, and flower abortion was found in T1 and T2. Photosynthetic rates of *Cymbidium* reached a maximum value at 10:00 a.m. Forcing *Cymbidium* by growing in a 50% shading greenhouse for 3 months before transplanting to a glasshouse could stimulate flowering within 144 days with 2 stems/pot with 12.4 florets/stem, 64.9 cm of inflorescence length.

Keywords: agricultural management, control flowering, crop improvement, crop management, cymbidium, growth and development, temperature

P-7

Longevity of *Lachenalia* cut flowers

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Lachenalia (*Asparagaceae*) is a bulbous gephyte endemic to winter-rainfall region of southern Africa. A breeding program resulted in obtaining extremely attractive cultivars with high potential for commercialization on the international market of cut and potted flowers. In this study, *Lachenalia* cultivars, 'Ronina' (yellow flowers) and 'Rupert' (lilac-purple flowers), were evaluated for a vase life of inflorescences. Stems were cut from plants forced in a greenhouse and then placed in glass vases filled with distilled water. The first flowers dried on the inflorescence stem after 12 or 10 days in 'Ronina' and 'Rupert', respectively. The tested genotypes turned out to be very long-lasting. After 24 days of experiment in 'Ronina' and 20 days in 'Rupert', half of the flowers in the inflorescence were still open and kept the right turgor and color. On the 28th and 24th day in 'Ronina' and 'Rupert', respectively, more than 20% of flowers in inflorescences were still decorative. Finally, all flowers (or unopened buds) withered on day 30 in 'Ronina' and on day 26 in 'Rupert'. All the buds of 'Ronina' cultivar developed into mature flowers but in case of 'Rupert', more than 30% of the green buds did not open at all. The obtained results indicate that the tested cultivars are characterized by slow-to-age and long-lasting flowers, which even during aging retain their decorativeness, slightly changing color.

Keywords: African geophyte, Cape hyacinth, 'Ronina', 'Rupert', vase life

P-8

Breeding of *Rudbeckia hirta* L. using mutation techniques

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The role of mutation breeding in ornamental plant breeding has increased significantly in recent decades. Within mutation breeding, gamma radiation is a very effective method, as phenotypically different variants can be created relatively easily. And this will be very necessary in the future, as the trade in ornamental plants constantly requires new cultivars, and in addition, due to climate change, cultivars resistant to abiotic stress are becoming more and more important. *Rudbeckia hirta* L. has long been a very popular species in urban landscaping. *Rudbeckia hirta* is officially an annual species, but it can be grown as a short-lived perennial in several countries – mainly due to climate change since increasing global warming. The famous Hungarian *Rudbeckia hirta* cultivars create a very rich gene bank for breeding. The plants created during different doses of gamma radiation can be suitable as the genetic basis of new cultivars. In our measurements, we used different doses of gamma radiation, and we subjected the variants to morphological, histological tests. The aim of our measurements is to breed new cultivars for public areas that can withstand the current climate.

Keywords: annual, climate, cultivar, gamma, novelty, ornamental, perennial

P-9

Use of miscanthus-based substrate in nursery production of *Rudbeckia fulgida* 'Goldsturm'

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Rudbeckia fulgida 'Goldsturm' is a medium-height perennial with an erect, straight stem covered with fine hairs. Clasping leaves wrap around the stem, the lower leaves are characterized by a broad ovate shape with a sharp tip and serration, while the upper leaves are lanceolate in shape and are entire-edged, also covered with rough hairs. The outer lingual flowers are yellow, while the inner tubular flowers are dark brown. The bottom of the basket is strongly convex. Flowering in the climatic conditions of Poland takes place in summer and early autumn – from July to mid-October. The plant reaches a height of 40–60 cm. The purpose of the study was to examine the suitability of fresh miscanthus straw in *Rudbeckia* nursery production used both separately and in substrate mixtures. We considered five types of substrate mixtures – mixtures containing 100% peat, 100% miscanthus straw, a mixture of 50% each of straw and peat, and a mixture of 70% peat and 30% miscanthus and 70% miscanthus and 30% peat were used. Each mixture was treated with three fertilizer mixtures: Basacote (3 g·dm^{-3}, premixed with substrate), Basacote (3 g·dm^{-3}, premixed with substrate) + YaraMila Complex (top dressing, three times during vegetation period at a dose of 1 g·dm^{-3}) and YaraMila Complex (3 g·dm^{-3}, premixed with substrate and top dressing, three times during vegetation period at a dose of 1 g·dm^{-3}). The tests were performed in an outdoor nursery – rooted plant cuttings were transplanted into 3L pots with the appropriate substrate mix and placed on black nursery fabric with sprinkling irrigation. For each fertilizer mixture, plants had greater height and diameter in the substrate that was 100% peat, but greater leaf size and area in the mixture of 50% peat and miscanthus. Both average plant height and inflorescence diameter were lowest for substrates predominatly made of miscanthus straw. The average number of leaves per plant was smallest for substrates based mostly on miscanthus.

Keywords: grow, fertilizer, perennial

P-10

Phenotypic and cytogenetic characteristics study of winter hardy woody and herbaceous *Hibiscus*

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Modern plant breeding requires knowing phenotypic features and information on cytogenetic traits prior to the breeding program. The purpose of this study was to determine phenotypic and cytogenetic characteristics of winter hardy woody and herbaceous *Hibiscus*. Four cultivars from woody *Hibiscus syriacus* and two cultivars from herbaceous *Hibiscus moscheutos* were used in this experiment. Among the study materials, *H. moscheutos* 'Carousel Jolly Heart' had the largest flower diameter (16.70 cm), with a crimson color, whereas *H. syriacus* 'Yaum,' had the smallest flower size (9.60 cm), with light pink color. The leaves of *H. syriacus* 'Yaum' and 'Freedom' were lanceolate and the leaves of *H. moscheutos* 'Carousel Jolly Heart'were elliptical. *H. syriacus* 'Sukim', 'Wasung' and *H. moscheutos* 'Carousel Pink Passion' had palmate leaves. Chromosomes' number reported in *H. moscheutos* was 38 while *H. syriacus* 'Sukim', 'Freedom', 'Wasung' and'Yuam' possessed 84, 84, 82, and 86 chromosomes sequentially. According to fluorescence *in situ* hybridization (FISH) results, two 5S rDNA loci were detected in all cultivars of *H. syriacus* and *H. moscheutos*. While four 18S rDNA loci were detected in *H. syriacus*, *H. moscheutos* 'Carousel Jolly Heart' and 'Carousel Pink Passion'. Flow cytometry results showed, 2C-DNA contents of *H. syriacus* 'Sukim', 'Freedom', 'Wasung' and 'Yaum' had 4.18, 4.27, 4.17, 4.08 pg respectively whereas 'Carousel Jolly Heart', and 'Carousel Pink Passion' had 2.06 pg and 2.05 pg correspondingly. These findings will help with the in-depth cytogenetic investigation of *H. syriacus* and *H. moscheutos*, which will assist with plant breeding in this genus.

Keywords: 5S rDNA, 18S rDNA, cytogenetics, fluorescence *in situ* hybridization, phenotype

P-11

Effect of aeration and volume of medium on biomass growth and shoot propagation in bioreactor cultures of *Heuchera*, *Hosta* and *Echinacea*

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Production efficiency in bioreactors depends primarily on the method and degree of aeration of the culture immersed in the medium, conditioned by the construction of the vessel, the way the system works, and the production technology. A bioreactor Setis™ was selected for the experiment, which makes it possible not only to set the frequency of culture immersion with the medium but also the frequency of aeration of the culture and the volume of the medium. The aim of the experiment was to establish the effect of aeration (20 sec/120 min or 60 sec/120 min) and volume of medium (1200 or 1800 mL in a six-liter culture vessel, with a culture density of 10 explants per 200 mL of medium) on the growth of six *Heuchera*, *Hosta*, and *Echinacea* genotypes. For each genotype, predetermined optimal compositions of propagation media as well as frequencies of immersion were used. After four weeks, the indexes of shoot multiplication and biomass growth were determined. Both indexes were genotype-dependent. The multiplication of shoots can be intensified by increasing the volume of the medium in the case of both *Heuchera* cultivars and one of the *Echinacea* cultivars. The growth of *Heuchera* biomass is affected by the volume of the medium and aeration. Increasing the media volume and extending the aeration time (up to 60 sec) is conducive to *Heuchera* biomass growth. Extending the aeration time resulted in a decrease in the number of shoots obtained in one of the *Hosta* cultivars. Depending on the levels of the aeration time and volume of medium, the shoot multiplication and biomass growth indexes were, respectively, were as follows: 4.9–16.4 and 5.6–19.2 in *Heuchera*, 2.4–5.2 and 17.9–39.9 in *Echinacea*, 3.2–5.8 and 4.5–10.6 in *Hosta*.

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Keywords: *in vitro*, perennials, Setis, temporary immersion system

P-12

Effect of fluridone on the growth and some physiological features in leaves and roots of uncooled *Muscari armeniacum* bulbs

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The herbicide fluridone (1-methyl-3-phenyl-5-[3-trifluoromethyl(phenyl)]-4(1H)-pyridinone) disrupts the carotenoid biosynthetic pathway in plants. Fluridone inhibits the activity of phytoene desaturase, the enzyme responsible for converting phytoene to phytofluene, and indirectly inhibits the biosynthesis of plant hormones such as abscisic acid (ABA) and strigolactones. Fluridone also affects many physiological and biochemical processes related to plant growth and development. For our experiments with fluridone, uncooled *Muscari armeniacum* bulbs with fully differentiated primary roots were used. Continuous soaking of bulbs with fluridone at concentrations of 5 and 10 mg/l significantly inhibited root growth and caused the appearance of lateral roots. Besides, in the leaves of growing and treated with fluridone *M. armeniacum* plants, chlorophyll was degraded and red color appeared on them. Histological analysis showed that in *Muscari* leaves, anthocyanins are found only in the parenchyma, but not in the epidermis. Chlorophyll, carotenoids and anthocyanin analyses were carried out in the leaves of treated and untreated *M. armeniacum* plants. The results presented will be discussed with the results of available studies on the physiological and biochemical effects of fluridone on other plant species. It is worth mentioning that fluridone is considered as a new anti-inflammatory drug.

Keywords: anthocyanins, carotenoids, chlorophyll, fluridone, *Muscari armeniacum*

P-13

Effect of biostimulant Kelpak SL on growth, flowering and tuber yield of *Dahlia*

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Dahlias (*Dahlia hybrida*) are a valuable group of seasonal plants for growing in home gardens, landscaped areas, and as cut flowers. The advantages of the plants include a huge selection of cultivars, with varied size and shape of inflorescences, rich colors, and low cost of cultivation. The main problem is a low durability of cut flowers and large differences in yield of cultivated varieties. Two cultivars were used in the study: 'Franz Kafka' and 'White Aster' from the pompon group. Dahlias were grown from cuttings, obtained from mother carpels. The seedlings were planted in the open ground on June the 1st. Spraying with Kelpak SL biostimulant based on seaweed (*Ecklonia maxima*) at concentrations of 0.5%, 1.0% and 1.5% was carried out twice: 30 and 60 days after planting. During the growing season, plant height was measured twice, 3 weeks after the application of sprays. Inflorescence shoots were cut successively from August 23 till the end of September. In the case of both varieties cut shoots had several flowers, single inflorescences were not cut due to too short peduncles. The length and weight of inflorescence shoots, as well as peduncle length and flower diameter were analyzed. The yield of inflorescence shoots and the number of flowers were determined. The root carpels were dug out on October the 30th, and the weight of root tubers, number and length of tuberous roots were determined. Plant height after applying Kelpak SL as a spray at a concentration of 1.0–1.5% was higher than in control plants by 18–20% in 'Franz Kafka' and by 15–35% in 'White Aster'. Kelpak SL stimulated flowering of dahlias. The cultivar 'Franz Kafka' had 26% more inflorescence shoots and 51% more flowers were obtained. In 'White Aster' dahlias, the increases were, respectively: 20% and 34%. Kelpak SL applied at a concentration of 1.5% had a beneficial effect on shoot length and weight. There was no effect of the applied treatments on inflorescence diameter and inflorescence peduncle length. The biostimulant applied by foliar spray at a concentration of 1.5% favorably affected the weight of root stalks in the cultivar 'Franz Kafka'. The cultivar 'White Aster' treated with the biostimulant at a concentration of 0.5–1.5% formed longer root tubers, but no differences in the number and weight of root carpels were noted. The preparation had a beneficial effect on flower filling, shoot stiffness and leaf greening.

Keywords: foliar spray, quality of cut flowers, seedlings, yield of cut flowers, yield of root tubers

P-14

Effect of gibberellic acid on growth, flowering and tuber yield of *Dahlia*

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Dahlias (*Dahlia hybrida*) are popular cut flowers in summer and autumn. Their beautiful, colorful flowers are used for wedding and occasional bouquets and for interior decorations. Due to the low vase life of the flowers, they are not exported and their production is mainly local. The advantages of growing dahlias are low costs, low requirements of plants and a wide selection of varieties. The problem in cultivation is the large variation in the yield of cultivars, as well as the quality of the inflorescence stems. For cut flower cultivation, root tuber consisting of several tuberous roots are mainly used. In the present study, the possibility of growing dahlias for cut flower from stem cuttings was analyzed. Two cultivars from pompon flowers group: 'Franz Kafka' and 'White Aster', were used for experiments. The cuttings were rooted in March in the greenhouse and planted in the ground on June the 1st. Gibberellic acid GA_3 and GA_{4+7} (Gibb Plus 11SL formulation 75% GA_4 and 25% GA_7) were used for spraying at concentrations of 50, 100 and 150 mg·dm^{-3}. Sprays were made twice: 30 and 60 days after planting. During the growing season, plant height was measured twice, 3 weeks after the sprays were applied. The inflorescence shoots were cut successively from August 23 to the end of September. In both varieties, the cut shoots had several flowers each (twig cultivars). The length and weight of inflorescence shoots, as well as the length of the peduncle and the diameter of the flowers were measured. The yield of inflorescence shoots and the number of flowers were determined. Tuber carpels were dug out on October the 30th, the weight of root tubers, the number and length of tuberous roots were determined. GA_3 and GA_{4+7} applied at a concentration of 100–150 mg·dm^{-3} significantly increased plant height after a single spray application. After the second application, on already proliferated dahlias, gibberellic acid showed a strong stimulating effect even at a low concentration of 50 mg·dm^{-3}. The response of cultivars to gibberellic acid varied. In the case of cultivar 'Franz Kafka', GA_3 at 100–150 mg·dm^{-3} and GA_{4+7} at 150 mg·dm^{-3} increased the number of inflorescence shoots by 13–20% and 39%, respectively, and the number of inflorescences per plant on average by 10–21%. The cultivar 'White Aster' produced the most shoots and flowers (60 to 100% more) after application of GA_3 and GA_{4+7} at a concentration of 150 mg·dm^{-3}. Both cultivars treated with gibberellic acid produced shoots with lower fresh weight and smaller flower diameter. GA_3 had a stronger negative effect on these traits. Inflorescence shoots were characterized by lower stiffness compared to control plants. There was no effect of gibberellic acid on the yield of tubers and their biometric traits.

Keywords: dahlia, cut flowers, gibberellin, flower quality, foliar spaying, yield of cut flowers, yield of root tubers

P-15

Micropropagation, acclimatization and *in vitro* mutation breeding of ornamental perennial *Veronica* hybrid

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Perennial hybrids obtained from *Veronica spicata* and *V. longifolia* cross-breeding have been recently gaining the interest of gardeners and landscapers for their exceptional ornamental candle-shaped inflorescences, long flowering period and a palette of flower colors: from dark violet, purple and pink hues to white. The aim of the experiment was to elaborate the protocol for micropropagation and mutation breeding of *Veronica* hybrids.Three genotypes were selected for experiments, namely A,B and C, differing in colour. As starting explants third to fifth nodal segments of stems were excised from outdoor pot cultivated mother plants. The efficient disinfection (70% of sterile explants) was conducted with 1% sodium hypochloride with a drop of thymus oil for 10 min. For further multiplication stage the genotype A was chosen, since the other formed flowers *in vitro* at establishment stage. Clonal multiplication was conducted with single-node explants cultured on MS based medium supplemented with 0–0.3 mg/L of kinetin. The highest propagation rate was observed on medium with the highest kinetin concentration. Leaves and internodes segments were tested in terms of adventitious shoots formation for breeding purposes. Internodes formed more shoots than leaves, for both types of explants the best results were obtained on medium supplemented with 0.6 mg/L BAP and 2 mg/L IAA. Rooting of shoot tips with five fully developed leaves was performed on half-strength MS medium supplemented with 2.0 mg/L IAA. Root primordia of 1 mm length appeared after 11 days. The highest quality of acclimatized microshoots was observed with the application of BaktoTarcza (BioLider, Poland) microbial additive to substarte.For breeding experiments, leaves and internodes *in vitro* were irradiated with high-energy photons followed by adventitious regeneration *in vitro*. The irradiation was performed with VitalBeam 2.7 (Palo Alto, USA) at beam energy of 600 MV, total delivered doses were 5, 10 and 15 Gy, the dose rate was 4.95 Gy/min. The regeneration efficiency was affected by the dose delivered and explant type: the lowest number of adventitious shoots were formed on leaves irradiated with 15 Gy.

Keywords: micropropagation, mutation breeding, *Veronica spicata*, *Veronica longifolia*

P-16

Bioactive compounds analysis in inflorescences of Polish winterhardy hybrids of chrysanthemum: the preliminary evaluation of possible herbal applications

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Chrysanthemum are not only the topmost ornamental plants worldwide but they also play an important role in Asian traditional medicine as well as cuisine. In Europe chrysanthemums are mainly greenhouse produced for ornamental purposes, both as pot and cut flowers, the small share of production is dedicated for landscape application. Herbal uses of chrysanthemums are hardly known in European countries, therefore cultivars showing the potential for herbal application that can be field cultivated in Europe are missing. The aim of our study was to take an attempt of evaluation of Polish winterhardy chrysanthemum hybrids in terms of bioactive compounds content. Nine genotypes were selected from the group of winterhardy Gardy hybrids (*Ch. morifolium* × *Ch. rubellum*) aimed at the flowering earliness. The white, full type chrysanthemum purchased from commercial grower as traditional Chinese tea cultivar served as reference plant. The inflorescences at full flowering were collected in September and they were submitted to bioflavonoids and carotenoids estimation with spectrophotometric method following the extraction. Three genotypes, namely CD4, CD26 i CD31, showed significantly higher bioflavonoids content than reference cultivar. Since these genotypes present also valuable appearance, hardiness and earliness of flowering, they can be valuable components of herbal gardens with double application: ornamental and edible.These preliminary studies will be continued in terms of more detailed specification of bioactive compounds content in Polish hardy chrysanthemums and they potential uses in herbal medicine.

Keywords: bioflavonoids content, *Chrysanthemum rubellum* × *Ch. morifolium*

P-17

Controlling plant height in three oxalis (*Oxalis* spp.) using plant growth regulators

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The shamrock plant (*O. regnellii*), purple shamrock (*O. triangularis*) and iron cross shamrock (*O. deppeii*) are specialty potted floriculture bulb crops, grown for their clover-like leaves and flowers and are commonly produced around the St. Patrick's Day holiday. Applications of plant growth regulators (PGRs) (anti-gibberellins) can be applied to many different greenhouse grown potted plants during production to assist in controlling plant height in order to achieve quality, marketable plants. The objective of this research was to quantify the efficacy of different commercial PGRs on plant growth and development in pre-plant rhizome soaks and substrate drenches of different oxalis species. In experiment one, *O. regnellii*, *O. triangularis*, and *O. deppei* rhizomes were soaked before planting in different PGR solutions of water (control), flurprimidol (50, 100, and 200 ppm), paclobutrazol (50, 100, and 200 ppm), uniconazole (5, 10, and 20 ppm), or ethephon (100, 250, and 500 ppm). In a second experiment, *O. regnellii* and *O. deppei* plants were treated with media drenches of the same PGRs; water (control), flurprimidol (0.25, 0.50, and 1.0 mg a.i.), paclobutrazol (0.125, 0.250, and 0.375 mg), uniconazole (0.025, 0.05, and 0.1 mg), or ethephon (100, 250, and 500 ppm). Our results showed all concentrations of paclobutrazol, flurprimidol, and uniconazole pre-plant rhizome soak treatments, for all three species, significantly reduced plant heights, between 54% and 98% compared to control plant heights. Ethephon pre-plant treatments reduced plant heights for *O. regnellii*, while they increased *O. deppeii* plant heights up to 33%. Similar results were found in media drenches; compared to control plants, plant heights were reduced between 24% and 77% for paclobutrazol, flurprimidol, and uniconazole treatments in both species. Ethephon 100 and 250 ppm treatments increased plant heights, while 500 ppm treatments reduced plant heights.

Keywords: floriculture, greenhouse production, horticulture, media drench, potted plants, rhizome

P-18

Performance of *Achimenes* in landscape trials

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Achimenes are a member of the *Gesneriaceae* and a geophytic herbaceous plant, arising from scaly rhizomes. The genus has typically been produced for use as a potted flowering plant and used in mixed containers and hanging baskets. Plants bloom continuously throughout the summer in a wide spectrum of colors; reds, yellows, pinks, blues, violets, and whites, in single and double forms. However, limited cultural information exists on landscape use of *Achimenes*. The objective of this study was to assess plant performance of several *Achimenes* cultivars in different landscape microclimates at two different geographic locations in public garden spaces at Kansas State University [(KSU) Manhattan, KS USA] and Colorado State University [(CSU) Fort Collins, CO USA]. Plants were evaluated in two landscape situations: in the ground and in large planters. Plants were evaluated in sun and part-shade to shade conditions. Growth parameters measured included plant height and width, ratings (scale of 0 to 6) for water spotting, sunscald, and overall plant quality were recorded weekly for 6 weeks. At KSU, 'Purple Prince' achimenes were planted into the landscape on 21 Jun and data collection ended on 2 Aug 2023. At CSU, several cultivars were planted in the landscape on 12 Jul and data collected ended on 24 Aug 2023. 'Pink Clouds' was trialed in both containers and in the ground soil. 'Purple Prince' performed better in the soilless substrate of containers compared to the soil. Similarly, 'Pink Clouds' performed slightly better in soilless substrate plantings. Plant quality for 'Purple Prince' deteriorated rapidly in high light intensity environments, and sun scald ratings were ~two ratings units worse in sun compared to shade each week. Water spotting from cold irrigation water, which causes irreversible foliar damage, limits overhead irrigation in the landscape. 'Pink Clouds' was more resistant to foliage damage.

Keywords: floriculture, gesneriad, horticulture, hot water plant, monkey-faced pansy, nut orchid

P-19

Effects of exogenous plant growth regulators on rhizome coloration in red rhizome lotus

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Lotus (*Nelumbo nucifera* Gaertn.) is an aquatic plant cultivated for edible as well as ornamental uses in Japan since ancient times. Of these, 'Tomohiro' is a remarkable cultivar because of its reddish rhizome coloration. The flower color of the cultivar is deep-red, darker than other red flower cultivars, so that it is expected to have high commercial potential. Rhizomes of the cultivar are not colored in the early stages of growth, and rhizome coloration develops as growth progresses. In common white rhizome lotus, it was reported that rhizome growth can be controlled by plant growth regulators. Rhizome elongation was promoted by the treatment with gibberellin, and rhizome hypertrophy was observed under the treatments with the gibberellin biosynthesis inhibitors and abscisic acid (ABA). However, the effects of plant growth regulators on rhizome growth and flower coloration in red rhizome lotus have been unknown. In this study, the effects of ABA and ethephon treatments on rhizome growth and coloration in red rhizome lotus 'Tomohiro' were investigated. There was no flowering in 'Tomohiro' in each treatment because of the limited cultivation area and genetic backgroung, so that effects of exogenous plant growth regulators on flowering was not elucidated. The results showed that 25 mg·L^{-1} ABA treatment enhanced red coloration of rhizome in both epidermal and internal parts, especially, at the distal internodes, whereas 10 mg·L^{-1} ethephon treatment delayed coloration in both parts of the rhizome. The results indicate that 25 mg·L^{-1} ABA treatment is effective for promoting red coloration in red rhizome lotus.

Keywords: abscisic acid, anthocyanin, gibberellin biosynthesis inhibitor, *Nelumbo nucifera*

P-20

Dynamic climate changes determine the new directions in ornamental perennials introduction in Poland

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The consequence of rapid climatic changes in last dozens of years are rising average air temperature and prolonged the growing season. The dormancy period, plant phenology, the life cycle of animals are undergoing significant changes and leading to the necessity of changing the existing preferences in the selection of ornamental plants for cultivation. The extreme weather events, e.g., record-breaking heat waves, drenching rains, severe floods, years-long droughts, extreme wildfires, are becoming a "new norm" and intensifying a risk of plant production. Simultaneously, the climate change encourage plant invasions and spreading of invasive species regards to the geographic areas and various communities. The problems concern also ornamental plants, which determine the well-being of human especially in the anthropogenic environment of urbanized areas. The properly new ornamentals should be considered to the Green and Blue City ideas implementation in urbanized areas with a high degree of anthropopression and to the gardens with extensive methods of cultivation. The perennials create a favorable conditions for trees, pollinators and little animals life. In this work, we propose the rarely or unknown in cultivation species for north-east Europe, which currently occupy the areas with high biodiversity value, including biodiversity hotspots: (i) Mediterranean coasts and islands; (ii) Turkey, Iran; (iii) Caucasus; (iv) Altai; (v) Middle Asian mountains. The some of them are endemic and their cultivation may contribute to protect them. Exploration, especially of areas identified as biodiversity hotspots, can yield valuable taxa of ornamentals. There are, e.g. *Anchusa* sp., *Anemone* sp., *Anthericum liliago*, *Asphodeline lutea*, *Catananche caerulea*, *Corydalis caucasica*, *Crepis rubra*, *Digitalis lanata*, *Echium* sp., *Galega officinalis*, *Onosma* sp., *Vincetoxicum arundinaria*. However, their possibility of cultivation and impact on biodiversity should be assessed before they will be introduced to the production, bearing in mind that horticulture is an important source of invasive alien species.

Keywords: biodiversity, coastal flora, endemic plants, invasive species, mountain flora, water fluctuations

P-21

Hotspot geophytes may support biodiversity in green areas in Poland under changing climate conditions

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The droughts, heat waves and floods are considered to be the most destructive natural hazards connected with the climate changes in temperate zone. The changes in bud dormancy, plant phenology and simultaneously the life cycle of pollinators and herbivores are predicted. In the consequence, the numerous native species will no longer be able to develop in their current habitats and similarly the cultivated ornamental plants will not perform their function, due to lack of tolerance to new environmental conditions. Moreover, the currently tendences to the widening and rewilding the areas in cities and gardens could be difficult to realize in the anthropogenic environment, where the specific adaptation is needed. In conclusion, the geophytes presenting low level of invasiveness should be considered because of their ecological value for widening biodiversity of communities due to mostly early-spring or autumn flowering. The specific developmental mechanisms and whole-plant morphological diversity of geophytes present a growth model enabling adaptation to more seasonal climates and changing water and nutrients resources. Moreover, the higher tolerance to the salinity could be predicted in coastal taxa. The steppe and mountainous areas of middle Eurasian biodiversity hotspots present a particular wealth of geophytes, (i) Mediterranean Basin; (ii) Caucasus, (iii) Irano-Anatolian, (iv) Mountains of Central Asia. Numerous species coming from those regions are cultivated as known ornamentals, however their tremendous potential could be widely used in changing climatic conditions. Simultaneously, their cultivation and dissemination may contribute to the protection of threatened taxa. The following may be noticed as particularly noteworthy, *Allium* sp., *Asphodelus aestivus*, *Bellevalia forniculata*, *Colchicum* sp., *Corydalis caucasica*, *Crocus* sp., *Cyclamen* sp., *Drimia maritima*, *Eremurus* sp., *Erythronium caucasicum*, *E. dens-canis*, *Fritillaria* sp., *Iris* sp., *Hyacinthus litwinowii*, *Lilium ciliatum*, *Merendera sobolifera*, *Muscari* sp., *Narcissus* sp., *Nectaroscordium siculum*, *Pancratium maritimum*, *Romulea tempskyana*, *Scilla autumnalis*, *Sternbergia lutea*, *Tulipa* sp., *Ungernia sewerzowi*.

Keywords: autumn flowering, bulb, corm, green areas, ornamentals, temperate climate, underground storage organ

P-22

The effect of treatment of ornamental bulb plants on the settlement of bulbs and the substrate by fungi during the period of rooting and on the growth and development of plants

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The studies evaluated the effect of Bisteran (50% of silver-stabilized hydrogen peroxide) and the fungicides Biszop 80 WG (80% of captan), Signum 33 WG (67 g of piraclostrobin + 267 g of boscalid in 1 kg) and Yamato 303 SE (233 g of thiophanat methyl + 70 g of tetraconazole per l), used for dressing hyacinth and narcissus in the form of 30-minute soaking of bulbs to limit the development of fungi on bulbs and the substrate during the period of rooting in a cold store and their impact on plant growth and development. The research showed that silver-stabilized hydrogen peroxide (H_2O_2-Ag^+) at a concentration of 2% to 10% and fungicides used to treat bulbs on limiting the development of fungi on bulbs and the substrate during the rooting period. When the hyacinth and narcissus were in full bloom, biometric measurements were made of the above-ground parts of the plants, showing the growth and quality of the plants, and the content of chlorophyll, flavonoids and the nitrogen balance index index (NBI index) were determined using the Dualex 4 meter. For most of the tested traits, it was found that silver-stabilized hydrogen peroxide (H_2O_2-Ag^+) at a concentration of 2% to 10% and the tested fungicides significantly increased their parameters compared to control plants. However, depending on the tested plant species, the positive effect on the tested traits varied, therefore such studies must be carried out individually for a given plant species. It should be emphasized that none of the tested agents used to treat hyacinth and narcissus bulbs was phytotoxic. The obtained results may be useful for the practical application of hydrogen peroxide with silver as a completely safe agent for humans, animals and the environment in the form of dressing hyacinth and narcissus bulbs before rooting in a cold room.

The research was conducted as part of a research project co-financed by the European Union under the 'Cooperation' measure of the Rural Development Program 2014–2020 "Implementation of an improved product, innovative technology and production organization methods in the production of bulbous ornamental plants using high-pressure fogging of refrigerated rooms with silver-stabilized hydrogen peroxide".

Keywords: bulb rooting, fungicides, fungi on bulb surface and substrate, hydrogen peroxide stabilized with silver, *Hyacinthus*, inhibition, *Narcissus*, plant growth and development

P-23

In vitro effect of some compounds on fungi developing on bulbs during their rooting

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The *in vitro* effectiveness of Bisteran (50% of hydrogen peroxide stabilized with silver) and the fungicides Biszop 80 WG (80% of captan), Signum 33 WG (67 g of piraclostrobin + 267 g of boscalid in 1 kg) and Yamato 303 SE (233 g of thiophanat methyl + 70 g of tetraconazole per l) added to potato–dextrose agar (PDA), on the *in vitro* growth of *Neopestalotiopsis foedans*, *Penicillium olsonii*, *Rhizopus stolonifera* and *Trichoderma asperellum*, isolated from peat and bulbs of hyacinthus, narcissus and tulip during their rooting was evaluated. The product applied at concentrations ranging from 0.05% to 0.2%, inhibited the growth of *N. foedans* from 78.1% to 87%, and *P. olsonii* from 55.3% to 79% but did not influence the culture development of *R. stolonifera* and *T. asperellum* or only slightly stimulated the growth. Bishop 80 WP at a concentration of 0.19% almost completely inhibited the growth of *N. foedans*, *P. olsonii* and *R. stolonifera*, while *T. asperellum* at 75%. Signum 33 WG at concentration of 0.15% almost completely inhibited the growth of *N. foedans* and *P. olsonii*, *T. asperellum* in 92%, while *R. stolonifera* in about 21%. Application of Yamato 303 at a concentration of 0.15% resulted in growth inhibition for the tested fungus *N. foedans* 93%, *P. olsonii* 44%, *R. stolonifera* 7% and *T. asperellum* 99%, respectively.

The research was conducted as part of a research project co-financed by the European Union under the 'Cooperation' measure of the Rural Development Program 2014–2020 "Implementation of an improved product, innovative technology and production organization methods in the production of bulbous ornamental plants using high-pressure fogging of refrigerated rooms with silver-stabilized hydrogen peroxide".

Keywords: fungi, fungicides, *Hyacinthus*, hydrogen peroxide stabilized with silver, *Narcissus*, tulip

P-24

Nutrient deficiencies affect growth and development of *Curcuma* 'Golden Reign'

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Curcuma 'Golden Reign' is a beautiful gigantic tropical flower. It can be utilized in various ways such as landscaping plants, potted plant and cut flower. However, there are limited data about nutrient deficiency symptoms in ornamental curcuma. Therefore, the purpose of this experiment was to study effect of nutrient deficiencies on growth and development of curcuma plant. The curcuma rhizomes were grown in a hydroponics system. The experimental design was completely randomized design (CRD) for 3 replications per treatment and, 2 plants per replication with 14 treatments, T1: plants were supplied with complete solution as control treatment (Hoagland's solution), and T2-T14, plants were supplied with deficiency solutions of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), boron (B), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo) and deionized water, respectively. The results showed that at 18 weeks after planting, potassium deficiency treatment showed plant height lower than the control treatment. Moreover, the old leaves were burned, chlorophyll content in old leaves and young leaves were 26.50 and 31.20 SPAD unit, respectively. Magnesium deficiency treatment resulted in yellow color of old leaves and interveinal chlorosis. The shortest flower length was obtained from the boron deficiency treatment.

Keywords: fertilizer, flowering, ornamental curcuma, potted plant

P-25

Parks and gardens as a contributor to older people's perceived well-being and health

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Seniors are a group with specific requirements that also apply to the use of green spaces. The aim of the study was to analyse the relationship between the well-being and health of seniors and the perception and ways of using parks and gardens. Original non-standardised questionnaire was applied in the research, with: (1) self-developed questions regarding green areas, (2) questions about well-being, health and life satisfaction, and (3) the WHO-5 test. The survey was conducted in Poland, among people 61–98 years old. Analyses included descriptive statistics; frequency distributions; T-tests; ANOVA. Results indicated that, almost 90% of seniors declare that spending time outdoors is important or very important and those who describe their health as good or very good, 69% consider being outdoors as very important. In the group of respondents who describe their health as bad, only 50% recognise spending time outdoors as very important. People over eighty spend more than 7 hours a week in the garden, while younger seniors only from 1 to 3 hours a week. More than half of seniors (58%) prefer spending time in the garden, and only 22% favour the park. Seniors who feel very happy compared to seniors declaring non happy, often claim that a day spent in the garden contributes to a better quality of sleep and consider gardening as a form of physical activity. Unhappy seniors more likely declare that when they feel depressed, spending time in the garden lifts their spirits. Over 70% of seniors testify that pleasant memories are related to the garden from their childhood. The most remembered garden plants are: peonies (28% of respondents) and roses (26%), tomatoes (41%), and apples (38%). Research demonstrated that gardens and parks are an important contributor to older people's health and well-being.

Keywords: elderly citizen, green care, nature experiences, quality of life

P-26

LED light affects the biochemical composition of *Lilium candidum* adventitious bulbs formed *in vitro* on a cytokinin medium

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Lilium candidum (Madonna lily) is a bulbous geophyte that occurs naturally in the Mediterranean. It is characterized by early flowering in the season and pure white flowers with a strong pleasant fragrance. Bulb and flower extracts have been used in folk medicine, and scientific research has confirmed the presence of compounds with health-promoting properties. All this meant that the plants were obtained from natural sites and in some countries of origin the species is protected. We have evaluated biochemical composition of adventitious bulbs, contents of photosynthetic pigments (chlorophyll *a* + *b* and total carotenoids), soluble phenolics and soluble sugars in bulblets grown under different light conditions *in vitro*. Cultures were carried out under eight different LED lights, with fluorescent lamp and darkness used as a control. Murashige and Skoog medium has been enriched with 5 μM 6-benzylaminopurine (BA) and 0.5 μM 1-naphthaleneacetic acid (NAA). Bulbs formed under the mixture (7:3) of red and blue LED light (RB) were characterized by the highest content of all tested pigments. Lower but still high values were characteristic of bulblets from the white LED light (WLED) and RB light enriched with a UV diode (RBUV). This relationship was especially visible for chlorophyll *a* and *b*. WLED and RBUV, however, inhibited the synthesis of soluble phenolics, which was stimulated by blue LED light (B). In the case of soluble sugars, the light of the fluorescent lamp (FL) and WLED gave similar high values. Intermediate values were obtained under blue LED light. LED light can therefore be used to modify the biochemical composition of *L. candidum* bulblets in *in vitro* cultures. Blue or white LED light seem particularly valuable for this purpose.

Keywords: photosynthetic pigments, soluble phenolics, soluble sugars

P-27

Single-node cuttings constitute a highly efficient *Pennisetum* 'Vertigo®' propagation material

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Pennisetum 'Vertigo®' (*Poaceae*) is a newly released tender perennial hybrid most often recomended for container display. Because of pollen-and seed-sterility it is a vegetatively propagated ornamental grass with unique characteristics (burgundy-leaved, to 1.5 m tall). In present study the effect of four types of shoot single-node cuttings (with 1st, 2nd, 3rd, and 4th node, respectively, counting from the base of the grass crown) and two rooting media (peat and perlite) on the rooting proces were assessed. After a month it was found that, depending on the combination, the cuttings were 48–98% rooted, producing 1.4–2.6 roots per cutting, each 7.3–11.6 cm long. One shoot was formed on the rooted cutting, with 3.1–4.4 leaves on it, and the entire above-ground part of the rooted plant was 10.5–32.8 cm, depending on the combination. Results showed that, sterile *Pennisetum* 'Vertigo®' can be successfully propagated from shoot cuttings, but the rooting process depended on the type of cutting, with the benefit of those made from the nodes proximal to the grass crown.

Keywords: grass nodes, ornamentals, *Poaceae*, rooting media, vegetative propagation

P-28

The senescence of perianth and corona in cut daffodil ‘Dutch Master’ flowers

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Daffodils are one of the most known bulbous plants, most popularly chosen just after tulips and lilies. The most common, and also the most popular for cut flowers, are the Trumpet daffodil cultivars. The aim of the study was to evaluate the changes in cut daffodil ‘Dutch Master’ flowers and to find the response that the perianth senescence different way than corona in cut daffodil flowers and if the senescence of daffodil cut flowers is correlated with programmed cell death symptoms. Flower senescence is a highly organized process comprising structural, biochemical and molecular changes, which is the last stage of flower development, finally leading to death of an organ or organism. In order to evaluate the changes occurring during the senescence of daffodil ‘Dutch Master’ cut flowers, the content of total and reducing sugars, free proline, malondialdehyde, hydrogen peroxide, catalase activity and the degree of degradation of cell nuclei were determined. The effect of a preservatives based on nanosilver (0.1 or 1.0 $mg \cdot dm^{-3}$) and 10% sucrose on postharvest flower quality and the value of selected senescence parameters was also investigated. It was shown that during the senescence of cut daffodil flowers there is a decrease in the content of total and reducing sugars, a decrease in malondialdehyde content, an increase in free proline, hydrogen peroxide and an increase in catalase activity. One of the symptoms of flower senescence was the degradation of cell nuclei. Typical senescence processes occurred faster in the perianth than in the corona. The use of a preservative containing nanosilver with 10% sucrose does not affect the rate of flower bud opening, but extends the vase life of daffodil flowers by 2–4 days. This preservative also increases the reducing sugars content, decreases the free proline and hydrogen peroxide content and affects the decrease of the catalase activity.

Keywords: free proline, malondialdehyde, nanosilver, oxidative stress, postharvest life, preservatives, total and reducing sugars

P-29

Organic and conventional agriculture in tulip flower greenhouse production

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This study evaluated the development of tulip flowers in pots using different substrates in two production systems: organic and conventional under greenhouse conditions. The organic production system consisted of inoculating beneficial microorganisms (arbuscular mycorrhizal fungi, *Trichoderma* spp., and *Azotobacter* spp.) and using organic fertilization. The conventional system used commercial fertilizers and agrochemicals. The experimental design was completely randomized, with ten treatments and five replications, considering each pot as an experimental unit. The substrates included mixtures of tezontle (TZ), leaf mold (LM), peat moss (PM), and vermicompost (VC). All substrates included 20% TZ, and either LM and PM alone (80%) or a combination of two substrates (40% LM and 40% PM, 40% LM and 40% VC, or 40% PM and 40% VC). The tulip flowers were grown in the five substrate combinations using either organic or conventional (chemical) fertilization. Yield and plant quality (plant height, stem diameter, bud diameter, and open corolla diameter) were evaluated. The results of the contrast analysis showed that the organic agriculture system was superior to the conventional system since the tulips showed significantly larger stem and flower diameters. The best substrate for producing this species was the mixture of 80% LM + 20% TZ. Our study shows that tulip flower production in greenhouse conditions is feasible under the organic agriculture model.

Keywords: arbuscular mycorrhizal fungi, *Azotobacter*, *Trichoderma*, *Tulipa* spp.

P-30

Light emitting diode for off-season flowering of *Curcuma alismatifolia* Gagnep

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Curcuma alismatifolia Gagnep is one of the popular tropical flowers in the world market. Seasonal flowering in Thailand is in rainy season during July-August and plant goes to dormancy during December to February then start to sprout again in May. Off-season flower forcing could be done to serve market demand for all year round. Since *Curcuma alismatifolia* is facultative long day plant therefore this research was aimed to use different type of artificial light supplement for flower quality improvement. Rhizomes were stored in 15°C cold room for 6 months then they were grown in plastic bags using soil, rice husk charcoal, sand, rice hull and coconut dust with the ratio of 1:1:1:1:1 as growing media under plastic greenhouse (24°C, 65% RH and 1,000 μmol m^{-2} s^{-1}). The experimental design was completely randomized design with 6 treatments i.e. treatment 1) no supplement lighting, treatments 2–3) plants were supplied with different artificial lighting using 13 and 18 W of light emitting diode (LED), treatment 4–5 using 15, 24 W of compact fluorescent lamps (CFL) and treatment 6) using 400 W of high pressure sodium (HPS) lamp. Supplement lighting was applied at 20.00–22.00 o'clock every day until plant dormancy. Irrigation was done every day and 15 N-15 P_2O_5-15 K_2O fertilizer with 2 g/pot was supplied every 2 weeks. The results showed using LED lighting could promote the flower quality in term of flower stalk length and inflorescence height than control treatment. However, plants supplied with 400 W HPS gave the highest of plant height, flower stalk length, inflorescence height than the other artificial light sources and control treatment. Rhizome quality also was promoted by using artificial lighting supplement compared to control treatment.

Keywords: energy saving, flower quality, forcing, LED, supplement lighting

P-31

The effect of postharvest treatments with commercial preservatives on keeping qualities of cut peony flowers

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Special treatments and various preparations are used during all phases of the market chain to sustain life of cut flowers and to maintain their good quality. Recently, cut peonies have gained worldwide popularity so the development of appropriate postharvest treatments is in order. In this experiment two types of flower preservatives produced by Chrysal International and Floralife were tested on several peony cultivars: the so called „trade" preparations used to sustain flower life during the turnover (Chrysal Professional 2, Floralife 200) and the so called „flower food" preparations used to prolong the flower vase life (Chrysal Clear, Floralife 300). The first were applied for 72 hours after harvest, i.e. the period simulating the turnover phase; after that flower food preparations were used. The treatment effects were compared with those of the standard preservative composed of 2% sucrose plus 200 mg L^{1} 8-hydroxyquinoline (8-HQC), and distilled water was used as the control. The cultivars tested were: 'Charles Binder', 'Gayborder June', 'Jamachina', 'Laura Dessert', 'Marguerite Gaudichau', 'Othello' and 'Vogue', all of which responded poorly to the treatments and in all cases responses were cultivar-specific. The vase life was prolonged in only 9 out of 49 treatments, with 'Charles Binder' and 'Jamachina' showing no positive reaction to any of the holding solutions while 4 out of 7 treatments increased the vase life of 'Gayborder June'. The rate of bud opening was different among cultivars and flower diameters increased in *ca* 50% of cases – in 24 out of 49 treatments. As the responses to treatments were so cultivar-specific, any recommendations for specific preparations must be preceded by tests with individual cultivars.

Keywords: flower diameter, flower food, re-hydrating, vase life

P-32

The possibility of using new plant growth regulators in micropropagation of Polish tulip (*Tulipa* L.) cultivar 'Heart of Warsaw'

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High demand for tulip bulbs and accelerated introduction of new cultivars to the market prompt further work on improving the method of *in vitro* propagation of this genus. The object of the research was the new Polish cultivar 'Heart of Warsaw' (= 'Serce Warszawy', in Polish), baptized at the Royal Castle in Warsaw in 2019 at the opening of the Lower Gardens, the reconstruction of which was the culmination of the post-war rebuilding of the Castle. *Meta*-topolin(mT) – new aromatic cytokinin in micro-propagation of tulip and karrikin (KAR1) – completely new plant growth regulator (PGR) – were checked and compared with other PGRs at different stages of *in vitro* propagation on Murashige and Skoog (MS) medium using procedure of cyclic shoot multiplication. The results obtained from the regeneration and multiplication of the 'Heart of Warsaw' tulip show that it has been possible to replace so far used thidiazuron (TDZ) and 2-isopentyladenine (2iP) by mT at concentration of 5 mg L^{-1}. However, the results with supplementation of the MS medium with mT were mostly not better, but also not different from those obtained on media with TDZ and 2iP. The expected positive effect of KAR[1] on the shoot proliferation of the 'Heart of Warsaw' tulip has not confirmed so far, indicating the need for further research. In conclusion, the method of cyclic tulip shoot multiplication using mT can be used to accelerate the propagation of the new tulip cultivar under study.

Keywords: *in vitro*, karrikin, KAR1, *meta*-Topolin, mT, PGRs, Royal Castle in Warsaw

P-33

Evaluation of ploidy level and genome size of *Hippeastrum*

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Hippeastrum Herb. belongs to the family *Amaryllidaceae*. The genus includes about 80 taxa found in South American countries. In commercial cultivation, the most frequently cultivated varieties are those belonging to *H. hybridum*, which have been obtained by crossing several wild species (*H. vitatum*, *H. leopoldii*, *H. reginae*, *H. aulicum*, *H. pardinum*). The goal of most breeding programs in the world is to improve flower attractiveness and plant resistance to *Phoma narcissi*. Information on the registration of new cultivars in 2018–2022, published by the Dutch Royal General Bulb Growers' Association (KAVB), shows that as many as 158 new cultivars have been registered. The largest number of registered cultivars belongs to the Galaxy group (65 cultivars). In 1993, *Hippeastrum* ×*chmielii*, a hybrid characterised by strong growth, a high vegetative reproduction rate and no apparent dormancy period, was bred at the Warsaw University of Life Sciences – SGGW, Poland. However, the flowers of this hybrid are relatively small and there islittle variation in colour, oscillating between red and orange. Therefore, two of its breeding clones (Nos. 6 and 18) were used for further creative breeding. The aim of the present study was to evaluate the ploidy level and genome size of selected individuals derived from crosses between *H.* ×*chmielii* (clones 6 and 18) and selected cultivars of *H. hybridum* ('Gervase', 'Rio Negro' and 'Royal Velvet'). The ploidy levels and genome size of the parental forms and 15 selected breeding clones derived from the crossings were evaluated by flow cytometry and based on chromosome number using Feulgen and DAPI staining methods. The results obtained indicate that a large part of the population studied (14 genotypes) are tetraploid forms ($2n = 4x = 44$), and the size of their genomes ranges from 57.44 to 61.61 pg of 2C DNA. Four triploid genotypes ($2n = 3x=33$) were also detected in the population, whose 2C DNA content was 43.68–47.08 pg. The cultivar 'Rio Negro' has a diploid somatic chromosome number of $2n = 2x = 22$ andgenome size of 32.63 pg 2C DNA. The cultivar 'Gervase' proved to be a mixoploid with tetraploid (60.29 pg) and aneuploid (47.94 pg) genomes based on flow cytometry analysis.

Keywords: breeding clones, DAPI, Feulgen, flow cytometry, *Hippeastrum* ×*chmielii*

P-34

Ecological aspects of *Tulip virus X* in the Netherlands

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Tulip virus X (TVX) is a member of the genus *Potexvirus* and can cause symptoms in tulips consisting of fine streaks on leaves and flowers. Being a potexvirus, TVX spreads through contact between plants and the usage of tools. Also, transmission by several mite species during storage of the bulbs is common. However, there have been reports of a soil-related transmission, but there was no evidence of any vector involved in such transmission. In relation to the growing fields, it is remarkable that TVX has a broad host range and can be found in various weeds. Recent studies revealed the presence of TVX in tulips, weeds, soil and in water of ditches around the tulip fields. TVX in soil was infectious on indicator plants for months after inoculation of the soil. Currently, the biological significance of TVX in weeds and the detection of the virus in water is under investigation.

Keywords: *Potexvirus*, soil, tulips, TVX, weeds

P-35

Conservation of plant genetic resources in Lithuania

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The study and conservation of plant genetic resources (PGRs) in Lithuania has a long tradition. Since 1994, efforts on PGRs have been concentrated within the National Programme on Plant Genetic Resources. This Programme encompasses the conservation and research of the genetic resources of agricultural and horticultural crops, medicinal and ornamental plants, and forest trees. For the implementation of this Programme, the collaboration of eight scientific institutions started, including Vilnius University Botanical Garden and Vytautas Magnus University Kaunas Botanical Garden. In 2001, the Seimas (Parliament) of the Republic of Lithuania adopted the Law on National Genetic Resources of Plants, which regulates the accumulation, preservation, and use of National PGR and stipulates how to provide for the sustainable use of these resources, protect them from devastation, extinction and compete with destruction as well as to save the biological diversity. According to the provisions of this law, PGR, which have ecological, selective, and economic value for the Republic of Lithuania, are selected and included in the central database of the National PGRs. It might be plant cultivars, plant populations or their parts, single plants or their groups, or re-productional parts of plants (seeds, pollen, embryos, meristematic tissues, buds, sprouts, etc.). The Plant Gene Bank (currently – State Forest Service) with coordination centers of different plant groups (agricultural plants, forest trees, fruits and vegetables, ornamental plants, and medicinal plants) has been established. At the end of 2022, there were 5914 accessions on the National List of PGR in Lithuania. In 2022, the State Forest Service signed an agreement with the Nordic Center for Genetic Resources NordGen. According to this agreement, NordGen will store the seeds of 123 accessions of Lithuanian PGR in the Svalbard Global Seed Vault.

Keywords: biological diversity, database, ornamental crops, PGRs, preservation

P-36

Interspecific hybridization between *Cyclamen hederifolium* Aiton and *C. purpurascens* Mill.

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In recent years, horticultural cyclamen (*Cyclamen persicum*) cultivars have been used as garden plants as well as indoor potted plants in Japan. There are, however, few suitable cyclamen cultivars for growing in a garden in Japan, yet almost all cyclamen cultivars have been bred as indoor potted flowers. Nearly all the horticultural cyclamen cultivars have been bred through intraspecific cross-breeding in *C. persicum*, whereas some wild species in the genus *Cyclamen* have useful characteristics. *C. hederifolium* is one of the most vigorous and hardy species in the genus *Cyclamen*. Although almost all *Cyclamen* species, including *C. hederifolium*, have a dormant period in their life cycle in Japan, *C. purpurascens* doesn't have this trait. Therefore, interspecific crosses between *C. hederifolium* and *C. purpurascens* were performed. After the interspecific crosses, ovule cultures with and without chromosome doubling were also examined. The interspecific hybrids were obtained by the ovule culture, and some plantlets were expected to be amphidiploids. There was, however, no amphidiploid among the flowering hybrids. The hybrids were sterile, and showed an intermediate life cycle between those of *C. hederifolium* and *C. purpurascens*.

Keywords: hybrid, interspecific crosses, ovule culture

P-37

Effect of foliar fertilization on bulblet formation from leaf cuttings of *Lachenalia*

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Lachenalia species come from South Africa and have recently become more and more popular as attractive pot plants. Vegetative propagation methods of *Lachenalia* mostly include: seeds, side bulbs formed out of a mother bulb, bulbils (aerial bulblets) and bulblets production on leaf cuttings. In commercial reproduction, the method of leaf cuttings is more often used than in-vitro propagation. The aim of the study was to determine the effect of additional foliar fertilization using Agroleaf P fertilizer (12:52:5 +TE) during mother plants cultivation of two *Lachenalia* cultivars: 'Ronina' and 'Rupert'. It is assumed that increased P levels stimulate rooting in many species. Bulbs were planted in autumn into peat substrate and cultivated in pots at controlled climate chambers. Two months after planting the bulbs, when leaves reached 15–20 cm in length and 2.0–3.5 cm in width, the plants were sprayed three times at weekly intervals with 0.2% Agroleaf P. Control plants were sprayed with water. Just before flowering (mid of December) randomly selected leaves reached 20 cm in length and 2.03 cm in width from both treatments were cut off at the plant base plants. Leaves cuttings were rooted in plastic boxes using and mixture of vermiculite and sand (10:1 v:v). Bulbils production on each cutting were evaluated five months after planting. Application of P foliar fertilizer during mother plant cultivation stimulated the number of bulbils formation in both cultivars. However, the bulbils fresh mass was not influenced by leaf spraying.

Keywords: Cape hyacinth, geophyte, 'Ronina', 'Rupert'

P-38

Effect of elicitors on *Fusarium* development in tulip bulbs

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Tulip growers are affected by the fungus *Fusarium oxysporum* f. sp. *tulipae* (FOT), which can cause rot and significantly reduce yields. FOT could develop thereby causing yield loss in open field conditions with a soil temperature above 12°C, but also during the storage after harvest. Currently there is little experience with the use of elicitors in postharvest conditions. This study tested the effect of elicitors on FOT development in tulip bulbs, cultivars 'Leen van de Mark' and 'Miranda' in two subsequent years 2022 and 2023. In 2022, we tested several doses of the plant hormones, jasmonic acid and salicylic acid. In 2023, we tested the plant hormones and in addition acibenzolar-S-methyl, and *Bacillus amyloliquefaciens*. Within a week after harvest, tulip bulbs were dipped in elicitor/bacterium solutions, and dipping in water was used as control. One week after treatment, the bulbs were damaged to increase the chance of infection with FOT. Two types of damage treatment were applied: by either scratching with a knife or rubbing on a stone. Immediately after damaging, the bulbs were exposed to FOT by dipping in a solution with FOT spores (mixture of different strains) and disease symptoms were assessed in the following months on a two-weekly basis. In both years, salicylic acid treatment led to a decrease in the number of infected bulbs resulting in almost half of the infection rate compared to control with water. In 2023, acibenzolar-S-methyl and *Bacillus amyloliquefaciens* showed the same trend, lower bulb infection rate after application. In 2023, bulbs treated with jasmonic acid showed higher infection rate than water control, suggesting antagonistic roles of the two plant hormones jasmonic acid and salicylic acid. These findings will help to come to a tulip cultivation and storage system that is future-proof, meaning not dependent on high-risk pesticides and with low emissions to the environment.

Keywords: bulbs, elicitors, fungi, *Fusarium oxysporum* f. sp. *tulipae*, storage, *Tulipa*

P-39

Wood fibre as a component of sustainable substrates for pot plant production of *Helenium hybridum*

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For perennial container growers a major challenge in the next few years will be the necessity to use sustainable substrates with limited peat content and, in the future peat-free substrates. In this context, substrate producers have recently turned their attention to wood fibre (WF) as a renewable organic material that can partly replace high peat (SP). In this experiment, four substrate mixtures containing in different proportions wood fibre, high peat, and local raw materials: green compost (GC), fen peat (FP) and brown coal (BC) were tested. For trial, young plants of *Helenium hybridum* 'Fuego' were potted in the following mixtures: (T1) SP 100% used as control; (T2) WF 20%, SP 30%, GC 20%, FP 20%, BC 10%; (T3) WF 30%, SP 20%, GC 20%, FP 20%, BC 10%; (T4) WF 40%, SP 20%, GC 20%, FP 10%, BC 10%. The height and width of plants grown in mixtures containing 20–40% of wood fibre (T2, T3 and T4) and the diameter of their flower heads did not differ strongly from plants grown in peat control (T1). The highest fresh and dry plant biomass, leaf greening index and number of flower heads had the plants grown in a mixture with 20% of wood fibre (T2). There was significant reduction in the fresh and dry weight plant biomass in the medium containing 40% of wood fibre (T4) versus those grown in peat. Generally, *Helenium* plants can be grown in a substrate containing up to 30% of wood fibre mixture without loss of biomass and plant quality.

Keywords: growing media, perennials, sneezeweed, SPAD

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