

IHC2018-Symposium 14

11th International Symposium on Postharvest Quality of Ornamental Plants

ORAL PRESENTATIONS

15 August 2018, Wednesday

WELCOME and INTRODUCTION

Fisun G. Çelikel (Convener)

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The Symposium is the 11th meeting of the 4-yearly symposium following the last meeting in Brazil in 2012. Since then, major events that embraced this topic were the 'Ornamental Horticulture in the Global Greenhouse Symposium' held during the last IHC2014 in Brisbane, Australia, and the '3rd International Symposium on Quality Management in Supply Chains of Ornamentals' held in May 2015 in Kermanshah, Iran.

The purpose of the 11th International Symposium on Postharvest Quality of Ornamental Plants is to bring together researchers, scientists, students, growers, extension people, and exporters dealing with postharvest physiology, marketing and quality of cut flowers/greens, potted plants, ornamental geophytes, and other ornamental products from all over the world, and to discuss the progress and advances in postharvest science and technologies. Our aim is to present and share the important results and new developments on postharvest issues of ornamental plants, to achieve a better understanding of the postharvest physiology of ornamentals, to control and maintain their quality and extend their vase/shelf life. The results will also help to encourage implementation of the environmental friendly concepts in postharvest treatments and lead to future research work. The Symposium will surely improve the network and collaboration among researchers, breeders, extension people, growers, exporters and ornamental industry representatives.

Main themes

The symposium intends to express and highlight the most recent developments, innovations and scientific topics dealing with improving our understanding, and sharing knowledge regarding various issues of ornamental postharvest as follows:

- ✓ Flower senescence and programmed cell death (PCD)
- ✓ Postharvest physiology of cut flowers and greens
- ✓ The role of ethylene and other plant hormones in flower opening, senescence and abscission
- ✓ Effect of pre-harvest factors on postharvest quality of potted plants and cut flowers/greens
- ✓ Post-production handling and maintaining quality of potted ornamental plants
- ✓ Postharvest handling and maintaining quality of cut flowers and greens (treatments, improving vase life, storage, sea transport)
- ✓ Postharvest handling and temperature management for ornamental geophytes
- ✓ Postharvest pathology and entomology of cut flowers and greens
- ✓ Introducing environmental friendly and sustainable green concepts in keeping quality of ornamentals (organic cut flowers; imported products versus local production)
- ✓ Economics and marketing: Production systems, quality in handling systems, market developments, floral business, commercialization and economical consideration

Participants

2 keynotes, 19 oral and 4 poster, total 25 presentations by 22 participants from 17 countries: Belgium, Brazil, China, Chinese Taipei, Denmark (2), India (2), Iran, Nigeria, Norway, Pakistan, Somali (participated from Turkey), South Africa, Thailand, The Netherlands, Turkey (3), United Kingdom (3) and United States.



Conveners

Prof. Dr. Fisun G. Çelikel

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Full professor at the Department of Horticulture, Ondokuz Mayıs University, Samsun since 2007. Graduated from University of Ege, Izmir. Worked at Atatürk Central Horticultural Research Institute, Yalova (1984-2007). Visited the ATO-DLO, Wageningen Holland (one year in 1993), University of California Davis USA (9 months June 1998- March 1999, 2 months in 2000, 3 months in 2011), University of Queensland, Gatton Australia (5 months in 2009) for research programmes. Her scientific research is focused on postharvest physiology of ornamental plants and horticultural crops. In addition, Dr. Çelikel has research interest on other aspects of ornamental plants, such as plant height control, growing techniques and propagation methods of geophytes and other native plants, with her Ph.D and M.Sci students. Her research activities have resulted in publications in professional journals, book chapters, symposium proceedings and refereed scientific journals.

Dr. Shimon Meir

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Dr. Shimon Meir is based at the Department of Postharvest Science of Fresh Produce, The Volcani Center, Israel. He has a Ph.D. in plant physiology from the Hebrew University of Jerusalem in Israel (1985). He spent a postdoctoral period with Prof. William Bramlage at the University of Massachusetts USA (1987) and a sabbatical leave with Prof. Michael Reid at the University of California Davis, USA (2001). For the last 26 years he has an active research program in improving postharvest quality of ornamentals, focusing on cut flowers and potted plants. His horticultural research is focused on developing means for improving the quality of ornamentals exported by air and sea transport, including developing postharvest technologies and application of plant growth regulators and inhibitors. His current research is focused on regulation of abscission, senescence and colour development. He co-chaired and organized an International Abscission Workshop as part of the International Horticultural Congress (IHC2010) in Lisbon, and a symposium on "Abscission Processes in Horticulture and their Manipulation to Improve Crop Growth" as part of the IHC2014 in Brisbane, Australia. Currently he serves as a Chair of the ISHS Working Group Quality of Ornamentals.

Invited speaker

Prof. Dr. Ernst Woltering

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Prof. Dr. Ernst Woltering is senior scientist at Wageningen Food and Biobased Research and professor of Product Physiology and Quality at the Wageningen University (Dept. of Plant Sciences) in The Netherlands. Ernst Woltering has a life-long experience in postharvest research (fruit and vegetables, flowers and pot plants) and apart from the scientific work is involved in the development of e.g. new flower treatment solutions, markers for flower quality and advanced protocols for long-term storage/transportation of flowers and pot plants. Ernst Woltering's research activities have resulted in publications in professional journals (>50 papers), book chapters and symposium proceedings (> 30 papers) and > 60 papers in refereed scientific journals. Current H-index = 32. The industry-related research has resulted in new products that have entered the market; research resulted in 5 patents. In addition, he is a consultant for international flower and fruit distribution companies and associated technology providers.

Scientific Committee

Antonio Ferrante (University of Milan, Milano, Italy)
Antony Stead (Royal Holloway University of London, UK)
Cai-Zhong Jiang (University of California, Davis, USA)
Ernst Woltering (Wageningen Univ. Res. Centre, Holland)
Fisun G. Çelikel (Ondokuz Mayıs University, Samsun, Turkey)
Kürşat Demiryürek (Ondokuz Mayıs University, Samsun, Turkey)
Margrethe Serek (Leibniz University Hannover, Germany)
Michael S. Reid (University of California, Davis, USA)
Michelle L. Jones (The Ohio State University, USA)
Olaf van Kooten (Wageningen Univ. Res. Centre, Holland)
Shimon Meir (Agr.Res.Org., The Volcani Center, Israel)
Sonia Philosoph-Hadas (Agr.Res.Org., The Volcani Center, Israel)
Vivian Loges (University Federal Rural de Pernambuco, Brazil)



KEYNOTE 1

LONG-TERM STORAGE OF CUT ROSES FOR OPERATIONAL PURPOSES AND TO FACILITATE LONG DISTANCE TRANSPORT IN REEFER CONTAINERS

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Long-term shipment of flowers in reefer containers as a replacement of airfreight is the method of choice with respect to saving on transport costs and decreasing the carbon footprint. Long term storage (buffering), also facilitates the required delivery of larger volumes on peak days such as Mother's day or Valentine's Day and may create new business opportunities. Optimal storage conditions have been developed over the years for a number of flowers and cultivars with varying degrees of success. In roses, the protocols consist of strict recommendations concerning the cultivars to be used, the flower developmental stage at harvest, the type of packaging, the post-harvest application of fungicides and the use of pre-treatment, transport and (when stored dry) rehydration solutions. Still several problems occur with long-term stored flowers. According to a large scale investigation on the causes of flower failure at the FloraHolland flower auction, the larger part of the auction-supplied roses ends their vase life due to water balance problems (impaired flower opening, premature wilting, bent neck). Second main reason for end of vase life is *Botrytis cinerea*. Effective solutions to suppress botrytis infection during storage have been developed. A single 1 s dip in a hypochlorite solution proved effective in many of the investigated cases. The physical and physiological background of flower failure caused by a negative water balance following long-term storage was investigated. Long term storage did not affect the xylem hydraulic conductivity and did not alter the petal sugar status or petal electrolyte leakage (indicator of membrane integrity). Storage was found to affect the functionality of stomata leading to less adequate stomata closing in response to mild water stress. New solutions to improve flower quality after long-term storage will be discussed.

Keywords: rose, long-term storage, botrytis, water balance, stomatal functionality, reefer

SESSION I: STORAGE, TRANSPORT, HANDLING AND POSTHARVEST QUALITY OF CUT FLOWERS AND POT PLANTS - Chair: Fisun G. Çelikel

OS 1-1:

POSTHARVEST HANDLING OF CUT EUSTOMA FLOWERS IN TAIWAN: A REVIEW

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In recent year, there is a dramatic increase in the amount of cut *Eustoma* flowers exported to Japan from Taiwan. A major reason for this is the improvement of postharvest technique by the cooperation among local growers, exporters and researchers. The present review will illustrate the factors influencing the postharvest quality of cut *Eustoma* flowers grown in Taiwan and the key aspects related to the extension of vase life and improvement of overall quality. Aside from the establishment of the SOP exporting to Japan from Taiwan, e.g. harvesting, grading, packing, precooling, etc. much emphasis will be made on the development of effective pretreatment solutions by combination of various chemicals, namely, carbohydrates, and ethylene inhibitors.

Keywords: postharvest handling, *Eustoma*, ethylene inhibitors, sugar, standard operating procedures (SOP)



OS 1-2:

THE EFFECTS OF DIFFERENT STORAGE METHODS AND PERIODS ON VASE LIFE OF CUT NARCISSUS (*Narcissus tazetta* L. 'KARABURUN')

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The aim of this study was to investigate the prolonging opportunities of the marketing period of cut narcissus flowers by different cold storing techniques and vase solutions. For this purpose, the effects of different storage methods and storage periods were detected by determining the vase life of narcissus flowers after storage. Double flowers of a local narcissus variety of *Narcissus tazetta* L. 'Karaburun' from İzmir were used as plant material. In the trial flowers were stored in wrapped paper or modified atmosphere packing bags at the storage conditions at the temperature of 0°C for 1, 2, 3, 4, 5 or 6 weeks. Silver thiosulphate (STS) solution (25 ppm) or just distilled water was used for pulsing treatment. Vase life was measured in days from the first day of storage exit. The day, when the 50% of the florets of cluster withered, was accepted as the end of the vase life. With the prolongation of the storage period vase life were shortened but the storage with wrapped paper and STS pulsing gave better results.

Keywords: narcissus, vase life, silver thiosulphate, cold storage

OS 1-3:

WHAT CAUSES PEDUNCLE NECKING IN CUT ROSA HYBRIDA TRANSCRIPTOME ANALYSIS OF ROSE STEM TISSUE AND ANALYSIS OF MICROBIAL LOAD

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Bent-neck or 'necking' is a phenomenon often seen in cut roses, whereby the flower head droops due to a bending of the peduncle. Necking is thought to be caused by a blockage of the xylem, either due to an air embolism or an accumulation of microbial populations, limiting water uptake to the flower head and causing the stem to bend. Despite the use of biocides to reduce microbial load, necking still remains an issue for the cut flower sector and roses continue to die prematurely.

As the occurrence of necking varies widely within and between cultivars, a transcriptome analysis of cut *Rosa hybrida* cultivar 'H30' has been carried out to investigate the potential responses in the rose tissue and the mechanisms involved. Transcriptomes from peduncle samples at three stages of necking (straight, 90°) were sequenced using next generation sequencing to produce over 100 million reads per stage and generating nearly 300,000 contigs following de novo assembly. Differential expression analysis of the three different stages of necking identified more than 900 genes that changed in transcription during necking (>90°) compared to straight stems. Functional analysis of these differentially expressed genes has revealed multiple pathways that may contribute to the necking response. The variation in microbial loads associated with stem ends has also been analysed and together with the transcriptomics data may help gain a better understanding of the process of necking.

Keywords: transcriptome, de novo assembly, *Rosa hybrida*, necking, differential expression



OS 1-4:

HORMONAL REGULATION OF PLANT HEIGHT IN POTTED MINIATURE ROSE

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Treatment of potted rose plants with thidiazuron (N-phenyl-N'-1, 2, 3-thiadiazol-5-ylurea, TDZ), a non-metabolized cytokinin analog, resulted in compact plants with shorter shoots and thicker internodes. Two weeks after treatment with 100 µM TDZ, new shoots were half as long as those in control plants, and stem diameter were about 40% greater. Although TDZ treatment stimulated ethylene production by the plants, inhibitors of ethylene biosynthesis (2-aminoethoxyvinyl glycine - AVG) or action (silver thiosulfate - STS) did not affect the plants' response to TDZ. Application of GA₃ and TDZ together resulted in normal elongation growth, although stem diameters were still somewhat thicker. Our results suggest that TDZ and GA regulates shoot elongation and stem diameter in potted rose plants. Therefore, we suggest that TDZ is a new tool in research study of plant height control for pot plants.

Keywords: shoot growth, internode length, internode thickness, thidiazuron, gibberellin, ethylene, potted rose

16 August 2018, Thursday

KEYNOTE 2

XYLOSE CONCENTRATION IN PETALS PREDICTS THE REMAINING VASE LIFE OF ROSES

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Flowers are often cultivated at considerable distance from the main consumer locations. This necessitates long term transport by truck, plane, boat or by combinations of these transport modes. At arrival it is often hard to judge the remaining quality or to estimate the remaining vase life. A method was developed to estimate the physiological age of the flower. Xylose concentrations in petals were shown to increase, in a temperature and time dependent manner, during storage of the flowers. The increase was observed in a great many cultivars, stored under different temperature scenarios. Also the expression of β-xylosidase gene showed an increase during storage. This indicates that xylose is produced through the action of β-xylosidase from structural carbohydrates (cell wall compounds). The produced xylose is apparently poorly metabolized and accumulates in the tissue. Petal xylose concentration showed a good correlation with the remaining vase life of both flowers in water and in a commercial flower food. Xylose can easily be determined in (hot water) petal extracts using a commercially available kit (Megazyme D-xylose assay kit). Xylose level in petals is proposed as a novel biomarker for storage history and an indirect predictor of the remaining vase life.

Keywords: rose, biomarker, vase life prediction, xylose, storage



SESSION II: FLOWER QUALITY AND SENESCENCE - Chair: Gary Chastagner

OS 2-1:

HYPERSPECTRAL IMAGING AS A MEANS TO ASSESS QUALITY ISSUES OF CUT FLOWERS

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The vase life of cut flowers is an important parameter influencing the value of individual species or cultivars. This vase life is affected by growing, packing and transport conditions and yet the subsequent effects of such treatments can only be quantified concurrent with the consumers' experience. Any detrimental consequences on vase life can cause difficulties for wholesalers and retailers when a guaranteed vase life is offered - a practice common in the EU and a growing trend in the US. A non-invasive diagnostic test that can establish the quality of cut flowers and their potential vase life is needed and in other areas of the agri-food industry hyperspectral imaging is proving a very promising means to rapidly quantify the quality non-destructively.

This paper will review the progress made in using hyperspectral imaging, and related technologies, with cut flowers and highlight some of the potential drawbacks that still need to be overcome.

Keywords: hyperspectral, vase-life, cut flowers, quality

OS 2-2:

THE PHYSIOLOGY AND TRANSCRIPTOMICS UNDERLYING DAHLIA FLOWER SENESCENCE

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The dahlia is popular as an ornamental garden plant in the UK, however its value as a cut flower has been undermined by its short vase life. The vase life of dahlias is often no more than 5 days, whereas 10-14 days are required by the cut flower industry due to the supply chain involved in transporting cut flowers from growers to retailers, sufficient time in store, and still guaranteeing 5 days vase life to a consumer. The current study has considered ethylene sensitivity and how phytohormones interact with one another during the senescence process. In conjunction with these traditional methods RNA sequencing and de-novo assembly of the dahlia transcriptome in the cultivar 'Sylvia' has been carried out resulting an assembly of over 20 000 genes, many of which change in expression during floret senescence.

Keywords: flower senescence, ethylene, cytokinins, transcriptome



OS 2-3:

GIBBERELLINS AND CYTOKININS MODULATE FLOWER SENESCENCE AND LONGEVITY IN *Nicotiana plumbaginifolia* VIV

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Efficacy of various growth regulators viz. gibberellic acid (GA3), kinetin (KIN) and benzylamino purine (BAP) in improving senescence and longevity of isolated flowers in *Nicotiana plumbaginifolia* Viv. was examined. Excised buds of *N. plumbaginifolia* were harvested one day before anthesis and cut to a uniform pedicel length of 3 cm and divided into different sets, each set comprising of 25 vials with 5 ml of respective test solutions. Each set was supplied with various grades of GA3, BAP and KIN viz., 25 mgL⁻¹, 50 mgL⁻¹, 75 mgL⁻¹, 100 mgL⁻¹, 125 mgL⁻¹ and 150 mgL⁻¹. A separate set of flowers held in distilled water (DW) designated the control. The growth regulators used during the present study resulted in significant enhancement of flower longevity as compared to the control. The exogenous application of kinetin in the solution was found to be quite effective in improving the flower longevity by an increment of 4.2 days as compared to BAP and GA3 in which the increment of improvement was 3.9 and 3.5 days respectively as compared to the control, where it was only 3 days. Increased flower longevity by the application of GA3, BAP and KIN was associated with decrease in lipid peroxidase and lipoxygenase activity, besides an increased activity of various antioxidant enzymes viz., catalase, superoxide dismutase and ascorbate peroxidase. Higher values of soluble proteins, sugar fractions, total phenols and membrane stability index was maintained in the petal tissues from flowers held in various growth regulators.

Keywords: *nicotiana plumbaginifolia*, antioxidant, superoxide dismutase, catalase, soluble proteins

OS 2-4:

ISOLATION AND EXPRESSION ANALYSIS OF AN ETHYLENE RECEPTOR GENE *Ps-ETR2* IN TREE PEONY CUT FLOWERS

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Tree peony (*Paeonia suffruticosa*) is a well known traditional flower with broad market prospect in China. In order to understand the role of ethylene receptor gene in postharvest development of tree peony cut flowers, an ethylene receptor gene *Ps-ETR2* was isolated and analyzed in this study. An ethylene-sensitive cultivar 'Luoyang Hong' and an ethylene-insensitive cultivar 'Xue Ying Tao Hua' were selected to analyze the expression pattern of *Ps-ETR2* gene in petals of different developmental stages by quantitative real-time PCR. The result showed that the expression pattern of *Ps-ETR2* exhibited significant differences between 'Luoyang Hong' and 'Xue Ying Tao Hua'. During cut flower postharvest development, *Ps-ETR2* transcripts in petals of 'Luoyang Hong' cut flowers had a rapid and obvious rise at the pre-opening stage followed by a gradually decline from pre-opening to full opening stage, and then reached the highest level of mRNA accumulation at senescence. However, *Ps-ETR2* transcripts in petals of 'Xue Ying Tao Hua' cut flowers stayed at a relatively low level during opening and only increased a little when petals wilted. These results suggested that the *Ps-ETR2* gene and its resultant protein may be involved in the regulation of ethylene sensitivity of tree peony cut flowers. This will provide theoretical basis for further research on molecular mechanism of ethylene-mediated opening and senescence of tree peony cut flowers.

Keywords: *Paeonia suffruticosa*, cut flowers, ethylene receptor, ethylene sensitive



SESSION III: EFFECT OF LIGHT, POSTHARVEST QUALITY AND PEST CONTROL IN ORNAMENTAL PLANTS - Chair: Ernst J. Woltering

OS 3-1:

GENETIC SCREENING TO IMPROVE THE POSTHARVEST NEEDLE RETENTION OF CUT CHRISTMAS TREES AND GREENERY

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Christmas trees and conifer boughs represent important, high-value specialty crops in certain regions of the United States. American consumers purchase 28-32 million Christmas trees annually with a retail value of \$1.32 billion in 2015. Five states (Oregon, North Carolina, Michigan, Pennsylvania, Wisconsin and Washington.) accounted for about 80% of the Christmas trees produced, with growers in the Pacific Northwest (PNW) providing ~40% of the U.S. production. In addition, boughs are harvested from natural stands and plantations for use in the greenery industry for wreaths, etc. Nationally, noble (*Abies procera*) and Fraser fir (*A. fraseri*) account for over 50% of the volume of trees sold and a larger portion of the industry's revenue due to their higher retail value. The U.S. Christmas tree industry faces stiff competition from artificial trees. The percentage of households displaying a real tree has been decreasing while the use of artificial trees has increased. Consumer surveys indicated that needle loss and moisture retention are critical traits in real tree acceptance. Given that Christmas trees and boughs are harvested and shipped weeks before being displayed in consumers' homes, species must have excellent postharvest needle and moisture retention characteristics to be acceptable. Unlike noble and Fraser fir, which tend to have excellent postharvest needle retention, there is considerable variation within most tree species with respect to the shedding of green needles as they dry. This variation has the potential to provide opportunities to improve the postharvest quality of Christmas trees in the U.S. This paper presents a summary of research on five Christmas tree species at Washington State University where a detached branch technique has been used to screen individual trees within seed orchards, plantations, and natural stands to identify sources of trees that have superior postharvest needle retention characteristics.

Keywords: Pb, postharvest quality, Douglas-fir, Nordmann fir, Turkish fir, Canaan fir, Balsam fir

OS 3-2:

IMPACT OF LIGHTING CONDITIONS DURING FORCING ON FLOWERING TIME, MORPHOLOGY AND POSTHARVEST TRANSPIRATION OF *Hydrangea macrophylla*

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In this study, the main objective was to evaluate the impact of lighting conditions and to test effects of continuous lighting and light quality on morphology, number of flowering shoots, flowering time and postharvest transpiration. *Hydrangea macrophylla* 'Clarissa' was forced in controlled climate chambers. Extending the photoperiod from 16 h to 24 h with high pressure sodium lamps (HPS) did not affect forcing time or morphology but postharvest transpiration was more than 50% higher when the plants were forced at 24 h compared to 16 h lighting. Additional blue light (30% BL, 400-500 nm) in combination with HPS (HPS + B) did not change the postharvest transpiration compared to HPS but resulted in more compact plants and one week earlier flowering. White light emitting diodes (LEDs) with 20% BL induced more compact plants compared with HPS but the flowering was delayed with one week and postharvest transpiration increased compared to HPS.

Keywords: blue light, flowering time, photomorphogenesis, hydrangea (*Hydrangea macrophylla*), transpiration



OS 3-3:

POSTHARVEST QUALITY OF ORNAMENTAL CUTTINGS EVALUATED BY CHLOROPHYLL FLUORESCENCE

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Globalization of the ornamental industry leads to an increased import and export of young plants and cuttings. In the Belgian ornamental industry, there is an increasing trend of producing high quality cuttings in favourable climatic regions worldwide. Transport of these cuttings to the Belgian nurseries and worldwide can affect the quality. To assess postharvest quality after transport or storage, chlorophyll fluorescence was evaluated as a non-destructive method. Therefore, cuttings from two pot chrysanthemum (*Chrysanthemum morifolium*) cultivars, 'Conaco' and 'Jasoda', were stored in dark conditions at $3.1 \pm 0.3^\circ\text{C}$ for 35 days. After 0, 5, 10, 15, 21, 28 and 35 days, cuttings were removed from the cold room and rooted. Chlorophyll fluorescence was measured during the first days of rooting. Results show optimal levels of F_q'/F_m' already 24 hours after sticking for 'Conaco' for all storage treatments. 'Jasoda' showed suboptimal levels of F_q'/F_m' 24 hours after sticking for cuttings that were stored for at least 21 days. Two days after sticking, a suboptimal level of F_q'/F_m' was still seen for cuttings stored for 35 days. This was also reflected by visual leaf damage. It is concluded that below a certain threshold for F_q'/F_m' , measured 24 hours after sticking, the quality of rooted cuttings will be poor.

Keywords: chlorophyll fluorescence, *Chrysanthemum morifolium*, storage, PSII operating efficiency

OS 3-4:

POSTHARVEST QUALITY OF NOVEL *CAMPANULA* LINES - ASSESSMENT OF INDOOR LONGEVITY AND QUALITY

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The production of ornamental plants has a yearly turnover in billions of euros with Europe as the major producer. It is important to assess the postharvest quality of potted plants to provide tools to reduce the losses during transport and/or handling. The producers examine postharvest quality e.g. by assessment of the plants' tolerance to different temperatures and light conditions. In the current study, two potted *Campanula* lines, i.e. 1 and 2, were evaluated in terms of postharvest performance, longevity and plant quality. Plants were kept under different temperatures (i.e. 5, 23 and 28°C , treatments) and low light intensity ($50 \mu\text{mol m}^{-2} \text{s}^{-1}$) mimicking transport/storage and indoor conditions. Furthermore, plants were kept in the greenhouse as control. The plants were evaluated every week by measurement of height, diameter, number of flowers and leaf color. Additionally, photos of flowers and whole plants were taken. The experimental data showed that both lines did not tolerate the highest temperatures. Plants kept at 23°C senesced after 3 weeks and plants kept at 28°C completely senesced after 2 weeks, due to wilting and fungal infections. Plants kept at 5°C did not notably increase in size over the 3 weeks neither did the flower number increase compared to the other treatments. Both *Campanula* lines tolerated being kept at low temperatures, thus exhibiting potential to be stored and transported under cold environment before sale, hence potentially lowering postharvest losses. Line 1 kept in the greenhouse produced more flowers than plants kept in any other treatments. Furthermore, line 2 only displayed flowers when kept in the greenhouse. This could indicate that the two *Campanula* lines need higher light intensity to initiate anthesis. Collectively, it was found that none of the *Campanula* lines tolerated warm temperatures and low light intensity. However, the plants coped with low temperatures and only developed slowly.

Keywords: color, flowers, ornamental plants, potted plants, senescence, temperature



OS 3-5:

EFFECTS OF DIFFERENT LIGHT SPECTRA ON POSTHARVEST WATER RELATIONS OF ANTHURIUM UNDER CHILLING CONDITION

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Anthurium (*Anthurium andraeanum* L.) is a cold-sensitive species belonging to tropical region of the world. However, this plant is widely cultivated all around the world for its ornamental spathes. To test whether quality of light can influence water loss of anthurium cut flowers under chilling stress condition, two cultivars of anthurium cut flowers [Calore (red spathe) and Angel (white spathe)] were exposed to cold temperature (4°C) under different light spectra [including darkness (D), red (R), blue (B), 70:30% red:blue (RB) and white (W)]. Results showed that Angel cultivar under B containing spectra had the lowest relative water content and specific surface area. Angel cultivar under B light also showed the lowest spathe water content on dry weight basis. The lowest vase life was observed in Angel cultivar under B light spectrum, while the longest vase life was observed under red light in both studied cultivar. More open stomata were observed in blue light treatment. As a result the highest percentage of water loss was observed in treatments with B light in their spectra and the lowest percentage of water loss was observed in dark and red light especially in Angel cultivar. In conclusion, B part of light spectrum through its negative effects on water relations of the spathes can negatively influence vase life of anthurium cut flowers.

Keywords: Anthurium, chilling stress, light spectrum, stomata, transpiration rate

OS 3-5:

POSTHARVEST INSECT PEST CONTROL FOR WESTERN FLOWER THRIPS, *Frankliniella occidentalis*, IN EXPORT PROTEACEAE CUT FLOWERS

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A seriously limiting factor to the Proteaceae cut flower export industry of South Africa is the presence of entomofauna within export consignments, which lead to rejection of consignments when exporting to stricter international markets. This study aimed to assess the efficacy of two potential postharvest pest disinfestation techniques, Controlled Atmosphere and Temperature Treatment Systems (CATTS) technology, which is a heated controlled atmosphere treatment, and ethyl formate (EF) fumigation treatment. Post-treatment flower quality was evaluated in two *Leucadendron* cultivars, 'Safari Sunset' and 'Jade Pearl', as well as the *Chamelaucium* cultivar 'Ofir'. A small and cryptic insect pest, that can be present in high numbers post harvest, are thrips. Both CATTS and EF treatments were assessed for their efficacy against the Western flower thrips, *Frankliniella occidentalis*. In the CATTS treatments the temperature was ramped up from 23°C at 30°C hour⁻¹ and 35°C hour⁻¹ to 40°C in atmospheres of 1% O₂, 15% CO₂ in N₂. EF fumigation treatments were carried out at room temperature with EF concentrations at 10g m⁻³ or 20g m⁻³ for 1 and 2 hours. Untreated control and treated flowers were stored in air- and ship-freight simulated conditions, after which flower quality and vase-life were determined. CATTS treatments yielded the best results, as flower quality and vase-life matched untreated controls across all commodities and treatments, with no reduction in either following simulated air- and ship-freighting (3 and 21 days respectively). EF treatments however resulted in rapid flower deterioration and unacceptable quality soon after treatment. Both CATTS and EF were highly effective in controlling the Western flower thrips, as 100% mortality was achieved across all treatments within 24 hours of treatment. For the cultivars tested here, CATTS technology holds great promise as a post harvest treatment for thrips, as flower quality was maintained under treatment conditions that effectively controlled the insect pest.

Keywords: controlled atmosphere temperature treatment system technology, CATTS, ethyl formate, ornamental cutflowers, Proteaceae, *Leucadendron*, *Chamelaucium*, postharvest, phytosanitary control, vase life



SESSION VI: POSTHARVEST PHYSIOLOGY AND EXTENDING VASE LIFE OF CUT FLOWERS - Chair: Tony Stead

OS 4-1:

POSTHARVEST PHYSIOLOGY OF CUT *Gardenia jasminoides* FLOWERS

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Gardenia jasminoides from the family Rubiaceae is the most popular cultivated *Gardenia* species. It is an evergreen flowering shrub plant with its shiny green leaves and heavily fragrant creamy white summer flowers. The flowers are very delicate and mostly used as a bride flower. There is a new interest of using gardenia as cut flowers. However, short vase life severely limits its application. So far, there is no published research studies on postharvest physiology and quality of gardenia as cut flowers.

Therefore, we investigated the postharvest physiology and the possibility of using the *Gardenia jasminoides* as a cut flower. The effects of treatments on the postharvest performance of cut gardenia flowers were studied by measuring the water uptake (WU) and relative fresh weight (RFW) during vase life. Cut flowers were harvested from a commercial greenhouse, transported to the lab in 4 hours and were immediately used in the experiments. Stems were recut to about 40 cm under water before placing them into vase solution.

Ethylene action inhibitor Silver Thiosulfate (STS) pulsing had no effect on the vase life of gardenia flowers. Absciscic acid (ABA) significantly increased the vase life of flowers to 5 days by maintaining RFW. Benzyladenine (BA) in vase solution was the most effective plant growth regulator by doubling the vase life to 5.5 days. A biocide in vase solution significantly increased the vase life of gardenia flowers about one day for NaOCl and 1.7 days for aluminum sulfate. Citric acid in vase solution increased WU and vase life about 3 days by providing a 6 days vase life for these delicate flowers. Half of the buds in each stem were opened in control whereas adding citric acid into the sucrose plus biocide solution provided 100% bud opening and doubled the vase life of gardenia flowers. Our results suggest that improvement of water uptake may result in longer vase life of cut gardenia flowers.

Keywords: Gardenia, bud opening, vase life, pulsing, vase solutions, water uptake



OS 4-2:

USE OF ORGANIC AND INORGANIC SOLUTIONS IN EXTENDING THE VASE LIFE OF HELICONIA CUT FLOWERS

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The use of organic solutions as floral preservatives in extending the vase life of cut flowers has been seen to be a cheaper and ecofriendly alternative as compared to inorganic solutions. This study was carried out to investigate the use of aloe vera (*Aloe vera barbadensis*) and moringa (*Moringa oleifera* Lam.) solutions compared with calcium chloride and salicylic acid solutions on the postharvest longevity of *Heliconia* cut flower. The experiment was carried out in the floriculture laboratory, National Horticultural Research Institute, (NIHORT); Ibadan, Nigeria (7°25' N and 3°52' E). Treatments (preservative solutions) include Aloe vera and Moringa leaf extracts at 2.5, 5.0 and 7.5% (w/v), calcium chloride solution (350 ppm) and a combination of calcium chloride solution (200 ppm) and Salicylic acid solution (150 ppm). Some of the treatments were complemented with 4% sucrose. Tap water was used as the control treatment for the cut flowers. All treatments showed improved vase life of *Heliconia* cut flowers compared to the control except for moringa solutions with the highest wilted petals at day 10. Solutions of aloe vera at 5.0% complemented with 4% sucrose showed best water uptake and percentage of maximum increase in opened petals (85.6%) and relative water content (78.9%). The quality and vase life of *Heliconia* cut flowers was extended significantly beyond 14 days with Aloe vera extract > calcium chloride / salicylic acid solution > control > Moringa treatments in comparison.

Keywords: sucrose, aloe-vera, moringa, calcium, salicylic acid, longevity

OS 4-3:

SUCROSE AND ALUMINUM SULFATE AFFECT LONGEVITY AND WATER RELATIONS OF SELECTED CUT FOLIAGE SPECIES

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Cut foliage stems of *Alpinia zerumbet*, *Asparagus densiflorus*, *Canna indica*, *Cyperus alternifolius*, *Dracena marginata*, *Iris pallida*, *Murraya exotica*, *Phoenix rubellini*, *Syngonium podophyllum*, *Ruscus hypophyllum* and *Thuja orientalis* were evaluated for their postharvest performance. Stems were subjected to various pulse and vase solutions of sucrose supplemented with 100 mg L⁻¹ aluminum sulfate, after which longevity (vase life) and water relations [relative fresh weight (RFW) and vase solution uptake (VSU)] were quantified. Among all tested species, *Cyperus alternifolius*, *Phoenix rubillini*, *Ruscus hypophyllum*, and *Thuja orientalis* had an acceptable vase life of greater than 7 days, while the others were only 5 days. *Ruscus hypophyllum* and *Thuja orientalis* had longest vase life (38.6 and 26.8 d, respectively) when kept in 2% sucrose solution supplemented with 100 mg L⁻¹ aluminum sulfate until termination. Majority of tested species had higher vase solution uptake when placed in 2% sucrose supplemented with 100 mg L⁻¹ aluminum sulfate, while stems placed in solutions containing 100 mg L⁻¹ aluminum sulfate alone had higher relative fresh weight during the vase period. In summary, *Cyperus alternifolius*, *Phoenix rubillini*, *Ruscus hypophyllum*, and *Thuja orientalis* were considered highly desirable as cut foliage due to longer vase life and attractive appearance and treating stems with 2% sucrose supplemented with 100 mg L⁻¹ aluminum sulfate or aluminum sulfate alone will extend their vase life compared to non-treated stems.

Keywords: preservatives, relative fresh weight, *Ruscus hypophyllum*, vase life, vase solution uptake



OS 4-4:

POSTHARVEST QUALITY AND EXTENDING VASE LIFE OF NATIVE *Helleborus orientalis* FLOWERS

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Helleborus orientalis (Ranunculaceae) has greenish-white many flowers bearing in a long stem with nice leathery leaves. There is no published postharvest study of these beautiful native flowers. We investigated the postharvest physiology and the possibility of extending the vase life of *Helleborus orientalis* naturally grown in Black Sea region of Turkey. Flowers were harvested at different development stages from native forest located in the campus of Ondokuz Mayıs University in March. Changes in wilting stages, bud opening, water uptake (WU), water loss (WL) and relative fresh weight (RFW) during vase life were determined daily in a standard vase life evaluation room at 20 °C and about 60% relative humidity. Artificial light was provided for 12 h day⁻¹ from cool-white fluorescent tubes. The vase life was recorded as the time to wilting of all open florets. Sucrose pulsing and thidiazuron (TDZ) spray treatments delayed the wilting of flowers. Flower stems pulsed for 24 hours with sucrose at 20% in combination with TDZ spray treatment significantly increased water uptake and vase life to about 24 days from 19 days in control flowers. In addition, sodium nitroprusside (SNP), nitric oxide (NO) donor, in vase solution increased WU and maintained the RFW of flowers, consequently significantly extended vase life by 6 days compared to control flowers. The results suggested that *Helleborus orientalis* with long vase life has commercial potential as cut flowers.

Keywords: *Helleborus orientalis*, vase life, cut flower, postharvest, water uptake, TDZ, sucrose, SNP

OS 4-5:

POSTHARVEST QUALITY AND EXTENDING VASE LIFE OF *Narcissus tazetta* FLOWERS

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Narcissus tazetta L. from the family Amaryllidaceae has nicely fragrant many flowers in a leafless stem. They are naturally grown in Black Sea region of Turkey and used locally as cut flowers. However, there is no detail postharvest study on these beautiful delicate flowers. Therefore, we investigated the postharvest physiology and the possibility of extending the vase life of flowers. The bulbs obtained from Ordu were grown in greenhouse of the University in Samsun. Flowers were harvested in February and March at 3 different stages according to the number of open flowers in each stem. Vase life, and water uptake (WU), water loss (WL) and relative fresh weight (RFW) during vase life were determined daily in a standard vase life evaluation room at 20 °C and about 60% relative humidity. Artificial light was provided for 12 h day⁻¹ from cool-white fluorescent tubes. The vase life was recorded as the time to wilting of all open florets in each stem. Sucrose at 2% + 200 ppm 8-HQC in vase solution significantly increased water uptake and vase life of flowers to about 7 days from 6 d in control ones. Sucrose at 20% pulse similarly extended the vase life one day by maintaining RFW. Application of a non-metabolized cytokinin analog thidiazuron (TDZ) as spray or pulse significantly delayed the wilting of flowers. In experiments, the treatments had more effect in early stage (only one bud open) of harvest than late stages (2-3 buds open). Promalin (benzyladenine plus gibberellins) spray at 50 mL L⁻¹ significantly extended the vase life of flowers from 5.6 d to 7 d. The results suggested that *Narcissus tazetta* has commercial potential as cut flowers.

Keywords: *Narcissus tazetta*, vase life, cut flower, postharvest, water uptake, TDZ, sucrose



POSTER PRESENTATIONS

POSTER 1:

DELAYING PETAL BLACKENING OF CUT SACRED LOTUS FLOWERS BY PACKAGING CONDITIONS DURING STORAGE

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The demand for cut flowers of sacred lotus (*Nelumbo nucifera* Gaertn.), is progressively increasing both in the local and export markets. However, flower marketability is limited mainly due to the rapid blackening of the outer petals after harvest, resulting in a very short vase life of only 2–3 days. The objective of this study was to develop optimal packaging conditions during transport for sacred lotus flowers. Cut lotus flowers were packed in the following conditions: No bags (paper wrap), perforated bags and Modified Atmosphere Packaging (MAP) - sealed bags in which MA was created. All bags were of 30 μ thickness. The packed flowers were stored at 13°C for two days and subsequently transferred to 25°C for additional 4-8 days (market simulation). The results showed that during the storage period under MAP, CO₂ and ethylene accumulated to high levels, while O₂ levels decreased. These treatments reduced the petal blackening after 3-day storage, compared to control bags. However, MAP at 13°C for two days delayed petal blackening by only one day compared to the other packaging treatments. Therefore, we further studied the effect of MAP with bags varying in their thickness (30 and 50 μ) during storage at 25°C. The results show that in the thick MAP bags, the gas levels ranged between 6-10% CO₂ and 8-32 ppm ethylene, while O₂ continuously decreased up to 5% throughout the storage period. Consequently, the petal blackening was delayed for 10 days, while in the other bags it was delayed for only 6 days. It seems, therefore, that packaging cut lotus flowers under MAP in sealed 50 μ -thick bags was the best method for delaying their petal blackening. This suggests a protective role for high CO₂ and low O₂ in preventing petal blackening.

Keywords: sacred lotus flowers, MAP, petal blackening, oxygen, carbon dioxide, ethylene

POSTER 2:

MORINGA LEAF EXTRACT PULSE EXTENDS LONGEVITY OF SELECTED CUT FLOWERS

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Pakistan cut flower industry is dominated by roses, gladioli and tuberose, which are only marketed locally due to poor postharvest handling chain and unavailability of commercial preservatives. A study was conducted to evaluate the effect of Moringa oleifera leaf extract (MLE) on postharvest performance of cut 'White Prosperity' *Gladiolus* hybrids, 'Anjlique', 'Gold Medal' and 'Kardinal' Rosa hybrids, and 'Single' Polianthes tuberosa stems. MLE was applied at 0, 1, 5, 10, 20 or 30 mL L⁻¹ as a pulsing solution for 24 h followed by placement in distilled water or continuous vase application at 0, 1, 2, 5, or 10 mL L⁻¹ until termination. Pulsing of cut stems with 10 mL L⁻¹ MLE for 24 h extended the vase life by 3.0 d for gladiolus, 2.7, 1.1 or 1.1 d for 'Anjlique', 'Gold Medal' or 'Kardinal' roses, respectively, and 2.5 d for tuberose stems, as compared with stems kept in water (control). Pulsing with MLE at 10 mL L⁻¹ also maintained higher water uptake of gladiolus, 'Gold Medal' rose



and tuberose and dry weight of the cut stems, and lowered electrolyte leakage of cut stems of all tested species and cultivars. For vase application experiment, application of 2 mL L⁻¹ MLE extended the vase life by \approx 1 d over control, maintained water uptake and dry weight of cut stems, and lowered electrolyte leakage of all species/cultivars. In summary, MLE can be used at 10 mL L⁻¹ as a 24 h pulse or 2 mL L⁻¹ as a vase solution to extend the vase life and maintain gladiolus, rose and tuberose flower quality. However, pulsing had a greater effect on longevity compared to continuous vase application.

Keywords: organic preservatives, vase life, gladiolus, rose, tuberose

POSTER 3:

ESSENTIAL OILS ON CALLA LILLY POSTHARVEST

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Calla lily (*Zantedeschia aethiopica*) is a cut flower widely used in floral arrangements, event decoration, however it presents low post-harvest durability. Thus, the objective was to evaluate the postharvest quality of the calla lily inflorescences when they were submitted to different concentrations of essential oils and storage temperatures. Calla lily stems with 50 cm long were immersed in containers containing 500 ml of pure water and sprayed with solutions of five essential oils: eucalyptus (*Eucalyptus citriodora*), cinnamon (*Cinnamomum zeylanicum*), lemon grass (*Cymbopogon citratus*) and peppermint (*Mentha piperita*) 1% and indian-clove (*Syzygium aromaticum*) 0.1%, plus a control, pure water. Subsequently, the stems were stored in three temperatures: 21o, 4o and 10°C. After the 5-day period stored in a cold room, the stems were transferred to another room (21°C), remaining until the loss of commercial quality. The evaluations were carried out every two days where was observed the commercial quality, the damages occurrence, dimensions of the spathe, presence of pollen, fresh weight of stems and volume of consumed water. In the second time, the stems were put in plastic containers with 5 L of eucalyptus essential oil solution in 6 concentrations: 0, 0.1; 0.25; 0.5; 0.75; 1%. The evaluations were carried out every 2 hour with a total of 10 hours of the experiment. For each evaluation three lengths of the stem (5, 10 and 15 cm) were collected to determine the sucrose content and, after 5 hours a 10cm length stem was collected for the analysis of electron microscopy. It was observed that the amount of water consumed increased over time for all temperatures while fresh weight and commercial quality varied at the three temperatures and in the different essential oils. The stems that were immersed in the solution of eucalyptus oil showed bottlenecks and the sucrose content varied. The use of essential oils promotes negative effects in calla lily post-harvest.

Keywords: *Zantedeschia aethiopica*, postharvest, essential oils



POSTER 4:

GAMMA RAY INDUCED FOLIAGE VARIEGATION AND ANATOMICAL ABERRATIONS IN CHRYSANTHEMUM (*Dendranthema grandiflora* R) cv MAGHI

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In the present study rooted cuttings of chrysanthemum (*Dendranthema grandiflora* R) cv. Maghi, were subjected to gamma radiation 0, 1, 1.5, 2, 2.5, 3, 3.5, 4 and 4.5 kR with the objective of developing novel variegated mutants as well as variation in flower color etc. The experiment was laid out in Randomized Block Design with nine treatments which were replicated three times. The quantitative and qualitative characters studied and revealed variegation in foliage and also in color and shape of flowers in plants treated with 1 and 1.5kR gamma radiation over control. Maximum number of variegated plants (6), number of branches (31), diameter of flower (3.60 cm.) and size of stomata (length of Guard cell 30 micron, width 17 micron, length of pore 26 micron and width of pore 7 micron) was recorded for the lower radiation doses (1 and 1.5 kR). Higher radiation doses of 3 to 4.5 kR were ineffective since they adversely affected the plant performance in terms of its survival, vegetative as well as flower growth. Chimeric plants were produced which could be multiplied for obtaining mutants in pure form.

Keywords: chrysanthemum, maghi, gamma radiation, chimera scanning electron microscope

