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## **S05: BERRIES BETWEEN OPPORTUNITIES AND CHALLENGES**

**Conveners:**

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**S05: BERRIES BETWEEN OPPORTUNITIES AND CHALLENGES;  
BUCHAREST, EHC2024, MAY 13-16**

**ORAL PRESENTATIONS**

**SESSION I: BREEDING, GENETICS, AND VARIETY  
ASSESSMENT**

S05-I-O-1

**Breeding strategies for new resilient cultivars for berry production**

**Bruno Mezzetti** (*Invited Speaker*)

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Drought represents one of the greatest risks in the agricultural sector, compromising the correct food supply every year. New strategies useful for countering the limited availability of water are essential to ensure the sustainability of agricultural productions with high water needs, as strawberries and other berries, especially in marginal and drought production areas such as those of the Maghreb. In this area strawberry already represent an important and still growing sector, followed by blueberry, raspberry, and blackberry. To support berries expansion in this area are needed new, more resilient cultivars suitable for cultivation systems based on the reduced use of local water resources. Therefore, it is needed a breeding strategy based on the use of genetic resources and the creation of new pre-breeding materials through plant genotyping, phenotyping, metabolomic and sensorial analyses to assess fruit quality. The assessment of the new genetic material must be primarily finalized to identify new cultivars with the highest adaptation to the reduced used of major cultivation factors, firstly water use. This is the strategy now developed by the EU Horizon2020 BreedingValue project that will make a significant impact on the future of berry fruit cultivation and its associated industries in Europe.

**Keywords:** Genetic resources, pre-breeding, genotyping, phenotyping, quality

S05-I-O-2

**Intragenic approach for remontant strawberry**

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The development of commercial octoploid cultivars with high quality and perpetual flowering (PF) character remains an important goal in the breeding of this crop, but this milestone is not easy to achieve with standard hybridization, and the genetic control behind PF is still under study. Flowering locus T2 gene of *Fragaria vesca* (FveFT2) has been recently validated as the non-photoperiodic florigen, which allows short-day flowering when overexpressed in both diploid and octoploid varieties, acting as a long-distance floral signal in strawberry. The advancement of new genomic techniques, like cisgenesis and intragenesis, has led to the development of strategies that allow the genetic improvement of plants through methods that do not involve the use of foreign genetic material, like genes of bacterial or viral origin, to meet public acceptance and less restrictive regulation procedures. In this study FveFT2 gene was inserted into three new intragenic constructs composed of regulatory regions and selectable/reporter genes isolated from *Fragaria x ananassa*, or of plant origin. In vitro leaves of the June-bearing strawberry cultivars Romina (F. x ananassa) were used as initial explants for *Agrobacterium tumefaciens*-mediated transformation assays. One of the three constructs, which also encodes for the EPSPs gene of the octoploid strawberry as selectable marker, providing greater resistance to the herbicide glyphosate, has favoured the regeneration and proliferation of several positive lines to preliminary PCR analysis. The other two constructs, which lack a selection gene in the T-DNA sequence, only led to the regeneration of chimeric or not transformed shoots, highlighting the difficulty in obtaining cisgenic/intragenic lines through these kinds of systems. The confirmed lines transformed with the construct FveFt2::FaEPSPs will be phenotypically characterized to confirm the acquisition of the PF character. This result will pave the way for future studies to transfer this strategy to other June-bearing octoploid strawberry varieties of commercial interest, and to obtain plants with a lower impact in terms of biosafety and with greater public acceptance.

**Keywords:** *Fragaria* spp., Flowering locus T, New genomic techniques, Cisgenesis, Intragenesis

S05-I-O-3

### **Recent Studies on Strawberry Breeding in Türkiye**

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Scientific research highlights the benefits of berries for human health, and increases the demand of consumption and production all over the world including Turkey. For this reason, berry breeders have started to work on the development of new varieties that are especially important for human health and nutrition. For this purpose, within the scope of the European Union project called "Breeding Value", which includes 8 different countries and 20 participants under the coordination of Professor Bruno Mezzetti, Turkey was involved in this project and the nutritional contents of local berries were examined, as well as their resistance to some biotic and abiotic stress factors. On the other hand, our country has participated in breeding studies to develop varieties resistant to gray mold disease, which causes significant commercial losses in strawberries, and to determine QTLs related to the disease, within the scope of the "MedBerry" project, which

is also supported by the European Union, under the coordination of Elena Baraldi, in which it is a part of 5 different European projects. In addition, development of new strawberry varieties tolerant to water stress by crossbreeding method and identification of candidate genes related to water stress", supported by national foundation TUBITAK (The Scientific and Technological Research Council of Türkiye) is continuing. Finally, in our project on the development of new varieties resistant to powdery mildew and gray mold in strawberries with different breeding strategies, were supported by the national TUBITAK with our international stakeholders Mezzetti and Baraldi, we will study classical hybridization and protoplast fusion techniques with the varieties determined within the scope of our MedBerry project has already finalized. In this article, the breeding studies we have done on strawberries in recent years are presented.

**Keywords:** Strawberry, breeding, botrytis, drought stress

S05-I-O-4

### **Genetic dissection of horticultural traits in a Reconstructed octoploid strawberry population: A Multi-Model GWAS Approach**

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The cultivated strawberry (*Fragaria ×ananassa*) has a rich historical genesis as it originated from the hybridization of two wild octoploid strawberry species *F. virginiana* and *F. chiloensis* in the 18th century. After two centuries of breeding, the current strawberry cultivars are reported to have a diminished allelic diversity. In order to enrich strawberry breeding germplasm, a population of reconstructed strawberry was created through controlled crosses between elite selections of the parental species, and a replicated field experiment was conducted in Southwestern Finland. We evaluated the performance of the reconstructed population for several horticulturally important traits over 2-3 years. Genotyping was performed using the 50k SNP array. Population structure analyses confirmed pedigree-based grouping of the progenies into distinct groups. Our multi-model GWAS identified marker-trait associations common to both single and multi-locus GWAS models. The identified genomic regions contained potential candidate genes for traits related to climatic adaptation and domestication. As far as we know, this study marks the first comprehensive investigation of adaptive and horticultural traits in a large, multi-familial reconstructed strawberry population using SNP markers. Our results provide valuable insights into the genetic basis of important horticultural traits in strawberries, which can be used to develop new cultivars with improved field performance and wider adaptability for Nordic region.

**Keywords:** BLINK; FarmCPU; GWAS; horticultural traits; MLM; pre-breeding; reconstruction; strawberry

S05-I-O-5

**Sensorial and nutritional quality of strawberry fruits (*Fragaria x ananassa* Duch.) obtained from plants subjected to drought stress**

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Drought is currently the riskiest abiotic stress affecting the agricultural sector. In fact, every year the proper food supply is compromised since this problem. The most important challenge of the modern agriculture is to satisfy the food needs, ensuring an environmental safety. To optimize the water use, soilless cultivation is recently one of the most popular farming systems. The following trial provides data concerning the organoleptic and nutritional quality of strawberry fruits (*Fragaria x ananassa* Duch.) obtained from plants cultivated in pots, under different water supplies. Three strawberry genotypes developed by the UNIVPM breeding program, 'Francesca', 'Lauretta' and AN15,07,53 were tested. Three randomized blocks of 27 plants, were differently irrigated. The control WW (about pF1 of the substrate's water holding capacity), the first stress WS1 (among pF 1-1.7) and the second stress WS2 (about pF 1.7-2). The results highlight the possibility to reduce the irrigation amount, without affecting the strawberry yield and fruit's healthy compounds content. Specifically, folic acid, anthocyanins, polyphenols, antioxidant capacity, ascorbic acid and phenolic acids were analyzed using spectrophotometry and high-performance liquid chromatography. This as a confirmation of the higher resilience of the new genetic material obtained by UNIVPM breeding program.

**Keywords:** *Fragaria x ananassa*, soilless, drought stress, nutritional quality

S05-I-O-6

**Primocane raspberry and blackberry cultivars from Polish breeding program dedicated for single and double-cropping pot production under tunnels.**

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Raspberry (red, yellow, and black) and blackberry cultivars that produce fruit on current-season canes (primocanes) can yield additional fruit the following year as second-year floricanes, a phenomenon referred to as double-cropping. The objective of this study was to assess the double-cropping potential of new raspberry and blackberry cultivars released by Niwa Berry Breeding Ltd. in a potted growing system under high tunnels in Southern Poland, specifically Brzezna. Among the evaluated raspberry varieties, 'Husaria' exhibited potential for double-cropping due to its high yield on floricanes (1.5 kg/cane) and the production of canes with a height of 1.7 meters. The remaining evaluated primocane raspberries demonstrated a higher yield on primocanes ('Magnat,'

'Baron,' 'Delniwa,' and 'Promyk,' 1 kg/cane). Concerning the evaluated primocane blackberries, 'Maryna' displayed greater height of floricanes (1.7 m), making it a suitable candidate for double-cropping. In the case of blackberries, larger fruit was observed on primocanes. Among the evaluated primocane blackberries, the Maryna variety had an average fruit size of 7.5 g, which was higher than the others.

**Keywords:** primocane, raspberries, blackberries, polish breeding program, double cropping.

S05-I-O-7

### **Can clonal rootstocks be used to manipulate fruit size in kiwifruit?**

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Fruit size is a key quality metric determining value with consumers in various markets. Fruit size is regulated by numerous factors; for example, kiwifruit grown in some Mediterranean climates produce smaller fruit than in temperate maritime climates. Clonal rootstocks have the potential to influence many vine and fruit quality metrics, including fruit size. As part of an evaluation of a clonal kiwifruit rootstock trial in New Zealand, we have assessed the population distributions of fruit size from 'Zesy002' scions. We will discuss the potential of clonal rootstocks to manipulate fruit size to enhance commercial production outcomes.

**Keywords:** *Actinidia sp.*, scions, fruit quality, commercial production,

S05-I-O-8

### **From Clone to Clone: The Yield Advantages of Interclonal Pollen Transfer**

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The interaction between clonality and reproductive biology is pivotal in horticulture. Inbreeding depression due to pollination between clones can lead to increased homozygosity and expression of deleterious alleles in closely related individuals. Lowbush blueberries (*Vaccinium angustifolium*) are susceptible to inbreeding depression, however, evidence suggest that pollen movement between distantly located flowers on the same plant increases fruit set. Our study explores the impact of pollen movement on fruit set and quality on highbush blueberry clones. We examine the differences between fruit produced from pollen movement within a blueberry plant

compared to pollen movement between plants of the same clonal variety. This was done by comparing fruit production, quality and ripening times after pollinations within plants versus fruit production, quality and ripening times after pollinations between plants of the same varietal clone. By comparing pollination outcomes within plants and between plants of the same varietal clone, we uncover intriguing discrepancies. Despite the genetic similarity of different blueberry varieties, our investigation unveils distinct variations in fruit attributes depending on the source of pollen. Whether from within the plant or between plants of the same variety, pollen origins influence fruit production, quality, and ripening time, albeit with variability across blueberry varieties. These findings also allude to the role of somatic mutations in driving these differences in between-plant crosses. However, this aspect requires further exploration for validation. Against the backdrop of clonality's intricacies, our study offers insights into the interplay between pollen movement and fruit production quality. These insights carry implications for optimizing horticultural strategies and emphasize the importance of understanding the interplay between genetic inheritance and reproductive biology.

**Keywords:** clonality; geitonogamous; pollen movement; blueberries; fruit quality

S05-I-O-9

### **Advances in blackberry synthetic seeds production**

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Recently, there has been a notable increase in both cultivation and consumption of blackberries, accompanied by a rising demand for high-quality nursery materials. Traditionally, blackberry plants have been propagated through agamic methods, primarily involving layering and cutting. However, these methods come with constraints such as the requirement for extensive planting area, and labor-intensive processes. As a solution to these limitations, in vitro propagation, specifically micropropagation, has been successfully proposed and widely adopted. Within this context, encapsulation aiming to produce synthetic seeds emerges as a strategy to enhance the productivity of in vitro propagation and facilitate the exchange of plant material between laboratories. Although synthetic seeds have shown applicative potential for various plant species, research on protocols for the production and utilization of encapsulated propagules in blackberry is still in its early stages. This study focuses on evaluating the impact of low-temperature conservation (4 °C) for 120 days and the type of in vitro sowing media (agarized, perlite, and potting substrates) on the performance of synthetic seeds of the blackberry cultivar Thornfree. The synthetic seeds were obtained through the encapsulation of the base of vitro-derived clumps. Results obtained using an agarized sowing substrate indicate that storing blackberry synthetic seeds at low temperatures has no adverse effects on their viability, regrowth, conversion, number of shoots, and rooting percentage. Moreover, certain parameters, such as the number and length of roots, shoot length, and fresh weight of plantlets, were found to be higher in the stored synthetic seeds compared to the unconserved seeds. The type of sowing substrate

significantly influences the performance of synthetic seeds, with satisfactory conversion rates and plantlet development observed only in the agarized substrate.

**Keywords:** *Rubus spp.*; micropropagation; alginate beads; in vitro culture.

S05-I-O-10

### **Insights into Romanian goji berry breeding**

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Goji berries, globally recognized as a superfruit, are witnessing increased production in Europe and North America due to rising demand. Romania has registered seven goji berry varieties, adapted to local conditions using imported germplasm, facilitating the establishment of certified *L. barbarum* and *L. chinense* commercial plantations across various counties. Historically used in Romania for ornamental, anti-erosion, and fencing purposes, current research compares genetic variations between cultivated and wild *L. barbarum* genotypes, focusing on the BDG 3 and 4 genes linked to cuticle resistance. Significant genetic differences, particularly in SNPs, were found between cultivated and wild genotypes, offering valuable insights for enhancing Romanian goji berry breeding and cultivation.

**Keywords:** *Lycium barbarum*, *L. chinense*, goji berry breeding; plant resistance; whole genome sequencing

## **SESSION II: BERRY PLANT PROTECTION**

S05-II-O-1

### **Decreased susceptibility to grey mould disease in *Fragaria x ananassa* through RNAi-based techniques**

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Strawberry (*Fragaria x ananassa*) is one of the most widespread berry fruits worldwide, subject to the attack of several fungal diseases, such as grey mould, caused by the ascomycete *Botrytis cinerea*, considered one of the most harmful pathogens for this crop both at pre- and post-harvest stages. Recently, it has been demonstrated that the exogenous application on strawberry fruits of double-stranded RNA (dsRNA) molecules, specifically responsible for the silencing of dicer-like 1 (DCL1) and 2 (DCL2) genes of *B.*



*cinerea*, can reduce susceptibility to grey mould. In this study, the efficacy of the same Bc-DCL1/2 dsRNA naked molecules in controlling this disease was validated by their exogenous application at different concentrations on plants of the cultivated strawberry cv. Romina grown in the greenhouse. This trial confirmed the capability of the Bc-DCL1/2 dsRNA to significantly reduce *B. cinerea* growth on strawberry fruits at each concentration assessed, up to 14 dpi, compared to the negative controls. Furthermore, a hairpin gene construct targeting the same Bc-DCL1/2 genes (hp-Bc-DCL1/2) was stably expressed in the same strawberry cultivar. The hp-Bc-DCL1/2 strawberry lines were verified through molecular analyses for the expression of the gene construct and for the accumulation of silencing effector molecules (siRNAs). In addition, both leaves and fruits detached from the hp-Bc-DCL1/2 lines showed significantly decreased susceptibility to *B. cinerea* up to 7 and 4 dpi, respectively, compared to the wild-type control. qRT-PCR analyses performed on inoculated hp-Bc-DCL1/2 strawberry fruits showed the reduction of the pathogen biomass and the downregulation of the target genes in *B. cinerea*, confirming that the silencing of BcDCL1 and BcDCL2 genes leads to the suppression of fungal virulence and growth. The two RNAi-based strategies described in this study show their strong potential in reducing the use of chemical pesticides and developing more sustainable agronomical solutions.

**Keywords:** cultivated strawberry; *Botrytis cinerea*; gene silencing; greenhouse trial; spray; in-planta stable expression

S05-II-O-2

### **Phytosanitary problems encountered in an organic kiwifruit orchard in Dobrogea region**

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The number of organic fruit plantations is recently increased in Romania, although the risk factors are more difficult to control, compared to conventional orchards. Walnut, blueberry and sea buckthorn are the species planted on several thousand hectares in organic system and the challenges are multiple. Kiwifruit is a new species for Romania and in 2021, a research and demonstration organic orchard was planted in Movilita, Constanta county. Several cultivars of *Actinidia deliciosa*, *Actinidia chinensis* and *Actinidia arguta*, have been planted at 4.5 x 3,0 m and at 4.5 x 2,0 m, respectively. A closed hail protection system, covered with black net, was installed on 4.5 m tall concrete poles, with the aim to reduce the wind speed and the solar radiation. Irrigation was provided with rotary micro sprinklers with a flow of 35 l/hour. The interrow was cultivated with several mixtures of perennial grass while the row was kept clean initially by mechanical tillage. In order to reduce the water loss and the weeds growth, a thick layer of straw mulch was placed on the row. In the first vegetation year, several phytosanitary problems occurred and the increased attacks of white garden snails, mice and earth squirrels were the most difficult to handle. The tested fight methods were mostly mechanical and physical with minimal efficiency. The plants straw mulching favoured the multiplication of rodents, while the orchard net cover, kept the predator birds out. Some soil-borne diseases that affected the plants root system were also found.

**Keywords:** *Actinidia deliciosa*, *A. chinensis*, *A. arguta*, phytosanitary control, mulching, rodents

## **SESSION III: ECONOMICS IN BERRY INDUSTRY**

S05-III-O-1

### **The wild and wide-ranging challenges and opportunities of producing berries in a global economy**

David Percival (*Invited Speaker*)

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Global berry production continues to increase with an estimated value of \$24.1 billion (USD) in 2023, that is projected to increase to \$35.6 billion by 2030. Despite labour, geopolitical, and climate change challenges, the ongoing global increase in berry production has been facilitated with advancements including new cultivars; production and postharvest handling technologies; an expanding and diversifying food processing sector; and perceived health and wellness attributes. The development of new cultivars in the public and private sectors has focused on improved composition and quality attributes, increased tolerance to biotic and abiotic stresses, ease of production management, and longer postharvest shelf-life. New and innovative agrotechnologies that are becoming increasingly common across the various berry sectors include wireless and remote sensors, predictive forecasting models, data analytics, advanced automation, precise agrochemical delivery, and robotics. Despite the challenges associated with cost, knowledge acquisition and technology transfer and implementation, benefits can be obtained with enhanced crop quality and productivity through precision automation, pest control and crop-health monitoring. These advancements however, need to be implemented in an accountable, ethical, and sustainable manner with transparent environmental footprint processes that transition production systems to “produce better with less.”

**Keywords:** Fruit production, new cultivars, farming technology

S05-III-O-2

### **Consumer awareness, buying behaviour and use of fresh berries in different countries**

**Eike Kaim**

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In the recent past, there have been and still are several horticultural projects in order to stimulate the improvement of sustainability of berry production, quality and nutritional value in a changing environment. In terms of the whole supply chain, the consumer's perspective needs to be taken into consideration as well. In order to stimulate the demand of fresh berries among the consumers, it is crucial to know, what consumer's preferences are in matters pertaining fresh berries. With respect to production, there is

statistical data available about fresh berries like e.g. strawberries, raspberries, blueberries, blackberries and currants. These data show a dynamic development of fresh berry production in different European countries. With respect to consumption, there are less data available and an information gap about consumer's preferences became obvious. This aim of this study is to contribute to the consumer's perspective. The objective of this research is consumer's awareness, their buying behavior and consumption habits of fresh berries in different countries. Assuming that consumer's preferences might show sex and age differences as well as regional distinctions, this study performed as a cross-national study. Countries involved are Germany, Italy, Poland and the United Kingdom. The sample size in each country is limited to 500 participants. In order not to distort the sample because of foreign language competences, the questionnaire was designed in the native language of each country. The survey was carried out online. The paper will present the results of this cross-national study about consumer's preferences like associations towards fresh berries ("mind set"), awareness of fresh berries, buying behavior and use and consumption habits in different countries.

**Keywords:** fresh berries consumption, buying behaviour

## **SESSION IVa: PLANT PHYSIOLOGY AND ENVIROMENT INTERACTION**

S05-IV-O-1

### **Analysis of the yield gap in open field strawberry in northern latitudes**

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Strawberry is the most important berry crop in Finland with an annual production of 16 million kg. While tunnel production is increasing, the majority of the strawberries are still produced in the open field. Both abiotic (climate, soil, weather) and biotic (cultivar, pests) factors influence the yield. In order to develop strategies for sustainable intensification of strawberry production, a more precise knowledge of the difference between the yield potential and actual yield is needed. The objectives of this study were i) to assess the growers' opinions on factors affecting yield, and ii) to quantify the yield gap in the main production areas in Finland. First, a case study was conducted. Seven strawberry growers were interviewed about their opinions and the importance of yield variation in their own production now and in the future. Secondly, the magnitude of the yield gap during the last decade was investigated. The analysis was based on comprehensive statistical data (years 2012-2021) which was modelled using a Bayesian approach. The

quantity and quality of the yield, the market price of both inputs and yield, and the weather during the growing season were found to highly affect the profitability of the production by the growers. In growers' opinions the effects of climate change (e.g. heat waves and flood risk) need more attention in the future. On the other hand, pests, agronomic expertise, and business skills were mentioned as key factors in achieving satisfactory yield levels and income. The results indicated that the growers were able to identify risks and the sources of yield variation. At the same time, the modelling of the yield gap suggested that these factors may be difficult to control.

**Keywords:** yield potential, profitability, Bayesian modelling

S05-IV-O-2

### **The effect of source-sink status on flowering and the performance of everbearing strawberry cultivars**

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Everbearing strawberry cultivars have the potential to extend the growing season and boost productivity through recurring flowering. However, fluctuations in cropping pattern pose challenges. Extended seasons cause simultaneous vegetative and reproductive growth, emphasizing an enhanced importance of source-sink balance. However, the regulatory relationships for everbearing strawberries are unclear. To elucidate the impact of source-sink balance on flowering and fruiting, we removed early inflorescences from two everbearing cultivars, namely 'Favori' and 'Murano'. Findings reveal continuous flower initiation is resource-limited. Altering source-sink status through early removal of inflorescences effectively manipulates flowering and fruiting patterns, leading to a more balanced and stable cropping with increased yields during the normal slowdown periods. Following flower removal, new flowers initiate, which appeared to be influenced by the photoperiod and temperature occurring at the time. Relieving internal competition enhances dry matter partitioning, increasing sugar concentrations in remaining fruits and improving crop quality. Yield redistribution to the lag phase and second flush post flower removal doesn't negatively impact assimilate partitioning, suggesting flower removal treatments enhance overall crop quality.

**Keywords:** fluctuations in cropping; flower initiation; fruit quality

S05-IV-O-3

### **Elderberry inflorescences – setting the perfect timing for optimal flavor**

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Elderberry (*Sambucus nigra*) is a wild plant known for its fragrant inflorescences. In Slovenia, they are traditionally harvested in spring to make typical beverages, such as elderberry syrup. However, little is known about the optimal harvest time and the variation of plant metabolism along the day, in order to achieve optimal flavor and fragrance. We

performed a description of the variation in primary and secondary metabolism of inflorescences throughout the day, considering four different stages of their development: completely closed, half open, fully open, and senescent. Metabolite analysis included sugars, organic acids, and phenolic compounds. Volatile organic compounds' daily variation was also described using HS-GC-MS, showing that the typical odor is a rich cocktail of alcohols, aldehydes, ketones, and terpenoids. The results suggest that the time of harvest and inflorescence stage is relevant, since volatile compounds, as well as other health-promoting compounds, vary during the day. Also, environmental factors correlate with their contents, which should also be considered at harvest to achieve an optimal flavor of the product.

**Keywords:** elderflower, primary metabolism, secondary metabolism, fragrance

S05-IV-O-4

### **Yield and morphological response of two segregating lines of *Rubus fruticosus* to three different periods of cold treatment**

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Production technologies allow blackberry growers to be competitive in a growing and increasingly demanding global market. The production of long-cane blackberries (plants with the first year of vegetative growth and second year of production after a cold period) under plastic high-tunnels allows growers to achieve high yields and enter in the market at crucial times to maximize profits. This study aimed to understand the morphological and yield response of two different segregating lines of open-pollinated varieties (OPs), of seminal origin, based on different cold storage periods. Long-canescanes of genotypes from seminal origin of two segregating lines of OPs, one primocane (Prime-Ark® 45) and one floricanecane (Midnight), were subjected to 3 cold treatments. The cold treatments consisted of different storage periods in cold rooms (F1 – 1300 h; F2 – 2000 h; F3 – 2700 h), at a temperature ranging from 0 to 2 °C and 92% relative humidity. The plants were all placed in the cold storage rooms at the same time (12th January 2023) and removed on three different dates (21st March, 19th April and 16th May 2023) according to the cold time established for each treatment. After coming out from the cold, the plants were randomly arranged in the field under plastic high-tunnels in batches of 18 plants per repetition (3 repetitions/treatment), in a total of 324 evaluated plants. A weekly evaluation of phenology was carried out until the mature fruit stage, and morphological characterization and production assessments for yield and fruit quality were performed. Preliminary results reveal greater sprouting (78,8 %) of Midnight's descendant genotypes in response to F1. The segregating line of Prime-Ark® 45 showed a higher tendency to emit root shoots (5 to 7 shoots/pot), as well as treatment F3, which led to a maximum of 7 root shoots/pot. In terms of yield, in both segregating lines, the fruit size is higher in F1 (3,6 to 3,7 g) and F2 (3,5 to 3,8 g), and the descendants of Midnight and Prime-Ark® 45 produce more fruits when treated by F1 (330,2 g) and F2 (357,5 g), respectively. This

research can further assist growers in making correct decisions regarding scheduling the entry and exit of plants from cold storage, as well as obtaining more profitable yields.

**Keywords:** blackberries; cold storage; floricanes; genotypes; long-canes; primocane; yield.

S05-IV-O-5

### **Detailed composition of white strawberries and how does it change during ripening**

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White strawberries (pineberries) are an exclusive product on the fruit market, which can offer consumers the characteristic taste of red strawberries but with a unique white appearance. However, there are limited studies describing the composition of white strawberries and the optimal ripening stage for harvest. Our study focuses on the composition of white strawberries (*Fragaria × ananassa* cv. 'White Dream') describing both the content of primary metabolites (ascorbic acid and other organic acids, sugars) and secondary metabolites (phenolic and volatile compounds). Furthermore, the composition was analysed at different ripening stages – from ripe to different levels of overripe fruit. The content of the metabolites was also compared with the physical parameters of the fruit (weight, colour, firmness, ripening index IAD). As the lack of pigment suggests, the content of anthocyanins in ripe white strawberries was only 18.9 mg/kg fresh weight and the major anthocyanin present in ripe white strawberries was cyanidin-3-O-glucoside. However, in later stages of overripe fruit, when the fruit started turning red, pelargonidin-3-O-glucoside dominated. In ripe white strawberries, the detected ascorbic acid content was 0.50 mg/g fresh weight and sugar content was 65.3 mg/g fresh weight. The sugar/acid ratio increased during ripening starting from 1.2 in unripe fruit to 5.6 in very overripe fruit, with average of 2.9 in ripe white fruit and was caused mainly by a higher content of acids in the white strawberries. The aroma profile of the white strawberry consisted of esters, aldehydes and alcohols typical for strawberries and the content of the aroma compounds increased during ripening. Our results show that the composition of white strawberries significantly changes during ripening which can consequently affect the quality of the fruit and consumer acceptance.

**Keywords:** white strawberry, ripening, phenolics, aroma, sugars, organic acids

## **POSTER PRESENTATIONS I**

S05-P-I-1

### **Effect of treatment with microalgae extracts on growth and development of raspberry**

**Kaspars Kampuss**<sup>1</sup>, Pavels Semjonovs<sup>2</sup>, *Kristine Afonina*<sup>1</sup>, *Ingrida Augspole*<sup>1</sup>, *Irina Sivicka*<sup>1</sup>

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Raspberries (cultivar 'Polana') were planted in 20 L pots, filled with peat (producer Laflora LTd., pHKCl 5.5) and grown under open field conditions during the season of 2023. In total, 6 plants per treatment were used and data recorded separately for each plant. The plants were sprayed with the solution of ethanol extractions of different microalgae species, e.g. Spirulina, Dunaliella, Chlorella in two concentrations and compared with sprays with corresponding ethanol solution as a control. In total, 9 sprays were applied weekly until berry harvest started. During the season, dynamics of a vegetative growth of productive shoots were measured, as well as starting dates of flowering and berry ripening recorded. Berries were harvested every 3 to 4 days, total yield, berry count and weight measured, and berries, damaged by Botrytis rot, were weighted. The main biochemical quality parameters were measured – soluble solids content, titratable acids, ascorbic acid, anthocyanin's and phenolic contents. After the treatments, leaf chlorophyll index, total vegetative growth, and proportion of a productive part of the shoots were measured. The effects of the treatments to raspberry growth, productivity and yield quality are discussed in this paper.

**Keywords:** microalgae extracts, raspberry, productivity, quality

S05-P-I-2

### **The evaluation of temperature and light conditions for strawberries grown vertically in open area and greenhouse and their plant morphological and biochemical parameters**

**Kaspars Kampuss**

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Research is still needed to optimize and evaluate growing methods and systems, their impact on yield quantity and quality as well as economic viability. The aim of this research was to evaluate the temperature and light conditions for strawberries grown vertically in open area and greenhouse, and their vegetative parameters and chemical composition in response to these conditions. Frigo plants of three strawberry cultivars - 'Honeoye', 'Sonata' and 'Rumba' were planted in double-layer plastic greenhouse and open field conditions. Plants were grown in growing bags with sphagnum peat. Bags were installed in vertical growing system in three layers – 10 cm, 90 cm, and 155 cm. The light intensity

and spectral content were detected by using spectroradiometer. Content of chlorophylls, carotenoids, phenols, flavonoids in leaves was analysed in this research. Daily temperature fluctuations were notable in both areas, especially in sunny days and in greenhouse. It was concluded, that 56.6% of light intensity was lost in the greenhouse, compared to the open area, and the bottom levels had just 71% of light intensity, compared to the top levels. Moreover, the light intensity in the bottom levels also varied more due to shadows. However, these differences in the light intensity did not significantly influence average leaf and inflorescence counts per plant. The differences in plant growth and biochemical content between cultivars and growing systems were detected. Although significant differences in leaf biochemical composition were found in tested growing conditions, cultivars responded differently to them.

**Keywords:** *Fragaria* × *ananassa*, vertical growing, temperature, light intensity, leaf chemical composition

S05-P-I-3

### **Phenolic compounds and antioxidant activity of *Actinidia kolomikta* and *Actinidia arguta* berry extracts**

**Remigijus Daubaras**<sup>1</sup>, Laima Cesoniene<sup>2</sup>, Sandra Saunoriute<sup>2</sup>, Viktorija Januskeviciene<sup>2</sup>

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Growing demand for healthy food products motivates the scientific community to expand the search and investigation of potential superfruits. Furthermore, neglected and underutilized indigenous and introduced berry plants could be considered new sources of vitamins. The berries' biochemical composition depends on various biotic and abiotic factors such as cultivar properties, ripening stage, cultivation conditions, and harvest time. In this study, the research was accomplished on berries of five cultivars of *A. kolomikta* and five cultivars and hybrids of *A. arguta*. Selected cultivars were chosen to determine the variety of phenolics between these two species and among cultivars. Comparing the amounts of TPC, it was found that *A. kolomikta* and *A. arguta* berries accumulated an average of 177.80 mg/g DW and 54.45 mg/g DW, respectively. The amounts of total flavonoids, hydroxycinnamic acid derivatives, and proanthocyanidins in berries of *A. kolomikta* cultivars were also statistically reliably higher. Flavan-3-ols, flavones, hydroxycinnamic acid derivatives, and flavonols were determined by the analysis of the qualitative and quantitative content of phenolic compounds using the UHPLC-ESI-MS/MS technique. Four phenolic acids, eight flavonols, two flavones, and five flavan-3-ols were identified in the berry extracts. Variation of antioxidant activity determined by CUPRAC, FRAP, and ABTS•+ methods was strongly influenced by different cultivars' characteristics. Our data indicated that berries of both hardy kiwi species were major sources of natural antioxidants.

**Keywords:** phenolic compounds, actinidia, berries, antioxidative activity



S05-P-I-4

### **Cultivation of blueberry saplings in peat substrates with different rates of spruce, pine fibre and perlite**

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Recently, there a rapid increase in interest in blueberries and cranberries in Europe and around the world has been observed. Consequently, the demand for large quantities of planting material for blueberry plantations has increased. Peat is an extremely important component in substrates; however, its extraction threatens sensitive ecosystems, causes carbon sinks, and increases greenhouse gas emissions. In this study, the impact of peat mixes with different rates of spruce or pine fibre and perlite on vegetative growth, content of nutrients and chlorophyll fluorescence in the leaves of blueberry saplings were studied. To define the suitability of substrates, plant vigour assessments of the cultivar 'Duke', including plant height and leaf weight, and the chlorophyll fluorescence, content of extractable macronutrients and organic carbon in leaves, were investigated. The best effect on the growth of blueberry saplings, the optimal content of macronutrients in the leaves was shown for substrates in which a part of the peat was replaced by 15%–45% v/v of pine wood fibre and by 15%–30% v/v of the spruce wood fibre. Pine bark fibre in the mix should not exceed 30% v/v. The addition of spruce bark fibre at different rates negatively affected the saplings' vegetative growth. The quantity of peat in the substrates can also be significantly reduced by adding 15%–45% v/v of perlite. These results corroborate that pine and spruce fibre or perlite in substrates for blueberry sapling growing could reduce the demand for peat and should significantly contribute to the preservation of unique wetland ecosystems.

**Keywords:** blueberry, substrate, peat, saplings, growing

S05-P-I-5

### **Application of polyploidy genotypes in breeding in genus *Ribes* and *Lonicera* at the National Institute of Horticultural Research in Skierniewice, Poland**

**Agnieszka Marasek-Ciolakowska**<sup>1</sup>, Lukasz Seliga<sup>1</sup>, Stanislaw Pluta<sup>1</sup>, Aleksandra Machlanska<sup>1</sup>, Malgorzata Podwyszynska<sup>1</sup>

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The polyploidization and intra and interspecific hybridization are the most important sources of phenotypic diversification in the cultivated crop plants. Polyploid individuals usually show higher plant vigor, a more compact growth habit and enlarged organ then diploid progenitors. The common consequence of polyploidy is the reduction of fertility and low rate of seed production. The aim of the presented study was the preliminary assessment of the usefulness of polyploids for the applied breeding in blackcurrant (*Ribes nigrum* L.) and honeyberry syn. Haskap (*Lonicera* sp.). The ploidy level of all

genotypes used for hybridization was confirmed by flow cytometry and chromosome count. In genus *Ribes*, the Polish diploid blackcurrant cultivars 'Gofert' and 'Polares' ( $2n=2x=16$ ) and their neotetraploid clones ( $2n=4x=32$ ) obtained via mitotic chromosome doubling were used in our studies. All cultivars of honeyberry (*Lonicera caerulea*) selected for the applied breeding program were tetraploids ( $2n=4x=36$ ). In practical plant breeding, including both species numerous seeds obtained from the pollination (hybridization) of parental forms is essential to produce of seedling's population for further evaluation and selection of valuable individuals and breeding clones. In our studies for both species pollen viability was assessed based on germination of pollen grains on media supplemented with 15% sucrose. The preliminary results showed the average pollen viability of tetraploid clones of blackcurrants was higher than honeyberry and ranged from 42.8% in 'Polares' to 51.7% in 'Gofert'. The pollen viability of honeyberry cultivars was low and amounted to an average of 10.2% for genotypes grown in greenhouse conditions and 28.3% for plants grown in the open field. The breeding program of blackcurrants involved tetraploids and their diploid initial forms. Twelve cross combinations ( $2x \times 4x$ ,  $4x \times 2x$ ,  $4x \times 4x$ ) were made in the spring 2023. In total, 416 flowers were pollinated from which 62 fruits were obtained. Seedlings obtained from the  $4x \times 4x$  crossing combinations were tetraploids. As a result of crossing diploids with tetraploids, diploid plants were obtained - probably resulting from the apomixis process, while the seeds from the  $4x \times 2x$  crosses did not germinate. In 2023 the breeding program of honeyberry included 36 crossing combinations. In total, 1,796 flowers were pollinated from which 470 fruits were produced and extracted ca. 3,300 seeds. Now seeds are being stratified for 1,5-2 months in the cooled incubator. In the early spring 2024 seeds will be germinated and produced seedlings in glasshouse conditions.

**Keywords:** *Lonicera caerulea*, *Ribes nigrum*, interspecific hybridization, pollen viability, polyploidy

S05-P-I-6

### **New advanced clones of red raspberry (*Rubus idaeus* L.) bred at the National Institute of Horticultural Research in Skierniewice, Poland**

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Breeding work on obtaining new innovative raspberry genotypes at the National Institute of Horticultural Research in Skierniewice, Poland, has been carried out for nearly 10 years. During this period, hundreds of crosses were made and thousands of seedlings were produced. Based on multiannual evaluation of breeding material, several valuable and promising advanced clones with innovative features were selected. M-14037E - 'Skierka' ('Canby'  $\times$  'Sokolica') was submitted for the registration procedure of the Central Center for Research on Cultivated Plant Varieties (COBORU) in December 2022. Its yield is very high, both on one-year and two-year-old canes. The fruits are large to very large, conical in shape, intensely red and shiny, attractive in appearance, very firm and tasty, resistant to mechanical damage during harvesting and transport, and little susceptible to rotting. M-14345E - 'Kanpola' ('Canby'  $\times$  'Polana') was submitted for the registration procedure of the COBORU in December 2023. Its yield is very high, both on

one-year and two-year-old canes. The fruits are large and very large, very attractive in appearance - with a uniform, spherical-oval shape and light red color with a slight shine. The shoots are almost completely spineless (single spines appear only at the base of the canes). M-14035E comes from the crossing of the cvs 'Polka' × 'Veten' cultivars. It is high yielding, it bears fruit on one-year and two-year-old canes. The fruits are large and medium-sized, attractive in appearance - light red in color, strong gloss and oval in shape. An additional, very valuable feature is the complete lack of thorns on the canes, which greatly facilitates the plant maintaining and harvesting of fruit. M-14026E was obtained from a cross between 'Laszka' × 'Polana'. Its yield is very high, both on two-year-old and one-year-old canes. The fruits are large and medium-sized, intensely red and shiny, in the shape of an elongated cone, very attractive in appearance. M-14104E ('Canby' × 'Polana') produces exceptionally abundant crops on one-year and two-year-old canes. The fruits are large and medium-sized, conical, intensely red with a slight shine, attractive in appearance. The research was carried out in the frame of subsidy of the Ministry of Agriculture and Rural Development special-purpose – Task 3.15: "Developing of red raspberry breeding materials for the breeding of innovative varieties with the following features: thorn lessness, double fruit set, increased post-harvest fruit durability, suitability for machine harvesting and increased plant resistance to drought stress"

**Keywords:** red raspberry, breeding clones, productivity, fruit quality, thorn lessness

S05-P-I-7

**Productivity value of new Saskatoon berry (*Amelanchier alnifolia* Nutt.) genotypes bred at the National Institute of Horticultural Research, Skierniewice, Poland**

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The Saskatoon berry (*Amelanchier alnifolia* Nutt.) is a minor berry crop with the prospect of implementation into commercial cultivation in Poland and other countries. This crop is native and grown on large scale in Canada and Northern states of the USA because of valuable and rich in nutrients fruits used both in fresh consumption and in processing and freezing industries. The lack of new Polish cultivars contributed to the start the applied breeding of this species at the National Institute of Horticultural Research (InHort) in Skierniewice, Poland in 2012. One of the final stages of breeding work is an assessment of advanced clones for selected plant and fruit traits. The new Polish cultivar 'Amela' (officially registered in the Community Plant Variety Office - CPVO in 2023) and two promising breeding clones (type H and type N) developed at the Department of Horticultural Plant Breeding of the InHort in Skierniewice, Poland were tested in the field trial. Five Canadian cultivars ('Honeywood', 'Martin', 'Northline', 'Smoky' and 'Thiessen') were used as control cultivars. The experiment was established in 2014. The plant morphology, ripening period, fruit yield, fruit weight and chemical composition of fruits (extract, dry matter, pH, acidity, anthocyanins, total polyphenols and ascorbic acid) were evaluated in 2022-2023. Results from our studies showed that the bushes of cv. 'Martin' grew the strongest white cvs. 'Smoky' and 'Thiessen' had the smallest plant growth. The remaining genotypes were classified as medium-strong growing in the experiment. Canadian cv. 'Martin' had the most upright plant habit and the other tested cultivars and

clones mid-spreading ones. Fruit ripening and harvesting period of all genotypes was in the first half of July, on average between July 4th and 8th in both years of the research in central Poland. The new Polish cv. 'Amela' produced the highest fruit yield, followed by clone type N and cv. 'Northline', but cvs. 'Martin,' 'Honeywood', 'Thiessen' and clone type H had the lowest yields. The fruit weight of tested genotypes also varied, cv. 'Martin' produced the largest fruit while the clone type H had the smallest ones. Other genotypes were characterized by the medium weight (size) of their fruits. Analysis of the internal fruit quality showed that soluble solids content in fruits of the tested genotypes ranged from 14,0 to 21,9 oBrix, while acidity and ascorbic acids content were very low. The study revealed that anthocyanins were the most abundant in total phenolic content in fruit of these cultivars and clones. The findings emphasize that most of the tested cultivars and the clone N type have potential in commercial cultivation for the fresh market and processing in Poland. The research was carried out in the frame of subsidy of the Ministry of Agriculture and Rural Development special-purpose – Task 3.11: „Developing of an initial Saskatoon berry (*Amelanchier alnifolia*) plant material for breeding of new cultivars with high-quality fruit and tolerance to abiotic stress”.

**Keywords:** plant growth and habit, ripening time, yield, fruit weight and chemical analysis.

S05-P-I-8

### **Varieties of Blackberries (*Rubus* spp.) of the Chapingo University with diseases tolerance**

**Sergio Segura**<sup>1</sup>, Geremías Rodríguez<sup>2</sup>, Regina Guerra<sup>3</sup>, David Rodríguez<sup>4</sup>, Oskar Segura<sup>5</sup>, Angel Rebollar<sup>1</sup>

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Mexico is the country where the largest number of blackberry varieties in the world have been patented, with more than 80 registrations in the last five years. Paradoxically, fungal diseases (Fusariosis: *Fusarium oxysporum* f.sp. *mori* and Mildew: *Peronospera sparsa* mainly) have caused a decrease from 13,175 ha. produced in 2010 to 9,660 ha. produced in 2022. Given this situation, a research team of the Chapingo Autonomous University has studied the endemic wild blackberries in the end to used them for genetic improvement in Mexico. With cytogenetic, floral biology, genome sizes by flow cytometry, pathogen variation and disease tolerances knowledge of six wild species, a breeding program has been established to obtain high-quality blackberry new varieties. A combination of the fruit quality, good plant productivity and tolerance to fungi diseases such as Mildew and Fusariosis has generated the Cituni, América, Voscke and Uruapan blackberry varieties which have been patented to the Mexican Ministry of Agriculture. The breeding program uses the recurrent selection method and backcrosses with cultivars and species with low chilling requirements as parentals in each cycle. Thanks to a backcrossing scheme through at least two cycles, it has been possible to transfer

tolerance to diseases conserving good plant productivity and fruit quality characteristics such as fruit size and tasty properties. Agronomic management programs for the varieties have been determined with collaborative growers and this varieties are now planting in Mexico. They are also proposed for cultivation in other blackberry producer areas worldwide.

**Keywords:** *Rubus*, Flow Citometry, Fusarium, Peronospera, México

S05-P-I-9

### **Varieties of Blueberry (*Vaccinium* spp.) of the University Chapingo with low chilling requirements**

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Blueberry (*Vaccinium* spp.) production in Mexico cultivate highbush southern varieties on at least 6,500 ha. Climatic conditions in Mexico allows a harvest throughout Novembre to Jun taking advantage of the proximity to USA market. Currently, consumers prefer big sizes of tasty fruits and growers want tolerant varieties to pest and diseases. At this end a research team of the Chapingo Autonomous University started a breeding program of blueberry varieties and the prospects are encouraging. Expanding the varietal diversity to producing good caliber fruits (> 18 mm) on basal canes, improving their acidity/sweetness ratio (organic acid concentration/sugar concentration) and tolerance to *Batryosphaeria* spp. are the main objectives of the program. The ploidy levels and other genetic and biology barriers of a core collection of southern and rabbiteye varieties were revised. The breeding program is based on recurrent selection with low chilling adapted cultivars and towards to the pot growing system. The varieties Chap Perla Negra, Chap Pepito and Chap Kikapu are issues from two selection cycles and subsequently tested in the field with collaborative farmers and they have shown good production characteristic with excellent productivity for subtropical conditions. In three test plots where our varieties were tested the yield per plant ( $\geq 3\text{Kg.}$ ), fruit size and weight (> 18 mm.), fruit firmness, ease of fruit cutting, and soluble solids (> 8°Brix) content and titratable acidity of fruits have been measured as well as plant health. The promotion of our varieties is directed towards growers and companies in European regions where chilling accumulation is low.

**Keywords:** *Vaccinium*, Breeding, *Batryosphaeria*, Southern varieties, México

S05-P-I-10

### **A genomic assembly elucidates the impact of drought stress on the expression of genes and the composition of metabolites in blackcurrant (*Ribes nigrum* L.)**

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Blackcurrant (*Ribes nigrum* L.), a perennial shrub belonging to the *Grossulariaceae* family, is extensively cultivated for its nutritious berries, renowned for their high levels of antioxidants, vitamin C, and anthocyanins. These attributes make blackcurrants a valuable component in the food and beverage industries. Nevertheless, the escalating challenges of water scarcity and drought stress pose significant ecological and agricultural threats, impacting the growth and yield of various crops, including blackcurrants. Prolonged dry periods, especially during the fruiting season, have been scientifically acknowledged as problematic for blackcurrant plants. Despite the absence of a characterized blackcurrant genome, research has delved into the molecular responses to drought stress at various developmental stages. This study presents the first comprehensive chromosome-scale assembly of the blackcurrant genome (cv. 'Rosenthals Langtraubige') and the genus *Ribes*. Although the blackcurrant genome had not been previously characterized, molecular aspects of drought stress at different developmental stages had been undertaken. RNA-Seq analysis comparing irrigated and drought-stressed blackcurrant plants identified 257 differentially expressed genes in leaves and 4,996 in roots. These genes serve various roles, including functioning as transcription factors like bZIP, bHLH, MYB, WRKY, or being classified within the TKL family, such as PERK and DUF26. Furthermore, the study correlated these findings with metabolite analysis, revealing significant alterations in 14 metabolites in leaves. Notable among these were amino acids such as alanine, GABA, and proline, as well as organic acids like quinic acid, and citric acid a part of the sugar derivative galactinol. These metabolites were found to be associated with genes involved in their respective metabolic responses such as amino acid metabolism. This research marks the generation of the first blackcurrant reference genome, providing valuable insights into the genetic foundations of drought stress responses in this species.

**Keywords:** blackcurrant, drought, differentially expressed genes, metabolomics, omics data integration

S05-P-I-11

### **The potential of the Hydreset irrigation support system to increase the productivity pot growing blueberries**

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In the experiment, the Duke blueberry variety was used, which was grown in an unheated foil tunnel in peat substrate in order to eliminate the influence of rainfall on the course of the experiment. Two-year-old bushes in three-liter containers were obtained from a specialized farm. In the first ten days of April, they were transplanted into ten-liter pots filled with peat substrate with a pH 4.25. The blueberries were pollinated by ground bumblebees. Fertilization in both experimental combinations was the same. Half of the plants were watered using the ISS Hydreset system, while the other half was used as control and watered from the same source without this system. The same irrigation doses and terms were used. Water treated with ISS Hydreset is characterized by higher oxygen saturation and lower viscosity. This is probably why it is more easily taken and transported up by plants, which have to use less energy for its transport. As a summary, it can be stated that the use of the ISS Hydreset system for blueberry irrigation had a positive effect on the yield, contributing to a significant increase in the total yield, average fruit weight and polyphenol content in berries. The total yield increased by 11.3%. These fruits were also larger which is what the market is looking for. The content of ash, total sugars and simple sugars in fruits was higher in combination with the use of an ISS Hydreset irrigation system, but the differences were not statistically confirmed. The remaining quality features were not significantly modified by the type of watering system used for irrigation.

**Keywords:** blueberry, irrigation, yield, quality, soilless cultivation.

S05-P-I-12

### **Remote monitoring of currant shoot borer (*Lampronia capitella*) moths in blackcurrant in Finland**

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One of the principles in integrated pest management is pest monitoring and identification. The main method of detection of common currant pests is laborious visual observation by manual pheromone traps. The pheromone-based monitoring has been in use in the Finnish currant orchards since 1990 whereas there is no experience of technology assisted remote monitoring. Two pheromone trap models, manual delta trap and remote imaging trap, were tested for currant shoot borer moth (*Lampronia capitella*) in 2021 and 2022. The study was carried out in close cooperation with berry growers in three blackcurrant production fields. The remotely readable technology worked in field conditions, and the machine vision algorithm identified caught currant shoot borers well. However, attention must be paid to choosing the operator of the network required for data transfer so that the signal strength is adequate, and images can be viewed in the cloud service without delay. The currant shoot borer had more dense population in 2022 than 2021. The currant shoot borer was on the flight about three weeks in June. The flight peak took place within one week. The comparison with the manual trap revealed the need to develop the trap housing, its colour, and the size of the flight hole, as the manual trap gathered more moths.

**Keywords:** artificial intelligence (AI), berry production, digitalization, integrated pest management (IPM), pheromones, remote sensing, *Ribes nigrum*

S05-P-I-13

### **Effect of biostimulants on nutrient contents of Duke blueberries**

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The aim of this field experiment was to evaluate the impact of biostimulants on the nutritional composition of blueberries Duke cv. at three distinct harvest stages. Kosovo's favorable agro-climatic conditions have historically supported high-quality agricultural production. However, the recent effects of climate change have led to an increased adoption of biostimulants within the local blueberry industry. This adoption aims to adapt to evolving climate conditions, enhance yields, and bolster the resilience of blueberries against environmental stressors. The experiment was conducted in the Vushtria region on a 6-hectare blueberry orchard using a nested experimental design. The results indicated that biostimulants can positively influence the nutritional quality of Duke cv. blueberries at different stages of harvest. Analysis of variance (ANOVA) revealed significant differences in the levels of P, K, Ca, Mg, B, Cu, Fe, and Zn among the various treatments. Additionally, variations were observed in pH levels, brix, dry matter content, acidity, and vitamin C content.

**Keywords:** biostimulants, Duke, climate, blueberry

S05-P-I-14

### **Effect of Pre-planting Fumigation on Quality and Yield of Raspberries**

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The effectiveness of fungicide programs aiming to control the yellow rust The study was carried out on a private orchard farm in southeastern Poland. The effect of soil fumigation was evaluated in a field where raspberry plants had previously been grown for 16 years. In the experiment, plants of the cultivar 'Enrosadira' were observed growing in a tunnel. In 2019, Basamid (dazomet 95%) was applied at a dose of 500 kg/ha before planting raspberries. Yield and fruit quality were evaluated for 3 years. Soil fumigation raised raspberry yields by 107% in the first year, by 61% in the second year and by 65% in the third year of production. Soil fumigation also had a positive effect on fruit size.

**Keywords:** primocane-fruiting, raspberry, fumigation



S05-P-I-15

### **Textural characterization of bread containing berries powders**

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Bread texture is one of the most appreciated quality of this product. Bread containing fruits powders as a substitute for wheat flour has a high antioxidant activity and high concentrations of phenolics, flavonoids, minerals, and cellulose. The texture of bread containing fruit powders (aronia, hawthorn, sea buckthorn, and two mixtures of hawthorn with grape seeds and hawthorn with carob) in 5% , 10%, 15% concentration in flour was analyzed by Texture Profile Analysis (TPA) using a texture analyzer equipment. Firmness, cohesiveness, springiness, springiness index, fracture force, chewiness, adhesive force, and stiffness were measured. The firmness of four bread assortments containing 10% hawthorn, 10% and 15% aronia and 15% sea buckthorn powders respectively was not significantly different from control (plain wheat bread). The hardest bread was the one containing 10% addition of hawthorn and carob (39.93N±14.93 N for a 50% compression at 1mm/s speed) and the softest was the bread containing 5% hawthorn and grape seeds powder (12,54N±4.66N). All other assortments had significantly different firmness compared to control. The cohesiveness of bread assortments containing 10% and 15% aronia, 10% and 15% hawthorn and 15% sea buckthorn powders was not significantly different from control. Grape seed powder addition tend to soften the additivated bread due to the high oil content.

**Keywords:** bread texture, textural characterization, berries powders, antioxidant activity, mineral concentration

S05-P-I-16

### **The in-vitro and ex-vitro propagation of the newest Polish early primocane raspberry releases 'Magnat' and 'Baron'.**

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This paper discusses the in-vitro and ex-vitro propagation of two early primocane releases, 'Magnat' and 'Baron,' from the Polish raspberry breeding program led by Dr. Agnieszka Orzeł at Niwa Berry Breeding Ltd. in Southern Poland. For culture initiation, ½ Murashige-Skoog (MS) medium was used. Trials were performed with MS medium and different combination of growth regulators were used for optimizing multiplication rate and cost-effectiveness. The percentage of rooted ex-vitro plants was evaluated using Rhizopon® AA 0.5%, FLORAHUMUS, CarboHumic, and CarboHumic Active Bio. Results indicated that the rooting rate is dependent on the rooting stymulator and the cultivar being rooted. Using CarboHumic Active Bio, which is based on natural active coal, presents an interesting alternative for hormone-free treatment.

**Keywords:** raspberry, primocane, Magnat, Baron, in-vitro, ex-vitro

S05-P-I-17

### **New kiwi cultivars – super fruits for Romanian producers and consumers**

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*Actinidia* is a new fruit specie in Romania and the creation, testing and introduction of new kiwifruit cultivars, adapted to the local harsh climate conditions represent a priority in the national fruit growing program. The first kiwifruit orchards with *A. deliciosa* and *A. arguta* were planted in Romania in 1993, at Ostrov (Constanța County), on the border of the Danube River. In the same year, a common Italian-Romanian kiwifruit breeding program was initiated at the Faculty of Horticulture within the University of Agronomic Sciences and Veterinary Medicine of Bucharest. Since 1993, research has been carried out to determine the best methods of propagation, growing and kiwifruit orchard management. Genotypes phenology was studied every year in comparison with the climatic data. In parallel, physical and biochemical fruit characteristics were evaluated after ripening and during the storage. After more than 25 years of research, the Faculty of Horticulture in Bucharest registered six new kiwi cultivars. Four cultivars from *A. deliciosa* (three female - 'Kisweet', 'Kiball', 'Kigiant' and one male - 'Kiflor') and two from *A. arguta* species (one female - 'Ariana' and one male - 'Andros') are available now for propagation for new orchards establishment. Another two new cultivars 'Vip Green' and 'Vip Red' registered few years ago at CPVO Angers showed a good adaptability to the Romanian local climate and pedological conditions, and they can be tested in other areas in order to be extended commercial orchards.

**Keywords:** *A. arguta*, *A. chinensis*, *A. deliciosa*, new varieties

S05-P-I-18

### **Leaf pubescence – an early identification key of Actinidia species and plant gender**

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Since 1993, at the Faculty of Horticulture within the USAMV Bucharest, a kiwifruit breeding program started with the purpose to select some valuable hybrid genotypes obtained through intra and interspecific crossovers. During the selection process, different genotypes showed distinct morphological features that have been used for their characterization. For an easier identification of the species influence on hybrids morphology and hybrids gender, we tried to create an identification key using leaf pubescence. Leica S8 APO Stereo Microscope with Leica DFC 295 Camera and Lascore Soft were used to analyze the leaf surface morphology. Several observations and measurements as number of ramifications per stellate hair, stellate hairs density, expressed as average number of stellate hairs per square millimeter, average length of a stellate hair ramifications, were done. Based on our own research related to the morphology and some measurable parameters of the stellate hair that forms the leaf pubescence in kiwifruit plants (*Actinidia* sp.), it is possible to determine the plants species

and gender. This research has a particular practical importance in the selection of kiwifruit hybrids in the genetic breeding process in order to characterize and identify the new genotypes. Further observations regarding leaf pubescence morphology of different *Actinidia* species are needed to be extended in different weather conditions and areas.

**Keywords:** kiwifruit, stereo microscope, stellate hairs, breeding program

## **SESSION IVb : PLANT PHYSIOLOGY AND ENVIROMENT INTERACTION**

S05-IV-O-1

### **Raspberry primocane and florican genotype, different plants type and fruit cycles manipulation**

**Gianluca Savini** (*Invited Speaker*)

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The raspberry growing industry is expanding in different climates and forcing systems to have on the market a year-around availability of attractive fruits. To achieve this goal and to maintain high orchard productivity, it is necessary to use growing techniques that manipulate the plant growth cycle, starting from the nursery. To produce good quality fruits it is essential to be familiar with the growth cycle and the factors that can influence it, however, it is also well important to deepen the knowledge about flower induction, plant architecture. Moreover, to obtain out of season production there is the need for programming the flower differentiation in very specific periods of the year (Carew et al., 2000). Knowledge about plant branching and flower position is fundamental to plan optimal pruning and cultivation methodologies, adapted to the specific cultivar characteristics. In fact, each cultivar has peculiar features in terms of timing of flowering, growing habits and fruit production. Cultivation techniques concerning nursery management, cold storage, transplanting date and pruning system should be adapted to the characteristics of every single cultivar in order to control fruit production date. Raspberry cultivars are normally classified in two categories: florican- (biennial) and primocane- (annual) bearing, according to their different growth and fruiting habits (Carew et al., 2000), in particular timing of flower initiation, flowering and fruiting. The distinction of the two groups is useful from an agronomic point of view, since primocane and biennial raspberries necessitate specific cultivation techniques. The main objective of this study it's to describe the manipulation growth cycle not just based only in florican and primocane genotype but through interaction plants physiology, genotype, artificial chilling requirement, date of transplanting, pruning system and type of plants (nursery) to decide which period do you want production for have 12 month raspberry fruits.

**Keywords:** florican, primocane, genotype, chilling requirement, nursery

S05-IV-O-2

### **Photosynthesis of Blueberry Grown in an Alternative Production System**

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Container blueberry production has been gaining popularity as a promising alternative to open-field planting. This method offers several advantages, including the ability to control soil conditions and drainage, which can be difficult in the open field. In 2022, researchers conducted a study to determine the photosynthetic activity of different blueberry cultivars during the first year of crop establishment. The study focused on three Southern highbush blueberry cultivars ('Jewel', 'Meadowlark', and 'Victoria') and one rabbiteye blueberry cultivar ('Baldwin') grown in containers. The objective was to identify the cultivars with the highest photosynthetic activity. The researchers used gas exchange data analyzers to measure photosynthesis every 2 hours throughout the day and on different dates, with fully expanded leaves located in the top-middle section of the canopy for each cultivar. The response curves showed that net photosynthesis became saturated at moderate light, with a photosynthetic photon flux density of 1932  $\mu\text{mol m}^{-2}\text{s}^{-1}$ , with CO<sub>2</sub> assimilation rates of 16.84  $\mu\text{mol m}^{-2}\text{s}^{-1}$ . No differences in photosynthesis were found among cultivars. These findings strongly support the use of containerized systems as a production method for early fruiting blueberries in Alabama, USA.

**Keywords:** *Container production, southern highbush, rabbiteye, photosynthetic characterization*

S05-IV-O-3

### **Floral Bud Modeling on Strawberries Grown in Hydroponics**

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The strawberry crop represents an essential economic resource, and for this reason, extensive research has been carried out on several aspects of its production. However, the phenological performance is still lacking information, particularly when it comes to modeling. The objective of this study is to develop a phenological model for flower bud development under hydroponic conditions to support growers' decision-making. The cultivation of two day-neutral cultivars, 'Albion' and 'San Andreas', was established in a drip hydroponic system in Auburn, Alabama, during the 2022-2023 production season. Data was collected daily for 30 flowers per cultivar for three periods. Weather data was registered from a weather station placed in the greenhouse. The growing degree days

(GDD) accumulation was calculated for each stage and cycle using a base temperature ( $T_b$ ) of 3°C. Six stages were identified, and their cycle ranged from 43-56 days to be completed. A non-linear procedure was used to adjust the Gaussian model for each stage cycle, and simulations were made for the model assuming that temperature would increase or decrease by 1°C to evaluate the sensitivity analysis of the temperature changes. Albion required more days to reach maturity compared to San Andreas. Additionally, not all the buds reached maturity as expected for cycles 1 and 2. Overall, San Andreas performed better than Albion, although further research would be necessary to identify the reasons for this outcome with certainty.

**Keywords:** *Fragaria×ananassa*, alternative production, flowering, bloom, nonlinear regression

S05-IV-O-4

### **Phenology of red and white currants in the climate of Kyiv, Ukraine**

**Halyna Andrusyk<sup>1</sup>, Yurii Andrusyk<sup>1</sup>, Volodymyr Voitsekhivskiy<sup>1</sup>**

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The phenology of red currants 'Buzhanska', 'Kyianochka', 'Poliana Holosiivska', 'Malva', 'Jonkheer van Tets' and white currants 'Lebidka', 'Snizhanka' (*Ribes rubrum* L.) were studied for four consecutive years (2012—2015) in the training laboratory «Fruit and Vegetable Garden» of the National University of Life and Environmental Sciences of Ukraine (NULES of Ukraine), 50°23'N 30°30'E, Kyiv, Ukraine. During the research, the lowest temperatures were in February 2012 -22.8 °C, and the average temperature of that month was -10.3 °C, but no freezing of plants was observed. In 2013, full flowering of plants (BBCH 65) lasted from May 2 to 6 at the sum of active temperatures of 10 °C and above 326 °C. In 2015, during the flowering phase, the minimum air temperature was recorded at -0.8 °C on April 21 and -0.3 °C on April 22, while in other years there were no frosts during flowering. The highest percentage of fruit setting was recorded in the variety 'Lebidka' (76%) with the number of berries in the cluster 16±4 pcs. and its length 9.4 cm, in the control — 'Jonkheer van Tets' this figure was 32% with a cluster length of 8.6 cm. In Kyiv, the first berries begin to ripen (BBCH 81) in early June, with most berries ripeness (BBCH 87) occurring in late June or early July. The earliest ripening varieties are 'Snizhanka' (26.06±4), 'Jonkheer van Tets' (26.06±5), and 'Buzhanska' (30.06±8) — these varieties are medium-early in terms of ripening, while the others can be classified as medium-late. The vegetation period of red currant varieties lasted from 173 to 205 days, depending on the variety.

**Keywords:** *Ribes rubrum* L., variety, BBCH, temperature, berry, fruit set, vegetation period

S05-IV-O-5

### **Evaluation of winter hardiness of raspberry cultivars (*Rubus idaeus* L.) in Estonia**

**Natallia Klakotskayaa<sup>1</sup>, Peeter Laurson<sup>1</sup>, Asta-Virve Libek<sup>1</sup>, Ave Kikas<sup>1</sup>**

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Winter hardiness is one of the primary characteristics of fruit and berry crop cultivars grown in Northern Europe. This biological property is of important economic significance, as it dictates the feasibility and potential for cultivation cultivars in alignment with the specific agroclimatic conditions of the region. This study describes the evaluation of winter damage of raspberry cultivars conducted at the Polli Horticultural Research Centre in Estonia from 2019 to 2022 and the analysis of winter hardiness carried out on this basis. Raspberry plants, particularly their above-ground parts, are highly sensitive to low winter temperatures. The many cultivars are also significantly damaged by cycles of cold winter periods alternating with thawing periods. The increase in winter temperature fluctuations in the last decade, the lengthening of thawing periods and the effect of unstable snow cover on the reduction of winter hardiness of raspberry cultivars in Estonia make it important to breed resistant cultivars to cope with the effects of climate-change. This research investigates the winter hardiness of raspberry cultivars from diverse geographical backgrounds, aiming to identify those more resistant to winter temperature stress factors in Estonia. The K-Means Clustering Method was used to identify three clusters of cultivars based on their levels of winter hardiness: high, medium, and low. Our research, based on winter damage data collected during four years of field trials with raspberry cultivars, shows a possible division of the studied raspberry cultivars into clear winter hardiness clusters. The findings highlight cultivars with maximum winter resistance, which are a valuable resource in breeding activities. The assessment of the winter hardiness of raspberry cultivars and screening using the K-Means Clustering Method paves the way for future research focused on increasing the resistance of horticultural crops to environmental influences.

**Keywords:** climate change, K-Means clustering method, cultivars, biodiversity

S05-IV-O-6

### **Impact of Drought Stress on Strawberry Production: A review**

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Drought is one of the catastrophic results of climate change restricting crop production worldwide, and will be great danger in the future. Turkey is one of the most affected country from climate change due to its geographical location and varying climatic conditions across the region. Among the berries, strawberry is one of the most

commercially important crop since its highly adaptation grown ability and rich in nutrient content, contributing to its steady rise in production and consumption globally. Depending on developmental stages of strawberry, drought stress causes morphological, physiological, biochemical and molecular damage on plant, resulting in significant losses in yield and quality. To overcome this problem, it is essential to understand mechanism by which plants respond to drought stress condition. Determination of drought tolerance cultivars among existing varieties and improving new strawberry cultivar tolerant to water stress through new breeding programs could be beneficial to manage with detrimental effect of drought stress on agricultural production. In this review, importance of strawberry production and effects of drought stress on strawberry production will be emphasized referring to previous studies. This review could be beneficial for future studies will be conducted to enhance new drought tolerance strawberry cultivars.

**Keywords:** *Fragaria × ananassa* Duch, water deficiency, plant response, production, yield

S05-IV-O-7

### **Strawberry taste like no other – quality of Norwegian produced berries**

**Ewelina Wojciechowska**<sup>1</sup>, Anne Linn Hykkerud<sup>1</sup>, Anita Sonsteby<sup>2</sup>, Tomasz Woznicki<sup>2</sup>

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The complex term of quality for strawberries consists of features including flavour. The characteristic of flavour is complex and depends on preharvest factors like environmental conditions, cultivations practices and genotype/cultivar. The project TastyStrawberry, aims to optimize the taste/flavour of strawberries produced in modern production systems in Norway, thereby increasing the value creation of Norwegian berries in a sustainable manner. The Norwegian consumers are favouring domestic strawberries due to their high-quality taste. It is claimed that the climate plays a crucial role for this preference. The project focuses on the effects of genotype/cultivar, cultivation practice, and environment on berry taste-quality. Among the tasks in the project is testing of cultivars under different environmental conditions to increase the knowledge about the effects of temperature and light on the taste. A range of cultivars have been grown at two locations in Norway (at a high and low latitude). The sugar and acid levels have been analysed and preliminary results indicate that the climate and light conditions especially temperature has an effect on the taste quality. The level of acids responds to temperature by being elevated at higher temperatures. Resulting in a higher sugar/acid ratio at the high latitude location.

**Keywords:** strawberry quality, flavour, high latitude, low latitude, sugar/acid content

## **SESSION V : ADVANCED IN PRODUCTION SYSTEMS**

S05-V-O-1

### **Precision irrigation strategy for climate change adaptation of kiwifruit**

**Bartolomeo Dichio**<sup>1</sup> (*Invited Speaker*), Maria Calabritto<sup>2</sup>, Alba Mininni<sup>2</sup>

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Global climate change significantly affects seasonal rainfall distribution, annual temperature and reference evapotranspiration altering crop water requirements, representing one of the major challenges for modern agriculture. In this scenario, the increasing trend of temperatures and evapotranspiration, on the one hand, can lead to daily water deficit conditions, while the change in rainfall distribution, on the other hand, can contribute to the establishment of waterlogging conditions in kiwifruit orchards. Innovative precision irrigation strategies play a crucial role for adaptation to diverse and changing climates, especially for highly sensitive crops such as kiwifruit, which has a high water requirement but, at the same time, is extremely vulnerable to waterlogging and low concentrations of oxygen in the root zone. In order to improve the resilience of kiwifruit vines to variable climatic conditions and ensure agricultural water sustainability, precision irrigation approaches based on a feedback soil-plant water status monitoring to adjust irrigation volume are needed. Precision irrigation strategies aim at distributing at the right time and soil zones the amount of water needed to satisfy vine water requirements, are important in Mediterranean regions, characterized by a high environmental evaporative demand, to prevent damage from high temperatures during the hottest hours of the day, such as midday depression and kiwifruit sunburn injury. Knowing the vine physiological responses to decreasing soil water content is essential to define soil moisture thresholds, identified for each soil layer as affected by root water uptake dynamics, which can be useful to support irrigation decisions. Considering the peculiar kiwifruit physiological traits and vine morpho-anatomy characteristics and the low readily available water (RAW), emphasis is given to the accurate irrigation management also to avoid the establishment of even temporary water shortage or excess in the root zone. The adoption of innovative irrigation strategies can help to manage the distribution of irrigation water along the soil profile, by controlling both the horizontal and vertical movement of water, and promote the aeration of the root zone, by alternately wetting different soil volumes and stimulating different portions of the root system involved in water uptake. Climate-smart precision irrigation strategies ensure optimal soil and plant water status, with 30-40% water saving, increasing water use efficiency and water productivity and reducing the water footprint, which are essential for sustainable water management and crop resilience under a changing climate and increasingly limited freshwater resources.

**Keywords:** climate variability, evapotranspiration, water stress, innovative irrigation management, agricultural water sustainability



S05-V-O-2

### **Optimizing kiwifruit quality through estimation of leaf stomatal conductance from sap flux density: the KiwiQuali project**

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Most fruit crop irrigation is performed on empirical basis, with very little awareness of the consequences on yield and on water use efficiency. A model was developed for leaf stomatal conductance assessment from sap flux measurements in olive, which is a fruit crop that requires less water than kiwifruit vines. The main objective of the KIWQUALI project is to estimate the leaf stomatal conductance (gs) through models from sap flux density (J) measurement in *Actinidia chinensis*, allowing assessment of plant water status continuously and improve irrigation management, while optimizing fruit quality. This goal will be reached through the following specific objectives: (i) to adjust models for estimation of kiwifruit trees gs from J continuous measurements and atmospheric vapor pressure deficit (VPD); (ii) to understand which irrigation level optimizes fruit quality and productivity; (iii) to develop precision irrigation protocols based on gs estimation. Aiming at obtaining measurements in different water status, kiwi vines in the Emilia Romagna region (Italy) will be submitted to four irrigation treatments: well-watered (100% of crop evapotranspiration ETc) and three deficit irrigation treatments (ca. 75%, 50% and 40% of ETc). The KIWQUALI project will lead to innovative results as it will (i) provide a model to continuously estimate gs on an isohydric, drought sensitive crop (kiwifruit), improving the knowledge on the hydraulic limitations and physiological responses of one of the most water requiring fruit crops; (ii) improve understanding on how different plant water status and physiological performance at source level affects fruit yield and quality, and (iii) provide a tool to optimize irrigation scheduling of *Actinidia chinensis*. The first season of measurements is currently in progress during the European summer (from June to ca. October), therefore, this contribution will present the KIWQUALI project and its preliminary results.

**Keywords:** Kiwi fruit, *Actinidia chinensis*, sap flow, stomatal conductance

S05-V-O-3

### **Raspberry primocane winter production in mild winter climates**

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Raspberry breeding programs focused on production for mild winter climates can screen and develop varieties for different production systems, compatible with the natural mild environmental conditions during winter. One possibility is primocane fruiting varieties able to produce during the first growing season in wintertime. In southwest coast of Alentejo, Portugal there is a recent raspberry breeding program, between the National Agrarian and Veterinary Research Institute (INAV, I.P.) and a private company, Beirabaga. One of the advanced selections from this breeding program, considered to

be well adapted and plastic to different environmental conditions, was chosen to study its ability for primocane winter production. Tray plants from this advanced selection were planted in three different dates one month apart, in July, August and September. Production and plant architecture (cane height, total number of nodes, number of laterals, number of productive nodes, number of reproductive structures - flower buds, flowers and fruits) were evaluated among the different dates. The main goal was to understand plant behaviour in degrading environmental conditions for primocane growth and production and to evaluate the limit of this advanced selection for fruit production and if registered production volumes were commercially acceptable. Although fruit set was observed in all plantation dates, the volume of fruit production was decreasing considerably as plantation dates were later. Regarding plant architecture some evaluated parameter had also considerable differences among plantation dates, specially related to production traits and internode length. This work is a first approach to test this advance selection for winter production and select genotypes within the breeding program that have the ability for primocane production during winter.

**Keywords:** *Rubus idaeus*, production systems, plant architecture, plasticity, breeding, tray plants

S05-V-O-4

### **Sustainable production of cranberries (*Vaccinium macrocarpon*) in a high tunnel soilless cultivation system**

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In Finland, the supply of wild cranberries (*Vaccinium oxycoccos*) is not adequate, and food industry imports field cultivated cranberry (*Vaccinium macrocarpon*) from North America. Our goal is to enable economically viable and ecologically sustainable cranberry production in the Northern latitudes utilizing high tunnel soilless table-top cultivation technology. The runners of seven cranberry cultivars received from the USDA NCGR (Corvallis, OR, USA) were rooted and grown in a high polytunnel in forest peat supplemented with slow-release fertilizer, and drip irrigated. Cv. Pilgrim proved to be the most productive and precocious under the Northern conditions. On the other hand, winter hardiness of cv. Stevens was better than that of cv. Pilgrim. While investigating the possibility of replacing peat with *Sphagnum moss* as a substrate for cranberry, we found that winter survival of cranberry roots in *Sphagnum moss* was superior to that in peat substrate. The berries produced in the high tunnel could be stored for up to six months in cold storage (+4 °C). To be able to steer berry quality in case the berries must be harvested partly unripe, we examined the effect of different light spectra applied postharvest on ethylene production, anthocyanin concentration, and color in cranberries harvested at different maturity stages. The treatments were darkness, blue light, red light, and wide spectrum. Ethylene production declined along with ripening of the berries. Light treatment, degree of maturity, and their interaction affected significantly the measured variables blue light having the most prominent effect on ethylene production, anthocyanin synthesis, and color development.

**Keywords:** cranberry, high tunnel, light spectrum, *Sphagnum moss*

S05-V-O-5

**Influence of drip irrigation and fertigation on yield and water use efficiency of white strawberry (*Fragaria × ananassa* ‘Snow White’) grown in Bulgaria**

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Water management is become a hot point in tackling of challenges to find the balance between efficient water uses and crop productivity increasing and taking steps to reduce environmental impacts of these activities. The aim of this paper is to present the effects of the applied regimes of fertilization and irrigation on the yield and water use efficiency (WUE) of white strawberry variety. A two factors experiment was conducted during 2023 in unheated greenhouse in the Chelopechene experimental field, Sofia, Bulgaria with drip irrigated and fertigated strawberry cultivar (*Fragaria × ananassa* ‘Snow White’). The irrigation and the fertilization factors were applied in two rates: I1 - 75% (ETc) I2 - 50% (ETc), F1: optimal fertilization N8.09P12.76K15.62; F2 – suboptimal fertilization - 75% (F1). Five treatments were tested: control: I0F0:100% (ETc) without fertigation; I1F1; I1F2; I2F1; I2F2. The highest yield (3598.23 kg ha<sup>-1</sup>) was found for I1F1 treatment and the highest WUE (1.67 kg m<sup>-3</sup>) was found for I2F1 treatment.

**Keywords:** strawberry, yield, irrigation, fertigation, WUE

S05-V-O-6

**Exploring biostimulant applications on small fruits: a case-study involving open-field grown raspberries (*Rubus idaeus* L.).**

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Improving environmental, social and economic sustainability in horticulture represents a crucial challenge that needs to be addressed with utmost priority. Recently, biostimulants have been broadly investigated in order to reduce fertilizers and chemical inputs; such products have been reported to successfully enhance productivity and quality whilst improving plants’ adaptability to abiotic stresses. Despite their potential usefulness, many constraints prevent biostimulants from being effectively implemented: therefore, there is still great room for research to define the best practices in terms of biostimulants application in horticultural crops. In this context, small fruits have been poorly considered and biostimulants’ suitability for their cultivation still needs to be thoroughly explored. The aim of this study was to evaluate biostimulant application on raspberry and it was pursued by running a trial on an open-field orchard in central Italy. The trial involved two double-bearing raspberry cultivars, namely ‘Autumn Bliss’ and ‘Zeva’. Plants were treated with three biostimulants through foliar spraying; treatment-related effects were assessed by monitoring eco-physiological parameters (chlorophyll, anthocyanins and flavonols content, photosynthetic fluorescence, Nitrogen Balance Index), along with fruit yield and quality traits. Biostimulants did not show to significantly influence values regarding eco-physiological parameters when compared to untreated bushes; however,

one biostimulant appeared to prompt vegetative growth on 'Autumn Bliss' plants, bringing to a slightly lower productivity in comparison to the other treatments. Analyses concerning quality traits highlighted some effects to be ascribed to biostimulant application both in 'Autumn Bliss' and 'Zeva' raspberries. The present work provided meaningful insights regarding the possible implementation of plant biostimulants in raspberry cultivation, thus contributing to shed light on the feasibility of this practice on a species which has been poorly considered within the scientific debate around biostimulants in horticulture.

**Keywords:** Horticulture, Small Fruits, Berries, Sustainability, Plant Growth Regulation

S05-V-O-7

### **Production of day-neutral strawberry under tunnel protection in North Dakota**

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The production of day-neutral strawberry (*Fragaria* × *ananassa*) under tunnel protection has the potential to extend the growing season and increase economic benefits for growers in North Dakota and northern regions between 46° N - 49° N. The objective of this research was to evaluate the production of six day-neutral strawberry cultivars (Fort Laramie, Evie-II, Albion, Portola, San Andreas, and Seascape) under three environments (high tunnel, low tunnels, and open field). Bare root plants were transplanted in the spring of 2021 and 2022 to evaluate the annual production cycles. 'Portola' and 'San Andreas' had poor transplant survival both years and were removed from the data analyses. A three-way interaction between year, environment, and cultivar occurred for the yield parameters measured. This was attributed to the extremely hot 2022 and cultivar responses to the high temperatures within each environment. 'Albion' had the greatest total and marketable yields in 2021 but this was only greater than the total and marketable yields for 'Albion' and 'Seascape' in 2022. Strawberries within low tunnels had the greatest total and marketable yields in 2021 but this was only greater than the total and marketable yields when strawberries were grown in the high tunnel and open field in 2022. 'Evie II' fruit were less sweet in 2022 compared to 2021, while 'Seascape' fruit were less sweet in 2021 compared to 2022. Plants in the high tunnel or grown in the open field produced sweeter fruit when compared to fruit from plants in the low tunnels. Fruit TA was higher for 'Albion', 'Fort Laramie' and 'Seascape' in 2022 compared to fruit TA from the same cultivars in 2021 and plants grown in the high tunnel produced fruit with a higher TA percentage. Fruit had a higher pH in 2021 than 2022 and fruit from 'Seascape' or 'Albion' had lower pH compared to fruit from 'Evie II' or 'Fort Laramie'. Overall, the experiment suggested that even though the tunnels extended the season in the early spring and late fall, this period may not be long enough to increase the day-neutral strawberry yield when grown in North Dakota.

**Keywords:** yield, fruit quality, low tunnels, high tunnel, open field

## **SESSION VI : MISCELLANEOUS**

S05-VI-O-1

### **Determination Phenolic compounds of Wolfberry grown in Central Anatolia**

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Goji berry (*Lycium* spp.), also known as “Wolfberry”, is native to China, and is most commonly grown in Tibet, Mongolia and the Himalayas. From a botanical point of view, it is a member of the Solanaceae family and the most common species are *Lycium barbarum*. Goji berry is a very resistant plant against environmental climatic conditions such as low temperature and drought. It is also suitable for cultivation in relatively humid conditions. After the adaptation of the root system to the soil, it can be easily grown in arid conditions as well. Goji berry plants like sunlight and can tolerate a temperature of + 39 °C in summer and –26 °C in winter. The goji berry fruit has a high capacity in terms of both nutrients and antioxidants; hence, it is a fruit consumed for human health and nutrition. At present, China is the greatest global producer and supplier of wolfberry products. *Lycium* fruits have been used as a remedy since ancient times in Asian countries, especially in China, for their emmenagogue, diuretic, antipyretic, tonic, aphrodisiac, hypnotic, and hepatoprotective effects. The purpose of this paper is to determine the phenolic compounds of wolfberries grown under the Aksaray and Niğde ecological conditions

**Keywords:** Wolfberry, *Lycium* spp., phenolic compounds, Central Anatolia

S05-VI-O-2

### **Preharvest Treatments Effects of Strawberry Fruit on Sugar, Organic Acid and Volatiles Compositions During Shelf Life**

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Strawberry is known as the distinctive flavors and unique taste that abundant in sugars, organic acids, and various volatiles. Strawberry is highly perishable and susceptible to rapid spoilage. Two strawberry cultivars, namely ‘Rubygem’ and ‘Calinda,’ were

cultivated within the commercial greenhouse situated in Adana, Turkey. Before 5 d of fruit harvest, when individual strawberries reached a stage of three-quarters to full red coloration, hexanal and  $\gamma$ -aminobutyric acid (GABA). In order to evaluate the effects of hexanal and GABA spray applications on amount of brix, sugar content, organic acids and volatile compositions stored at 2 °C and 90% RH, for 21 days were evaluated. Therefore, investigating the biochemical compositions effected beneficial to illustrating the fundamental of quality changes of strawberry fruit during cold. The findings revealed that, when comparison to the control, the preharvest applications in strawberry positive effects of sugar content, organic acids and volatile compositions compared control.

**Keywords:** strawberry, shelf life, hexanal, gaba spray, quality

S05-VI-O-3

### **The Effect of CO<sub>2</sub> Concentration and Temperature on the Germination of F1 Everbearing Strawberry Seeds**

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Increased atmospheric CO<sub>2</sub> concentration and global warming widely affect agricultural production. Understanding the effects of elevated CO<sub>2</sub> levels and temperature variations on crop production has become increasingly crucial. Strawberries, being C<sub>3</sub> plants, are particularly sensitive to variation in atmospheric CO<sub>2</sub> concentration and temperature. This experiment was designed to investigate how different CO<sub>2</sub> concentrations and temperatures affect the speed of germination of strawberry seeds. F1 strawberry seeds of two Everbearer cultivars, Estavana and Soraya were exposed to 4 different CO<sub>2</sub> concentrations (400, 800, 1200 and 1600ppm) and 3 temperatures (17, 21 and 25°C) established in controlled environment growth cabinets. Results revealed that an increase in temperature from 17°C to 25°C shortened the germination time by approximately 3.4 days. However, CO<sub>2</sub> concentration did not have a significant impact on the germination time in either cultivar.

**Keywords:** germination rate, CO<sub>2</sub> concentrations, temperature effects, controlled environments, everbearing strawberries, speeding breeding

S05-VI-O-4

### **Optimization of an in vitro regeneration protocol to induce organogenesis in four cultivars of *Fragaria x ananassa***

**Irene Piunti**<sup>1</sup>, Luca Capriotti<sup>1</sup>, Bruno Mezzetti<sup>1</sup>, Marzio Zaccarini<sup>2</sup>, Michela Mattioli<sup>2</sup>, Silvia Sabbadini<sup>1</sup>

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The cultivated strawberry (*Fragaria x ananassa*) is one of the most appreciated and popular fruit, and it is an allo-octoploid. Due to its complex genome and high

heterozygosity, improving specific traits through classical breeding methods becomes very challenging. Therefore, it is essential the development of efficient *in vitro* regeneration protocols, useful for the subsequent application of biotechnological tools aimed at the genetic improvement of selected strawberry varieties. In this study the optimization of an *in vitro* regeneration protocol for four different strawberry (*Fragaria x ananassa*) cultivars, Koinè, Shayda, Sibilla, and Murano was carried out. *In vitro* strawberry leaves were utilized as starting explant, which were injured on the abaxial surface to induce the regeneration process. Two different regeneration media were tested based on MS salts and vitamins, which were supplemented with TDZ 0.5 mg L<sup>-1</sup> plus 2,4-D 0.02 mg L<sup>-1</sup> (medium S1), or with BAP 3 mg L<sup>-1</sup> plus IBA 0.2 mg L<sup>-1</sup> (medium S2). The effect of leaf orientation (abaxial surface in contact or not with the medium) on regeneration efficiency was also investigated. Results showed that medium S1 led to the highest number of regenerated adventitious shoots per leaf compared to medium S2, with differences among the various genotypes. Indeed, the regeneration percentage in S1 was around 85% for Koinè, 50% for Shayda, 35% for Sibilla, and 22.5% for Murano. The orientation of the leaves on the medium influenced the regeneration efficiency only for some of the cultivars tested, with better results when the injured explant was in contact with the medium. The findings from this study will be exploited for future genetic engineering experiments on the cultivated strawberry.

**Keywords:** *in vitro* regeneration, strawberry, *Fragaria x ananassa*, organogenesis, leaves.

## **POSTER PRESENTATIONS II**

S05-P-II-1

### **Influence of Chemical Fertilization on the Growth and Production of Young Shrubs of *Pistacia lentiscus* var. Chia**

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Mastic gum or “mastiha” is a unique resin that is produced in the southern part of Chios Island (Greece). The mastic tree or mastiha tree (*Pistacia lentiscus* var. Chia) is a plant also used in landscaping. In the present study the effect of chemical fertilization on the growth and mastiha production of young plants was investigated. The application of fertilizers was carried on 90 young mastiha plants (5 years old), grown on the island of Chios in 10 L pots (50% soil and 50% peat, v/v), which were propagated by shoot cuttings. Five fertilization treatments were conducted by scattering the solid fertilizers uniformly over the surface of the soil mixture of each pot (top dressing). These were: a) ammonium sulphate [(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, 20 g/pot] in March, b) ammonium sulphate (20 g/pot) in March and repeated in June, c) ammonium sulphate (20 g/pot) in March followed by top dressing of potassium nitrate [(KNO<sub>3</sub>), 40 g/pot] in June, d) potassium nitrate (40 g/pot) in June, e) Complezal® [(N:12-P:12-K:17-Mg:2), 40 g/pot] in June, and f) control (no fertilization), using 15 plants per treatment. In mid-July, the young plants were wounded (“kentima”) to produce mastiha, and a month later the amount of mastiha

produced, the photosynthetic rate, chlorophyll content index and chlorophyll fluorescence (Fv/Fm) were recorded, as well as the main terpenes were detected in mastiha using GC/MS. According to the results, the chemical fertilization in March increased mastiha production (67.5 mg/plant) regardless of its repetition in June with either ammonium sulphate or potassium nitrate. In addition, the chemical fertilization increased the photosynthetic rate ( $7.57\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ), chlorophyll content index (47.5) and chlorophyll fluorescence (0.765) compared to control, but did not affect the chemical profile of mastiha.

**Keywords:** mastic gum, ammonium sulphate, potassium nitrate, photosynthetic rate, chlorophyll, chlorophyll fluorescence, terpenes

S05-P-II-2

**Effect of various stimulants on mastic gum production from young shrubs of *Pistacia lentiscus* var. Chia**

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*Pistacia lentiscus* var. Chia is known for the production of the valuable resin of mastic gum or “mastiha” and use as ornamental. Experiments were carried out on young mastic trees (4 years old), propagated by shoot cuttings, growing in 10 L pots (peat and local soil) in Chios Island. The canopy of plants, including branches, was sprayed with methyl jasmonate (0.2, 2.2 and 22 mL L<sup>-1</sup>), salicylic acid (0.069, 0.69 and 6.9 g L<sup>-1</sup>), abscisic acid (2.64, 26.4 and 264 mg L<sup>-1</sup>) or Ethrel (ethylene, 0.5, 5 and 50 mL L<sup>-1</sup>). Furthermore, ‘Humicraft’ (humic acids, 10 mL/pot), ‘Humi-forte’ (humic acids 0.02 mL/pot), ‘Bacillomix’ (active mycorrhizae, 30  $\mu\text{L}$ /pot), ‘Amino16’ (amino acids, 200  $\mu\text{L}$ /pot) and ‘Symbivit’ (mycorrhizal fungi, 50 g/pot) were applied. To check for the existence of possible symbiotic fungi: 1) local soil with mastic tree roots was used or 2) the same substrate was watered with fungicides (30 g/pot). The mechanical process of wounding the trunk and thick branches to induce the production of mastiha was applied to the young plants simultaneously with the treatments. After one month, the mastiha production, photosynthetic rate, chlorophyll content index and chlorophyll fluorescence were recorded. It was observed that 5 and 50 mL L<sup>-1</sup> of Ethrel caused a severe senescence to the leaves, whereas Ethrel and methyl jasmonate provoked the highest production of mastiha (83.82-91.57 mg/plant) compared to the control (37.14 mg/plant). The use of local soil recorded the highest rate of chlorophyll, whereas the application of fungicides resulted in lower chlorophyll fluorescence and less mastiha production, suggesting active symbiotic fungi on the roots of *P. lentiscus* in the local soil.

**Keywords:** Mastic tree, mastiha, photosynthetic rate, chlorophyll fluorescence, CCI



S05-P-II-3

### **Comparative assessment of sustainable cultivation practices and fertilization strategies for enhanced strawberry production**

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Studying the effects of fertilizers on plant growth, nutrient concentration, and fruit parameters is essential for increasing strawberry production and quality. This study introduces a novel table-top cultivation system for strawberries, employing 496 Albion variety runners in pots filled with sphagnum peat substrate. After one year, 30 plants in their second fruiting year were replanted in pots amended with either a biostimulant consisting in macroalgae residue enriched with amino acids (BIO) or a compost based on fish and algae residues (CW). Four treatments, including a control (CF), BIO, CW20 and CW40 (volumetric ratio between compost and peat of 20/80 and 40/60, respectively), were applied, with relevant plant parameters monitored for 5 months. The obtained results revealed that the mean values of crown diameter (D) at the final time were significantly higher ( $p < 0.05$ ) for BIO, CW20, and CW40 treatments than those for CF, while the mean D values between the initial and final times did not differ significantly ( $p \geq 0.5$ ) for each treatment. Strawberry production in the period 16/05–17/10/2023 ranged from 13.2 to 26.1 t/ha, consistent with the values reported in the related literature. Moreover, the production obtained by applying the BIO treatment (26.1 t/ha) was up to 2 times higher than the levels corresponding to the other treatments (13.2–14.8 t/ha). These findings suggest that the algal waste-based biostimulant and the fish and algae residue compost can be effective and sustainable alternatives for strawberry cultivation, potentially partially replacing mineral fertilizers. This study provides valuable information on environmentally friendly practices for enhancing strawberry production in table-top systems.

**Keywords:** *Fragaria x ananassa*, compost, macroalgae, biostimulant

S05-P-II-4

### **Resilient organic berry cropping systems through enhanced biodiversity and innovative management strategies**

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In Europe, berry production, sales and demands had an amazing ascending trend in the last decades. Berries are high in antioxidants, fibres, vitamin C and flavonoids and are known as superfoods being cultivable in different European climates and countries. Consequently, market values of berries are increasing. However, cultivation of berry is influenced by a variety of pathogens like grey mould *Botrytis cinerea* and invasive pests like the spotted wing drosophila (SWD) *Drosophila suzukii* or stink bugs like *Halymorpha halys* or *Nezara viridula*. At the same time, there is a growing demand of consumers for pesticide-residue-free fruits and thus for organically produced berries. Within the framework of the EU project ResBerry research activities were carried out on conservation biological control which implies setting up an improved habitat management or altering existing practices to protect and enhance specific natural enemies or other organisms that occur naturally to increase resilience of berries against major pests and diseases. Experimental sites of the project, located in Denmark, Poland, Germany, Romania and Morocco, were established for the implementation of new biological control techniques on organic berry production. New espalier and cutting techniques in berry cultivation which can be used to achieve more narrow rows of bushes with better air and light penetration were evaluated. This reduces diseases and supports the development of flowers and fruit, leading to large, high-quality berries. Also, there were tested companion plants in the form of flower strips or trap plants in intercropping with berry crops to provide food (pollen, nectar and alternative prey), habitat and overwintering sites for beneficial arthropods as well as increased biodiversity. Furthermore, cover crops were used to assess its influence on the composition of the soil microbiome. Moreover, alternative strategies to control specific pests were evaluated. For management of SWD *D. suzukii* it was assessed the efficacy of entomopathogenic nematodes which are naturally present in the soil and could be isolated and used as a biocontrol agent. Finally, all new methods to be implemented in organic berry cultivation were thoroughly evaluated for quality parameters of fruits. The methods are ecologically sustainable, can also be used by conventional producers, and can be an important help in conversion to organic production.

**Keywords:** berry cultivation; biological control; habitat management; soil microbiome; entomopathogenic nematodes; entomovectoring

S05-P-II-5

### **Evaluation of the growth and fruiting characteristics to some raspberry cultivars grown in the conditions of sandy soils from Southwestern Romania**

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Raspberry (*Rubus idaeus* L.) is one of the fruit species appreciated by consumers for the special taste of the fruits, and by the farmers for the fruit yield. The area of sandy

soils from the Southern Romania is characterized by a temperate climate with an emphasis on aridification, special conditions for the raspberry species' requirements. Starting from 2019, at SCDCPN Dăbuleni, eight raspberry genotypes were studied for the evaluation of growth characteristics, fruiting capacity, as well as fruit quality in order to expand the crop. Following the study, Maravilla and Poemat genotypes were noted with productions of over 11 tones/hectare.

**Keywords:** Raspberry, fruits, sandy soils, yield

S05-P-II-6

### **Textural profile analysis of some blueberry cultivars cultivated in Romania**

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Blueberries are highly appreciated fruits that can be found in abundance as cultivars as well as wild fruits in spontaneous flora in many regions of Romania. Blueberry cultivars may highly differ in fruit size and mass as well as in color. Blueberry fruits' textural properties may also differ by cultivar and between cultivars and wild fruits. Textural parameters of blueberry fruits such as: firmness, fracture force, and chewiness can be assessed by puncture and compression tests. The textural parameters may be influenced by the location of the culture (soil characteristics, temperature, and precipitation regime). This study investigates by double compression (Textural Profile Analysis) the textural parameters of several blueberry cultivars (Azur, Blue Gold, Blue Jay, Blue Ribbon, Hannah's Choice) and the culture location influence on these parameters as well as the possible textural differences between cultivars. For the Azur cultivar, the location did not influence firmness (hardness1,  $p=0,19$ ) and chewiness ( $p=0,24$ ) as well as springiness ( $p=0,47$ ). However, for the Azur cultivar, the fracture force was borderline not influenced by location ( $p=0,054$ ). Cultivation location also did not influence the firmness for the following cultivars: Blue Gold ( $p=0,51$ ), Blue Jay ( $p=0,65$ ), Blue Ribbon ( $p=0,098$ ), and Hannah's Choice ( $p=0,60$ ). Although there were differences in fruit size between cultivars (from a minimum of 1.978 g average mass/fruit for Hannah's Choice to a maximum of 3.174 g average mass/fruit for Blue Gold) firmness and chewiness did not differ between cultivars, however there were significant differences in fracture force.

**Keywords:** blueberry, textural parameters, firmness, chewiness, fracture force

S05-P-II-7

### **What fertilizer management strategy is the most effective to optimize the leaf and fruit nutrient content of soilless grown highbush blueberries?**

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A study was done to determine the influence of different fertilizer treatments on the leaf and fruit nutrient content of soilless grown highbush blueberry cv. 'Bluecrop'. A field study was conducted in 2020-2021 in an orchard near Belgrade (Serbia), planted in 50-l polypropylene pots at a density of 4,170 plants ha<sup>-1</sup>. The following fertilizer treatments were evaluated: i) organic fertilizers, Org (64 kg ha<sup>-1</sup> N, 42 kg ha<sup>-1</sup> P, 52 kg ha<sup>-1</sup> K); ii) mineral fertilizers, Min (85 kg ha<sup>-1</sup> N, 45 kg ha<sup>-1</sup> P, 64 kg ha<sup>-1</sup> K), and iii) combined application of organic and mineral fertilizers, Org-Min (72 kg ha<sup>-1</sup> N, 48 kg ha<sup>-1</sup> P, 68 kg ha<sup>-1</sup> K). The leaf and fruit samples for nutrient analysis were collected at the second harvest (in late June of both years). The index of deviation from optimal percentage (DOP) was calculated by comparing the values of foliar nutrient content with the lower and upper limits of optimal concentrations. The lowest leaf N, P, and K content was found in the Org treatment (2.19, 0.13, and 0.44%, respectively), while no significant differences were found in leaf N and K content between the Min and Org-Min treatments. The leaf concentration of Ca, Fe, and Mn was increased in the Min treatment (0.62%, 135.03 and 158.56 mg kg<sup>-1</sup> DW, respectively), whereas the leaf B content was the highest in Org-Min treatment (35.43 mg kg<sup>-1</sup> DW). Concerning the upper limit of optimal nutrient concentrations, the DOP index showed a deficiency of P, Ca, B, Fe, Mn, and Zn in leaf in all fertilizer treatments and deficiency of K in Org and Org-Min. The fertilization treatments did not affect the content of P, Mg, and Mn in the fruit, while content of K, Ca, B, Cu, Fe, and Zn were increased in Org treatment. These results indicated that a partial substitution of mineral by organic fertilizers may be considered as the most effective fertilizer management strategy in soilless grown blueberries.

**Keywords:** blueberry, fertilizers, soilless system, macro and microelements, DOP index.

S05-P-II-8

### **Assesment of adaptation potential of black currant cultivars based on growth, productivity and fruit quality**

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In changing environmental conditions, a certain degree of variability is constantly observed in fruit cultivars due to morphological adaptation in the growth, development and adaptation of the plant to different growing conditions. The objective of this study was to assess the adaptation potential of six black currant cultivars ('Čačanska Crna', 'Ben Lomond', 'Ben Sarek', 'Titania', 'Tisel' and 'Tiben') to agroecological conditions of Serbia based on their vegetative and generative potential, morphometric properties of berries and clusters and fruit quality. Vegetative potential (number of shoots per bush shoots length, bush height, width and radius), generative potential (number of flowers per inflorescence, number of berries per bunch, percentage of fruit set) and morphometric properties of berries and clusters (berries, clusters and stalk weight and

clusters length) were evaluated in this study. High-performance liquid chromatography (HPLC) was used for the identification of sugars and organic acids. The significantly higher values of most parameters of vegetative potential were recorded in the domestic black currant cultivar 'Čačanska crna'. Despite the high number of flowers and fruits in the cluster, 'Čačanska Crna' had significantly lower yields per plant compared to 'Ben Lomond' which had the highest yield per bush among tested currant cultivars (4.14 kg). Significantly higher fruit weight was recorded in cultivar 'Ben Sarek' (1.57 g) compared to all tested currant cultivars. 'Titania' was the cultivar with the highest content of all individual and total sugars (107.80 mg g<sup>-1</sup>), followed by 'Čačanska Crna' while 'Ben Lomond' was the cultivar with the highest content of all individual and total acids (53.51 mg g<sup>-1</sup>), except shikimic acid. The best sugar and acid ratio was recorded in 'Titania' and 'Čačanska Crna'. The high productivity and fruit quality of the cultivars 'Titania' and 'Ben Lomond' indicate good adaptability to local agro-ecological conditions, which together with 'Čačanska Crna' make them the most suitable cultivars for cultivation in Serbian agroecological conditions.

**Keywords:** black currant, vegetative potential, yield, sugars, organic acids

S05-P-II-9

### **Profiling sugars and polyphenolics in red raspberries grown in Serbia**

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Raspberry commercial importance for Serbia is great because it is mostly exported, with average income above 100 million USD. Serbia has a large raspberry production and in 2021 it ranked third in the World with more than 110,000 tonnes. The total acreage of raspberry production in the Republic of Serbia is about 20,000 ha, where more than 10% is organic. The aim of this study was to present sugar and polyphenolic profile of the mostly grown raspberry cultivars ('Wilamette', 'Tulameen', and 'Meeker') from both organic and conventional production all around the Serbia. The whole organic production was certified, so no mineral fertilizers were applied and pest control was done in accordance to the organic production guidelines. In both conventional and organic raspberries the most common sugars were glucose (16.549 – 47.171 mg/g), fructose (20.468 - 42.55 mg/g) and sucrose (10.01 – 22.84 mg/g), while ellagic acid (434.909 – 1034.25 mg/kg) and catechin (2.122 – 16.636 mg/g) were the most abundant polyphenolics. Sucrose, glucose and fructose averagely accounted together to 87% of all detected sugars, while ellagic acid averagely accounted 98% of all quantified polyphenols in raspberry fruits. The sample with the highest level of sugars was in organic 'Wilamette' from village Krzava, while the sample with the highest level of polyphenolics was organic 'Wilamette' from the village Sljivova. Regarding cultivars, 'Wilamette' showed the best results in both organic and conventional production. In behalf of the wide spectra of determined compounds and high content of sugars and the quantified polyphenolic compounds, especially ellagic acid, these different raspberry

cultivars, from both production systems and various places in Serbia could be treated as functional food.

**Keywords:** *Rubus idaeus*, organic production, ellagic acid, Wilamette, Tulameen, and Meeker

S05-P-II-10

### **Elicitation of strawberry defense response by external application of phenylalanine: a route to a future antifungal biocontrol solution**

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Botrytis fruit rot is a major concern for strawberry growers all over the world. This ubiquitous fungus can attack fruit before or after harvest, transforming a healthy fruit into an infectious mass of gray mold in just hours. Fungal diseases affect numerous crops, and antifungal agents have been widely used to improve crop yield, quality, and shelf life. Large-scale agriculture and concomitant active use of toxic pesticides are a major human health and environmental hazard. Innovative alternatives must be proposed to strike the right balance between yield and fresh produce quality. The aim of this study was to investigate the effect of phenylalanine (Phe) spray treatments on *Botrytis Cinerea* resistance of strawberries during post-harvest storage. Two doses of Phe were tested 6 mM and 10 mM. Preharvest treatments were realized 3 weeks before harvesting. Inoculation by *B. Cinerea* was realized the day of harvest. For postharvest trials, conventionally grown fruits were harvested and treated the same day. Then, inoculation with *B. Cinerea* was carried out 2 days after treatment. The treated and inoculated fruits were stored for 5 days in post-harvest conditions of 20°C and 70% Relative Humidity to evaluate their resistance to *B. cinerea*. 10mM Phe treatment resulted in an increase in fruit resistance to the pathogen by up to about 30% for preharvest and 40% for postharvest trials after 4 days of fruit storage. These experiments demonstrated that the efficacy of a Phe spray treatment was dose-dependent. The application time between the flowering stage and the commercial maturity state can probably affect the results. This study demonstrated the effectiveness of the Phe treatment on strawberry sensitivity to *B. cinerea*. However, further trials need to be conducted to optimize dosage and time application.

**Keywords:** Strawberry, Elicitation, Phenylalanin, *Botrytis Cinerea*

S05-P-II-11

### **The influence of the application of some ecological products on some quality indices of strawberry fruits**

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The objective of this study was to assess the effectiveness of specific complex fertilizers registered for use in organic farming systems in enhancing the fruit quality of cultivated strawberry plants. In general, pre-harvest treatments, specifically the application of designated complex fertilizers, have demonstrated efficacy in improving post-harvest crop performance and, correspondingly, enhancing the quality of strawberry fruits. The study spanned two consecutive years (2022 and 2023) and was conducted on a strawberry crop situated in the southern region of Romania, specifically within the Vlășia Plain. The study incorporated three strawberry varieties, namely "Onebor," "Premial," and "Sibilla." The cultivation method employed followed the traditional approach, involving field cultivation in double rows on plots covered with agro textile foil and irrigation facilitated through a drip irrigation system. Strawberry plants underwent treatment with various categories of biostimulants, including salts of humic acids, humic acids, fulvic acids, amino acids, micro and macro elements, live bacteria, and other readily absorbable substances. The application was administered from pre-flowering stages through berry maturation, adhering to commercially recommended dosages. The experimental treatments consisted of two applied variants: V1, a combination of "Etamin" and "BioHumus Sol," and V2, solely "Etamin," in comparison to the untreated control variant. The fruit samples comprised 20 fruits collected for each repetition and each of the four harvests from each year. During each sampling event, measurements were taken for fruit weight, diameter, length, firmness, titratable acidity, total soluble sugars, and pH. According to the statistical analysis, no significant differences were observed among the three experimental factors regarding pH, titratable acidity, firmness, color parameters, fruit diameter, and length, as well as mean fruit weight. To obtain a more comprehensive understanding, the study will be extended to include additional detailed statistical analyses.

**Keywords:** organic agriculture, strawberry, foliar treatments, biofertilizers, humic acids

S05-P-II-12

### **Comparison of field performance and fruit quality of 5 European june-bearing strawberry cultivars under alpine growing environment (South Tyrol, Italy)**

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Strawberry production in South Tyrol is primarily concentrated in mountainous areas above 900 m a.s.l. and focuses on the late market segment. As the vegetative period is short, mainly junebearing strawberry varieties are grown in soil and substrate. The short-day cv. Elsanta is considered the main variety for its excellent organoleptic characteristics, but due to its high susceptibility to powdery mildew (*Podosphaera aphanis* Wallr.), its low resistance to soil-borne pathogens and its relatively soft fruit, some alternative early to mid-season varieties are becoming increasingly important. Our two-year trial started in 2023 at the experimental field of San Genesio-Jenesien (1,200 m a.s.l., Province of Bolzano-Bozen, Italy) and will continue until 2024. Strawberry tray plants cv. Aprica, Clery, Duchesse, Elsanta and Falco were transplanted at a density of 8 plants per linear meter and grown in polyethylene tunnels under standard soil and soilless conditions with peat (Vigorplant Italia SRL, IT) as substrate. All plants were

managed in the same way in terms of watering, fertilisation and with minimal pest control. Parameters such as strawberry yield, fruit quality, precocity index and powdery mildew susceptibility were evaluated. Initial results show significant differences in the interaction between varieties and cropping systems for marketable ( $\varnothing > 25\text{mm}$ ) and total yield, while there were no significant differences in intrinsic quality attributes. Of all the strawberry cultivars, Falco had the highest yield, followed by Elsanta in both systems, producing over 60% and 70% more marketable fruit and total yield than Aprica, Clery and Duchesse in the soilless system and in soil, respectively. In terms of external characteristics, the Falco strawberries were more than 50% darker and firmer than Elsanta strawberries in both cultivation systems. On average, there was a 1 week delay in ripening in substrate compared to soil, with Aprica having the lowest precocity index and Elsanta and Falco having the highest. Our preliminary results show that the strawberry variety Falco has the highest proportion of marketable fruit and could be an interesting alternative to Elsanta due to its high flesh firmness and slightly higher powdery mildew tolerance. Aprica, Clery and Duchesse did not show any particular improvements over Elsanta, apart from improved powdery mildew tolerance. Further useful information will be available at the end of the second year of the trial.

**Keywords:** *Fragaria x ananassa*, short-day varieties, cultivation system, yield, intrinsic & extrinsic attributes, *Podosphaera aphanis*

S05-P-II-13

#### **Micropropagation studies on Ottoman Strawberry (*Fragaria x ananassa* Duch.)**

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In the western Black Sea region of Anatolia, particularly in "Karadeniz Ereğli," *Fragaria x ananassa* Duch., known locally as the "Ottoman Strawberry," is commonly cultivated. This distinctive fruit is characterized by its pale pink hue, oval shape, strong fragrance, and exceptional taste. The Ottoman strawberry is an ancient variety with uncertain origins. It stands out for its small, rounded berries with remarkably light skin with red achenes and white-cream flesh color. The most significant disadvantage of the Ottoman strawberry is its morphological sterility. Due to the absence of male organs, it must be cultivated alongside a pollinator variety. The plants exhibit vigorous growth with well-developed stems. While the yield of Ottoman strawberry is low, it is highly sought after in food processing due to its aroma and flavor. In addition, the freeze-drying performance of the Ottoman strawberry has been found to be quite successful conducted in recent studies. Various studies have also revealed that Ottoman strawberry and its hybrids possess rich phenolic content and high antioxidant capacities. In recent years, efforts have been made to preserve and propagate this valuable cultivar through modern techniques such as micropropagation. In this study, the capacity of micropropagation for the production of Ottoman strawberries was evaluated. To achieve this, micropropagation experiments were conducted using two different micro-cutting culture media. Upon calculations conducted at the 4th subculture stage, it was determined that both culture media yielded successful results in Ottoman strawberry micropropagation. The derived clone plants were rooted and acclimatized to greenhouse conditions. The



obtained plants were subsequently planted in the Ereğli and Bursa regions in Türkiye for field performance evaluation.

**Keywords:** Clonal propagation, in vitro regeneration, plant growth regulators, plant tissue culture, strawberry

S05-P-II-14

### **Application of biostimulants enhances precocity and king flowers number in a kiwifruit orchard in center Italy**

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In order to adopting sustainable agricultural methodologies, such as the incorporation of biostimulants, is a viable strategy. This study aimed to investigate the impact of a non-microbial biostimulant on the agronomic performance of *Actinidia deliciosa* (kiwifruit) trees. The experiment was carried out in 2018 in a 6-hectare eight-year-old kiwifruit vine located in Cisterna di Latina (Lazio, central Italy), in which a plastic film covered half of the orchard. A single application of a liquid biostimulant fertilizer (24 L per treatment) was carried out 30 days before the expected date of bud break. The foliar spraying application took place simultaneously for both covered and uncovered plots. This product, consisting of a mix of free amino acids and peptides, was used to observe the effects on dormancy interruption and floral biology. Comparative assessments were made between covered and uncovered sections, as well as between treated and untreated trees. The treated trees exhibited higher precocity compared to the untreated ones; in particular, a 10% higher number of 4th and 5th leaves were found for the treated trees in the covered orchard, while 9% less closed and cotton buds were observed in the uncovered. Moreover, an increment in the number of king flowers was observed in treated trees, resulting in 14 and 11% higher percentages than the covered and uncovered non-treated trees. This reduction is noteworthy as it signifies potential labor and time savings during thinning operations. While these promising outcomes provide impetus for further investigation, additional research is imperative to deepen the information about the response of kiwifruit trees to biostimulants, considering alternative products.

**Keywords:** Covered trees; flowering; dormancy interruption; cv. G3 Gold

S05-P-II-15

### **Preliminary results regarding the in vitro propagation of some kiwifruit genotypes**

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Over the past seventy years, kiwifruit (*Actinidia sp.*) has gained high popularity worldwide, driven by its recognized nutritional and medicinal properties. To support the increasing demand for planting materials, many countries are employing tissue culture techniques as alternative methods for plant propagation. This preliminary study offers

insights into how, some new romanian kiwifruit genotypes, respond to different culture media with different types and concentrations of growth regulators.

**Keywords:** *Actinidia sp.*, explants, culture media, growth regulators

S05-P-II-16

### **Evaluation of blackberry breeding selections for fruit quality traits**

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*Rubus fruticosus* L. is fruiting plant of the genus *Rubus*, subgenus *Rubus*, in the Rosaceae family. Species from within genus are adapted to a wide range of environments, from within the Arctic Circle to the tropics, from low to high altitude, from acid to alkaline soils, from very wet to very dry climates (Bailey 1923; Darrow 1937; 1967; Sherman and Sharpe 1971; Lawrence 1986b; Jennings 1988, Hummer, 2017). Fruit quality characteristics were studied for three consecutive years in 21 blackberry genotypes grown in a Romanian climate. Physical parameters studied are yield, berry weight (BW), shape index (SI), firmness and chemical parameters studied are soluble solids content (SSC), acidity, vitamin C, anthocyanins, pH, total polyphenols content (TPC). The results showed that fruit weight varied between 7.58 g ('13-7-31' hybrid) and 4.60 g ('13-2-3' hybrid), total soluble solids reached a maximum 16.15°Brix ('13-7-9' hybrid) and a minimum 10.44°Brix ('13-7-20' hybrid), the content of Vitamin C oscillated between 41.3 mg/100 g ('13-1-22' hybrid) and 13.56 mg/100 g ('13-7-9' hybrid), total polyphenols content had a maximum 465.77 mg GAE/100 g ('13-7-9' hybrid) and a minimum 296.50 mg GAE/100 g ('13-1-35' hybrid). Most of genotypes have good adaptation capability and respectable fruit quality traits and also had good potential as a commercial crop for fresh and processing markets and future breeding programs.

**Keywords:** berry size; firmness; *Rubus fruticosus* L.; soluble solids content;

S05-P-II-17

### **Sugar and organic acid content and antioxidant capacity of strawberry fruit in relation to colour stability of puree**

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Sugar and organic acids in fruit are important constituents as they contribute to the nutritional and organoleptic quality of the fruit. Strawberries are also appreciated by consumers for their nutritional quality which can be attributed to the content of phenolic compounds and ascorbic acid. However, ascorbic acid might have a negative effect on colour stability, which is a concern in processed strawberry products such as puree or nectar. The aim of this study is to determine if there is any relation between the content

of primary metabolites (ascorbic acid, other organic acids, and sugars) and antioxidant capacity (DPPH method) of 12 strawberry cultivars to the colour stability of strawberry puree made from these cultivars' fruit. The sugar content of the strawberry puree ranged between 38 to 77 mg/g of fresh weight and the organic acid content ranged between 13 to 26 mg/g of fresh weight. Even though no connection was found between the content of sugars or acids and the colour stability, there was a strong negative correlation ( $r = 0.60$ ) between the ascorbic acid content in the fruit and the colour acceptance factor. However, not all cultivars follow the same trend. Our results show that a high ascorbic acid content in fruit can have a negative effect on the colour stability of the fruit, but it depends on the chosen cultivar.

**Keywords:** strawberry, colour stability, sugars, organic acids, ascorbic acid