Bulduru Tehnikums

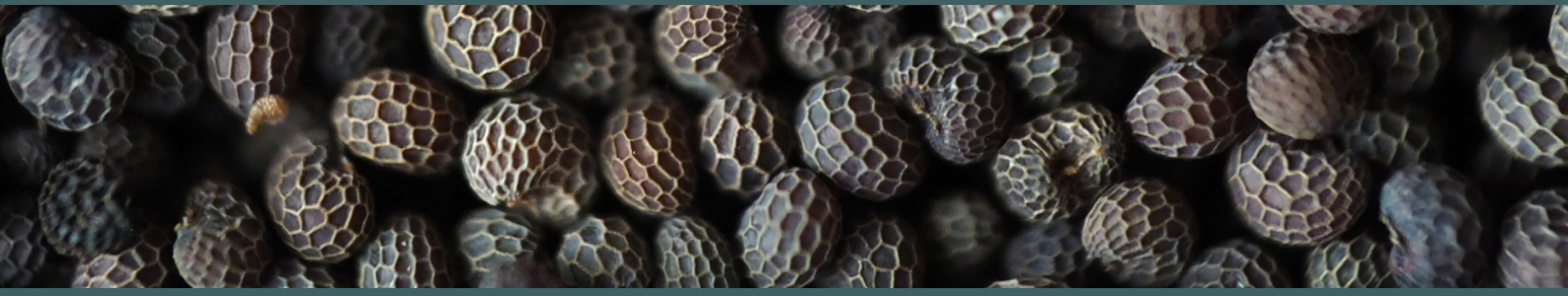
NACIONĀLAIS ATTĪSTĪBAS PLĀNS 2020

EIROPAS SAVIENĪBA
EIROPA INVESTĒ LAUKU APVIDOS
Eiropas Lauksaimniecības fonds lauku attīstībai

Bulduri, Latvia | January 26, 2023

INTERNATIONAL SYMPOSIUM OF CONTEMPORARY HORTICULTURE

BOOK OF ABSTRACTS



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International Symposium of Contemporary Horticulture

Planned agenda

9:30-10:00		**Registration, Coffee break**	
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10:40-10:45	**Līva Purmale** Bulduru Tehnikums	**Dasheen and konjac mosaic virus elimination attempts from *Zantedeschia* sp.**	**5**
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11:50-11:55	**Neda Zulge** Dārzkopības institūts	**The detection of viruses associated with crumbly raspberry fruit in Latvia and elimination possibilities by micropropagation | e-poster**	**7**
11:55-12:00	**Madara Lazdāne** Latvijas Universitāte, Botāniskais dārzs	**Micropropagation of *Rhaponticum carthamoides* (Willd.) Iljin | e-poster**	**8**
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14:00-14:15	**Irina Sivicka** Latvijas Biozinātņu un tehnoloģiju universitāte	**Challenges in conservation of oregano *Origanum vulgare* L. and thyme *Thymus* sp. genetic resources in *ex situ* collection**	**13**
14:15-14:20	**Ivona Jurenic** Erfurt Research Centre for Horticultural Crops	**Auxin homeostasis and signaling during adventitious rooting of two contrasting parental species of *Petunia* | e-poster**	**14**
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14:40-14:55	**Imants Zarembo** Rēzeknes Tehnoloģiju akadēmija	**Autonomous orchard monitoring system**	**18**
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from 15:10	**Uldis Muzikants**	**Photo exhibition "Contemporary Horticulture"**	

Dear researchers, horticulturists and gardeners -

I am pleased to announce the second international symposium on Contemporary horticulture, broadcast by the Bulduri Technical School. This conference is another great step forward to include Bulduri in the international society of horticulture and biotechnology.

The greatest challenge of this decade for the Bulduri Biotechnology Centre and all scientific institutions in agriculture is the flexible transition of research from intensive field work to multidisciplinary research that combines knowledge from agriculture, mechanization, plant physiology, genetics, informatics, mechatronics and other fields to achieve resource-efficient, sustainable, maximally climate-controlled and automated production of horticultural products. On the way to this goal, we must not forget that the results of applied science are also the automated equipment, databases and cultivation technologies themselves. Since processes that run smoothly in the laboratory do not always run smoothly in production, collaboration with stakeholders and scaling-up of successful laboratory experiments is also an essential task for the future.

I am confident that today's symposium will generate new collaborations and ideas for further research.

Happy gardening and researching!

RAFAELS JOFFE

CHAIR¬MAN OF THE BOARD OF BULDURI TECHNICAL SCHOOL

RESEARCH ON PLANT EXTRACTS FOR USE IN THE FOOD, PHARMACEUTICAL AND COSMETIC INDUSTRIES

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Key words: *plant leaves; bioactive compounds; Maral root.*

The leaves of many fruit plants have been known since ancient times as a suitable raw material for the preparation of high-quality extracts that have antioxidant and antimicrobial properties. It is important to find new sources of natural bioactive compounds, including those of local origin, as customers pay more attention to the quality of food, pharmaceuticals and cosmetics. Studies on the components of an unconventional plant grown in Latvia - Maral root - can expand the possibilities of its use.

Research objects: autumn and wild raspberry *Rubus idaeus*, sea buckthorn *Hippophae rhamnoides*, Japanese quince *Chaenomeles japonica* and blackberry (cultivated and wild) *Rubus allegheniensis* leaves, their combinations and Maral roots *Rhaponticum carthamoides*. Within the framework of the project, various factors affecting the content of biologically active substances, antiradical and antimicrobial activity in plant leaf extracts were studied: time of collection of plant material and pre-treatment method - fermentation. The characteristic indicators of leaf extracts were studied: content of polyphenols, tannins, flavonoids, antiradical activity (DPPH) and antimicrobial activity of selected samples was determined in accordance with the regulatory enactments for compliance of cosmetic products. Samples of Maral roots grown in Latvia and Russia were compared, the presence of ecdysteroids and their content changes during drug storage were determined.

The study observed the antimicrobial effect of leaf extracts against *Staphylococcus aureus* in all samples after 7 days and *Pseudomonas aeruginosa* after 14 days of storage. In general, autumn raspberry and Japanese quince leaf extracts showed antimicrobial activity against the broadest spectrum of microorganisms. The sea buckthorn sample should also be noted positively, as the extract of these leaves inhibited the growth of all the studied microorganisms. Aqueous extract (tea) from fermented autumn raspberry leaves contained higher total phenol, flavonoid and tannin content than wild raspberry leaf tea.

In the extracts obtained from *R.carthamoides* roots, 20-hydroxyecdysone was the only detected ecdysteroid molecule. The content of 20-hydroxyecdysone in *R.carthamoides* roots obtained in Latvia over two years was higher than that of samples obtained in Russia. This compound had good stability, decreasing in content by 10% over the course of 18 months.

ACKNOWLEDGEMENTS

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DEVELOPMENT OF TOOLS FOR *CHAENOMELES* GERMPLASM GENETIC EVALUATION

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Key words: *molecular markers; diversity; relatedness, breeding.*

Chaenomeles sp. plants as a fruit crop are relatively new. Until now, they were known mainly as ornamentals in various regions of the world. The Baltic countries are considered a place for the targeted creation of *C.japonica* as a fruit plant because their breeding was started in Latvia in the 1950s, and the first plantations were established in the 1970s. The next stage of Japanese quince breeding in Latvia was updated in the 1990s; as a result, local cultivars adapted to the Latvian climate were developed.

During 1998-2002, a joint international project was initiated in which scientists from Latvia, Lithuania and Sweden were involved, within the framework of which the more extensive *Chaenomeles* germplasm was involved in research and breeding, creating varieties with a broader genetic background [1,2]. As a result of all these *Chaenomeles* breeding attempts, the plant material obtained in Latvia forms today's germplasm in Latvia and is involved in current breeding activities.

Since Japanese quince as a fruit crop is very new, their genetic research is very limited - information is available only on a limited set of plant material, basically within the framework of one breeding program. For this reason, the availability of molecular genetics methods is also limited. Therefore, the goal of this study is to create or adapt molecular marker methods for the evaluation of genetic resources of *Chaenomeles* for the study of the heredity of agronomically important traits.

In the first stage of the study, Random Amplified Polymorphic DNA (RAPD) molecular markers were adapted, which ensured sample discrimination, but could not separate different *Chaenomeles* species. The set of markers tested also had repeatability problems typical of this marker type.

Simple Sequence Repeat (SSR) molecular markers were used in the study's next stage to overcome the shortcomings. As no genomic information is available for *Chaenomeles* and no such markers have been developed, those developed in the related genera *Malus* and *Pyrus* were used to adapt the methodology. For this purpose, a set of SSR markers representing all *Malus* linkage groups was selected, the amplification method in Japanese quince was adapted, and the most successful markers were identified.

As a result, a set of 25 markers was obtained, which provided a clear discrimination of *Chaenomeles* species, allowing to trace the origin of the existing germplasm (potential interspecies crosses), obtaining unique genotypes for each sample, ensuring individual identification and intraspecies genetic relatedness.

ACKNOWLEDGEMENTS

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[2]: Kaufmane, Edīte; Ruisa, Silvija; Kārkliņa, Katrīna; Proceedings of the Latvian Academy of Science. Section B, 76, 4/739, 477–481. DOI: 10.2478/prolas-2022-0073 (2022).

DASHEEN AND KONJAC MOSAIC VIRUS ELIMINATION ATTEMPTS FROM *ZANTEDESCHIA* SP.

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Key words: *in vitro; virus elimination; calla lily, DsMV, KoMV.*

Historically, in Latvia, Calla lily *Zantedeschia* sp. is a decorative plant that is grown in greenhouses. Around the years 2012-2013, local populations started to suffer from plant damage and crippled growth; plants lost their decorative properties. Calla lily is known to be susceptible to at least 16 viruses. Two viruses were detected: dasheen mosaic virus (DsMV) and konjac mosaic virus (KoMV). Several plant taxa have been shown to grow virus free using meristem cultures. For virus elimination several methods were tried: (i) apical meristem isolation; (ii) thermotherapy 14 days, 37 °C in combination with meristem culture; (iii) electro therapy in combination with meristem culture.

Plant material for meristem culture was placed on Murashige-Skoog medium supplemented with 2,5 mg L-1 BAP, 30 g L-1 sucrose and 6 g L-1 agar, pH was adjusted to 5,7 with 0,1M NaOH and HCl. For virus detection molecular methods were used. For RNS extraction Thermo Scientific™ GeneJET Plant RNA Purification Kit was used, then reverse transcription Applied Biosystems™ High-Capacity cDNA Reverse Transcription Kit, PCR reaction using Solis BioDyneHOT FIREPol® Blend Master Mix. For visualization 1,5% Agarose gel was used.

Meristem culture as well as thermotherapy in combination with meristem culture wasn't efficient. All plantlets obtained were infected. Electro therapy show some positive preliminary results but further research is required.

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MICROPROPAGATION OF *GENTIANA VERNA*

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Key words: *in vitro, spring gentian, shoot culture, acclimatization*.

Spring gentian *Gentiana verna* L. is small, decorative perennial plant growing on sunny alpine meadows and moorlands in Eurasia belonging to *Gentianaceae* family. Vegetative propagation of spring gentian is slow, seed germination rate low.

Plant material for *in vitro* culture initiation was collected in summer 2021 in plant nursery "Baižas" in Latvia. Shoots were surface sterilized 1 min in 70% ethanol followed by 20 min in 15% "Domestos" (<5% sodium hypochlorite) solution and three rinses of deionized autoclaved water. Explants were placed on Woody plant medium supplemented with 200 mg L-1 casein hydrolysate, 200 mg L-1 glutamine, 0,2 mg L-1 6-benzylaminopurine, 0,1 mg L-1 indole-3-butyric acid, 20 g L-1 sucrose and 7.5 g L−1 agar, pH was adjusted to 5,8. Adding plant preservative mixture (0.01-0,05%) reduced culture contamination level. After 4 weeks plants were transferred to fresh medium. For multiplication Murashige and Skoog (MS) basal mineral medium supplemented with 200 mg L-1 casein hydrolysate, 200 mg L-1 glutamine, 0,2 mg L-1 6-benzylaminopurine, 0,1 mg L-1 indole-3-butyric acid, 30 g L-1 sucrose and 7.5 g L−1 agar. Naturally *Gentiana verna* form very short internodes, nearly rosettes. Adding gibberellin acid 1 mg L-1 to multiplication medium increased distance between internodes making multiplication easier.

For rooting stage MS medium supplemented with 2 mg L-1 glutamine, 3 mg L-1 indole-3-butyric acid, 10 g L-1 sucrose was used. Plantlets were placed in darkness for one week. After one week plantlets were transfer to fresh hormone free medium. In approximately 4 weeks root development was observed.

For acclimatization several substrate mixes were tested peat, peat with base layer of expanded clay, base layer of expanded clay, peat with sand (1:1), base layer of expanded clay, peat with perlite (1:1), base layer of expanded clay, peat with gravel (1:1), base layer of expanded clay, peat with vermiculite (1:1). Preliminary results show that expanded clay improve acclimatization results but between variants that had expanded clay no significant difference was observed in early acclimatization stages.

ACKNOWLEDGEMENTS

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THE DETECTION OF VIRUSES ASSOCIATED WITH CRUMBLY RASPBERRY FRUIT IN LATVIA AND ELIMINATION POSSIBILITIES BY MICROPROPAGATION

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Key words: *RBDV, RLMV, RYNV, RpLV.*

As *Rubus* cultivars are propagated vegetatively, they are subjected to accumulate virus infection during propagation and fruit production stages. The crumbly fruit has become an increasingly serious problem in raspberry production worldwide [1]. It is caused by a complex of several viruses: raspberry bushy dwarf virus (RBDV) together with aphid-transmitted viruses, such as raspberry leaf mottle virus (RLMV), *Rubus* yellow net virus (RYNV) and raspberry latent virus (RpLV). The detection of RBDV, RLMV, RYNV and RpLV in raspberry was carried out by RT-PCR, and RBDV elimination possibilities by micropropagation were studied.

Our results show that 35% of the tested plants are infected with RBDV, and several popular raspberry cultivars (e.g., 'Balzam', 'Sputnica') are infected. The occurrence of other *Rubus* infecting viruses in Latvia is unknown, but they are present in Europe. The virus elimination by micro propagation usually was not effective, and plants remained infected with RBDV. Low elimination efficiency probably could be due to co-infection with other viruses, especially RLMV, which increases the replication titre of RBDV. The detection of RLMV, RYNV and RpLV in raspberry microplants and studies on the impact of other viruses on RBDV elimination efficiency is being continued.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of ERDF and the Ministry of Agriculture of Latvia, grant number No. 19-00-A01612-000006 "Development of biotechnology competence for introduction of high-quality horticultural products".

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MICROPROPAGATION OF *RHAPONTICUM CARTHAMOIDES* (WILLD.) ILJIN

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Key words: *Rhaponticum carthamoides, in vitro, micropropagation*.

Rhaponticum carthamoides is a medicinal plant from *Asteraceae* family, the native range of this species is Central Asia to Siberia. Growers of this plant in Latvia have noticed that after harvesting the seeds rapidly decrease their germination efficiency, so it is necessary to find other propagation methods. Micropropogation could be a good alternative to mass propagation.

For the *in vitro* shoot culture establishment *R.carthamoides* seeds were soaked in running tap water for 24 hours, disinfected by standard methods using 70% ethanol and 5% sodium hypochlorite, and germinated on Murashige-Skoog (MS) agarised medium (1962), supplemented with kinetin (0,02 mg/l) and gibberellic acid (0,1 mg/l). The development of infections was observed in all used sterilization methods, to prevent from infection forming Plant Preservative Mixture (PPM 2 ml/l), fungicide (Nystatin 10 mg/l), or bactericide (Cephalexin monohydrate 10 mg/l) were added to the germination medium. The lowest infection rate was obtained using PPM: after 4 weeks only 9,3% of seeds were infected.

Adventitious shoot formation was obtained through indirect organogenesis when seedling explants (hypocotyl, cotyledon and root) were used for regenerative callus initiation. Regenerative callus was obtained by cultivating the seedling explants on MS medium supplemented with NAA (0,5 mg/l) and BA (0,2 mg/l). For propagation, the newly formed shoots (microplantlets) were separated from the callus and transferred to MS medium supplemented with IAA (0,1 mg/l, 0,5 mg/l) or IBA (0,1 mg/l, 0,5 mg/l) in combination with BA (0,2 mg/l, 0,5 mg/l, 1 mg/l). The number of newly formed shoots and their length were measured after 5 weeks. The best average shoot number of 7,22 and average shoot length of 1,78 cm per microplantlet were achieved with IBA 0,5 mg/l and BA 0,2 mg/l. A similar result was obtained by using medium supplemented with IAA 0,5 mg/l and BA 0,2 mg/l (average number of shoots 7,22 but average length -1,76 cm per microplantlet).

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of ERDF and the Ministry of Agriculture of Latvia, grant number No. 19-00-A01612-000006 "Development of biotechnology competence for introduction of high-quality horticultural products".

MICROPROPAGATION ATTEMPTS OF *ACTAEA RACEMOSA* 'BRUNETTE'

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Key words: *in vitro; Actaea racemose, black cohosh; callus culture.*

Black cohosh *Actaea racemosa* L. is perennial plant belonging to *Ranunculaceae* family with great decorative properties. Vegetative propagation of black cohosh red forms is slow and rather difficult so *in vitro* approach was tried.

Callus culture was established form etiolated leaves on MS medium supplemented with 0.1 mg L-1 NAA in combination with 1 mg L-1 TDZ [1]. After several subcultivations masses of friable callus was obtained. Several combinations of phytohormones were tested to induce shoot formation (Table 1).

So far none of the combinations tested showed any positive results. Further research is required.

ACKNOWLEDGEMENTS

This work was supported by the ELFLA Project No. 19-00-A01620-000097.

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[1]: Lata, H., Bedir, E., Hosick, A., Ganzera, M., and Khan, I. (2002). In vitro Plant Regeneration from Leaf-Derived Callus of Cimicifuga racemosa.

Table 1. Phytohormone and combinations used to induce shoot formation from callus.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BAP	2				2	2		4							
Kin		1	1	1					2						
Naa	0,5		1,5					1	0,5				0,5	1	2
GA				4	4		4								
TDZ							1			0,5	2				
2.4 D										1				2	
2iP												2	1		

MANAGING MICROCLIMATE CHALLENGES, APPROACHES OVERVIEW, LESSONS LEARNED AND FUTURE RESEARCH

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Key words: *CEA, vertical farming, microclimate, grow room, air quality.*

Presentation will give an overview to different approaches used in implementation of eight vertical farms in Zagreb, Croatia by Vesela Motika and it teams members.

Different approaches in design and implementation lead to different challenges and risks. Through the years of implementation of vertical farming and interaction with other vertical farm designers few main design patterns emerged. These topics will be presented, including associated benefits and risks.

To manage the microclimate and collect right data from the first vertical farm laboratory, IoT solution was in continuous development according to the research needs. It is based on ESP32, low-cost, low-power system on a chip (SoC) series with Wi-Fi & dual-mode Bluetooth capabilities. Over the years we found out that for some cases it is needed to integrate custom made data collection and actuators settings solution, while in some cases we used available off-shelf solutions.

Importance of scope analysis in process of the microclimate management project planning will be presented together with different use cases.

In final, new research directions will be presented. That will include biological, technical and social challenges related to the microclimate and also addressing to increased energy cost. At this stage of research, main future direction is in consistency of plants quality, in lowering the variations between biochemical compounds produced by plants and grow to harvest cycles.

At the same time, presentation addreses to the climate change we evidence globally and underline the needs for implementing more complex solutions for industrial medical plants production used as raw materials in manufacturing processes. Recent report "Pharma supply chains of the future" by EY, addressing potential alternatives to localization of pharma supply chain and improvements of its resilience, lead toward the opportunity and at the same time challenge, that controlled environment and microclimate management could support proposed scenarios. Those potential solutions will be presented instead of conclusion.

THE POTATO *SOLANUM TUBEROSUM* PRODUCTION IN CONTROLLED ENVIRONMENT AEROPONICALLY

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Key words: *Solanum tuberosum, aeroponic, hydroponic.*

Aeroponics is a technique in which plants are supplied with nutrients through their roots by an air-water mist. In a relatively short time, aeroponic systems have become widely used. Potato mini-tubers produced by aeroponic systems are space and cost efficient and provide farmers with healthy propagation material (Tunio et al., 2020). Several trends can be observed in the world of aeroponic cultivation. Most innovations start by developing the technical solutions and then try to understand the needs of the plants in the final climate chamber. In our experiment, cultivation starts with minimal equipment, learning the needs of the plants under specific conditions and gradually improving the cultivation technologies and climate to find an optimal, energy-efficient and functional solution for growing healthy potato seedlings.

In 2020, the first trials for indoor potato cultivation in aeroponics were launched at the Biotechnology Centre of Bulduri Technical School. Varieties such as 'Agrie Dzeltenie' and 'Frieslander' were grown. The trials studied the effects of different temperature and light conditions, day length, concentration of nutrient solutions, pH and acclimatisation time on plant development. *In vitro* rooted pathogen-free potato seedlings were acclimated in hydroponics in vermiculite in trays for 3-4 weeks. Then, the seedlings were transferred to the aeroponic system-a 200-litre, 0.8-m-high tank with 3-cm-diameter holes in the lid. In the tank, the nutrient solution was sprayed from above under a pressure of 5.5 atmospheres with a 360° nozzle, and the duration and interval of spraying could be changed. The plantlets were fixed with a polyurethane sponge. The plants were planted in mid-December and in April. The temperature was kept between 16 and 20 oC. Unfortunately, it was not possible to maintain a sufficiently low temperature regime during summer cultivation, and the experiment had to be terminated prematurely. Plants planted before December have delayed growth during the first weeks, so it takes longer to plant them in the aeroponic system. Depending on the variety, the first tubers may form immediately after planting in the aeroponic system or not for several weeks. Under current conditions, potatoes in the winter cycle are grown until May and potatoes planted in April are grown until August. Of the potato varieties grown in the trials, the variety 'Frielandser' performed best.

ACKNOWLEDGEMENTS

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PHENOMENON – A MULTI-SENSORY PHENOTYPING ROBOT FOR PLANT TISSUE CULTURE

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The current development of sensor technologies towards ever more cost-effective and powerful systems is steadily increasing their areas of application in different horticultural sectors. In terms of plant *in vitro* culture being the basis of many biotechnological methods of breeding and of propagation of disease-free plants limited research regarding automated sensor application was carried out up to now. However, manual visual monitoring for contaminations and malformations of the cultures is a costly and time-consuming repetitive work for commercial in vitro laboratories. With about 60-70% labour costs in particular represent the largest share in the *in vitro* production and thus offer great potential for increasing the efficiency of micropropagation laboratories through automation of work processes.

Due to the specific growth conditions of *in vitro* plants cultured in closed vessels, monitoring approaches face a number of challenges like condense water formation, opacity and total reflection of parts of plastic lids or media surfaces. Therefore, most evaluation methods used for determination of plant growth *in vitro* were limited to destructive and non-real-time methods. In addition, digital phenotyping of *in vitro* plants could offer advantages with regard to the objective and continuous quantification of plant characteristics.

This project focuses on the development of a phenotyping platform (Bethge et al. 2023, submitted) for an automated acquisition of multi-sensor data, including RGB, thermal, depth and spectral data. Hardware components were selected to be exclusively low-cost and the software design is based on common open-source frameworks like Docker, OpenCV and PlantCV. The automated XYZ-scanning system collects data since August 2021 of *in vitro* cultures, thus first time-lapse videos and growth curves have already been recorded and analysed. Furthermore time-lapse depth-images of *in vitro* cultures were successful acquired by sequential shifting of the point measurement-based distance sensor. Sensor application in plant tissue culture promises great potential for a non-destructive growth analysis.

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CHALLENGES IN CONSERVATION OF OREGANO *ORIGANUM VULGARE* L. AND THYME *THYMUS* SP. GENETIC RESOURCES IN *EX SITU* COLLECTION

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Key words: *medicinal and aromatic plants, conservation*.

According to the European Cooperative Programme for the Plant Genetic Resources, oregano *Origanum vulgare* L. and thyme *Thymus vulgaris* L. and *T.serpyllum* L. are included in the List of "Priority Species" of medicinal and aromatic plants [1]. Since 1994 [2], different 44 oregano and 22 thyme accessions are growing at the *ex situ* collection of genetic resources of aromatic and medicinal plants (N 56°39´47´´; E 23°45´13´´), situated at the Laboratory of Horticulture and Beekeeping, Institute of Soil and Plant Sciences, Faculty of Agriculture, Latvia University of Life Sciences and Technologies. The aim of this research was to define the general problems connected with growing and conservation of oregano and thyme genetic resources during years.

It was observed, that despite of different meteorological conditions, oregano and thyme creates high fresh and dry biomass, but the content of essential oils has a tendency to decrease by years. The possible reasons of losses can be factors such as non-optimal average air temperature per vegetation period (lower than +20 °C), long-term vegetative propagation by division, for oregano – also fungal diseases infecting plants by a complex of pathogenic fungi as well as damages by insects (for example, *Cicadellidae*).

By winter hardiness, the proportion of damaged surface of leaves, stems and inflorescences was estimated visually on a scale as very low (0–4% of plants are damaged) for oregano, but for *T.vulgaris*, by years, it was evaluated till very high (95% or more plants are damaged). For genetic resources, because of polymorphism, receiving of seed material is possible using isolators only. For oregano, isolation seed production was not influenced significantly by isolators. But for thyme, significant negative influence of isolators on the seeds' yield was detected.

For understanding of oregano and thyme renovation, additional studies are still needed, but *in vitro* as general propagation method by should be recommended.

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AUXIN HOMEOSTASIS AND SIGNALING DURING ADVENTITIOUS ROOTING OF TWO CONTRASTING PARENTAL SPECIES OF *PETUNIA*

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Key words: *Petunia hybrida, cuttings, adventitious root formation (ARF), auxin, microarray.*

Petunia hybrida is economically important and many cultivars are propagated vegetatively. Under standard conditions (temperature: 22/20°C, light period: 7:00 - 17:00, PAR: 100 µmol m^{-2} s^{-1}) the intensity of AR formation is higher in the parental line *P.inflata* compared to the parental line *P.axillaris*.

Though the important role of auxin for AR induction is well established, the endogenous control of auxin action in response to cutting excision is far from being understood. Aiming at the identification of candidate genes that putatively control auxin-dependent AR formation in cuttings, we compared the two species. Thereby we analysed the dynamic of gene expression of auxin-related genes in the stem base as zone of root regeneration during AR induction and early AR initiation and also the systemic response in additional four upper cutting parts.

To this end, we developed and used a phytohormone-targeted microarray, that includes 617 sequences of auxin-related genes of both species, and further analysed endogenous IAA levels by LC-MS/MS. Genes that putatively control auxin biosynthesis showed almost no up-regulation, whereas the data of both species disclosed early up-regulation of genes in the stem base, that putatively control IAA-release from conjugates.

The better rooter *P.inflata* showed a stronger up-regulation of genes that putatively control polar auxin transport (PAT), auxin signaling and auxin-controlled AR primordia differentiation in the stem base. Correspondingly, endogenous auxin (IAA) reached higher levels in the stem base of *P.inflata* when compared with *P.axillaris*. The data indicate, that higher endogenous IAA levels that might be partially generated by exclusive upregulation of auxin transporters in cuttings leaves and the consequently stronger auxin signaling in the stem base provide better rooting of *P.inflata*, and highlight genes, which function will be analysed by CRISPR/Cas-based mutagenesis.

PROGRESS IN IMPROVING THE *PERENNA.BULDURI* DATA BASE

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Key words: *perennials description, planning planting, data base.*

Perenna data base was created based on a long-term program to study the biological potential of perennials as a material for planting. Investigations were made on a base of plant collections of Botanical Garden of the University of Latvia. Reaching a large array of data, it has become usable for practical work when planning planting and maintenance work in greenery.

As a result of cooperation with Bulduri Technical School that trains a wide range of specialists of greenery, and within the framework of the project 'Autonomous robotic platform iGarden for the sustainable development of the nursery industry', since 2021 *Perenna* has a new version – *Perenna.Bulduri* that is based on a PHP server of Bulduri Technical School. Work continues in the transformation of interfaces and new data input simultaneously. Solutions in data input are presented.

By the end of 2022, 543 plant records with descriptions of 70-120 descriptive criteria and photo have been prepared for wide range of users. Largest part between them is a group of herbaceous perennials – 485 taxa, bulbous plants – 52, annual – 4, climbing plants – 2. Work continues with the transformation of filters to request information on any combination of 10 criteria for Technical School purposes.

SMART GARDEN ENGINEERING FOR DATA-DRIVEN FRUIT-GROWING

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Key words: *Internet of Things, IoT, digitalization, system design, smart horticulture.*

Introduction: Horticulture modernization develops and the application of the agricultural Internet of Things (IoT) is becoming increasingly extensive. IoT is a relatively new technology, which is a base for the development of digital twins and precision horticulture to achieve data-driven decision-making. It is a fact that the development of IoT systems is complicated compared with traditional software systems, especially in relation to engineering requirements [1]. The construction of smart garden projects based on the integration of IoT requires the coordination of multiple disciplines. The construction of such projects is still in the exploration stage, and the relevant theoretical system is not yet perfect [2].

Our team developed the smart garden within project No. lzp2019/1-0094 at the Rezekne Academy of Technologies for education and experimental needs. In this article, we present the smart garden design and its development life cycle to exchange our experience.

The development life cycle consisted of four stages: 1) a geospatial analysis; 2) a garden planning; 3) a system design; 4) a smart garden implementation.

Geospatial analysis: this stage was related to location selection for the garden arrangement. Next physical properties were evaluated: soil quality, land area, sunlight, etc. Considering logical properties – pipeline maps, land use maps, etc.

Garden planning: it was related to the selection of plant crops and cultivars. Considered physical properties – climate, fruit tree sizes, scab resistance, etc. Logical – business targets, vendors, available shop list, supply options, fruit tree management methodology, etc.

System design: it is considered the selection of IoT devices and software technologies, and the development of system design. Physical properties – sensor parameters and their fitness to climate, locations of IoT devices, Wi-Fi availability, etc. Logical – security requirements, radio frequency, protocols, API availability, licences, etc.

Smart garden implementation: the practical development of the garden was completed. Physical tasks – fruit tree planting, sensor mounting, software development, etc. Logical – IoT system configuration, coordination, etc.

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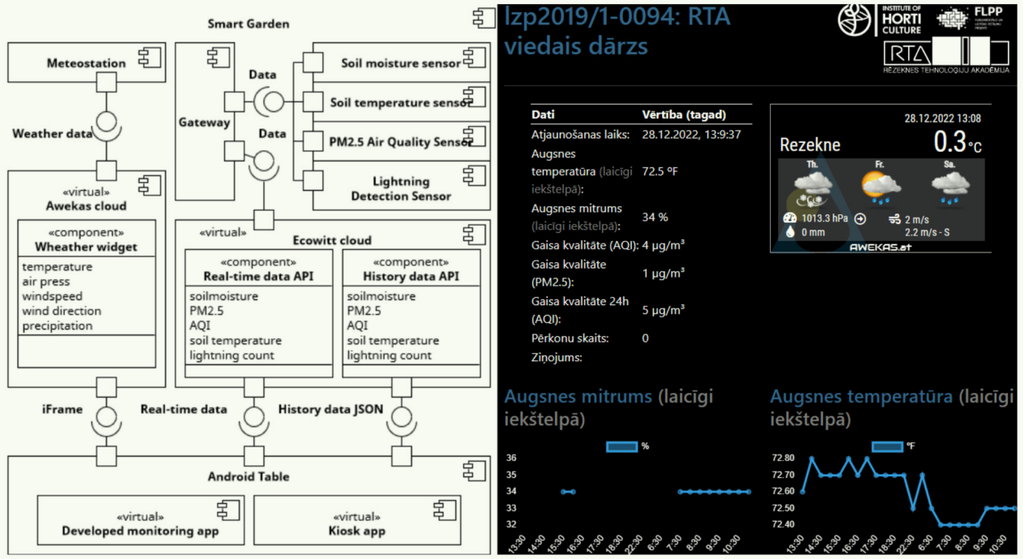

Fig. 1. The smart garden: left – the design (applied UML component diagram adapted for IoT domain[3]); right – developed monitoring application for Android tablet (GUI in Latvian) (S.Kodors).

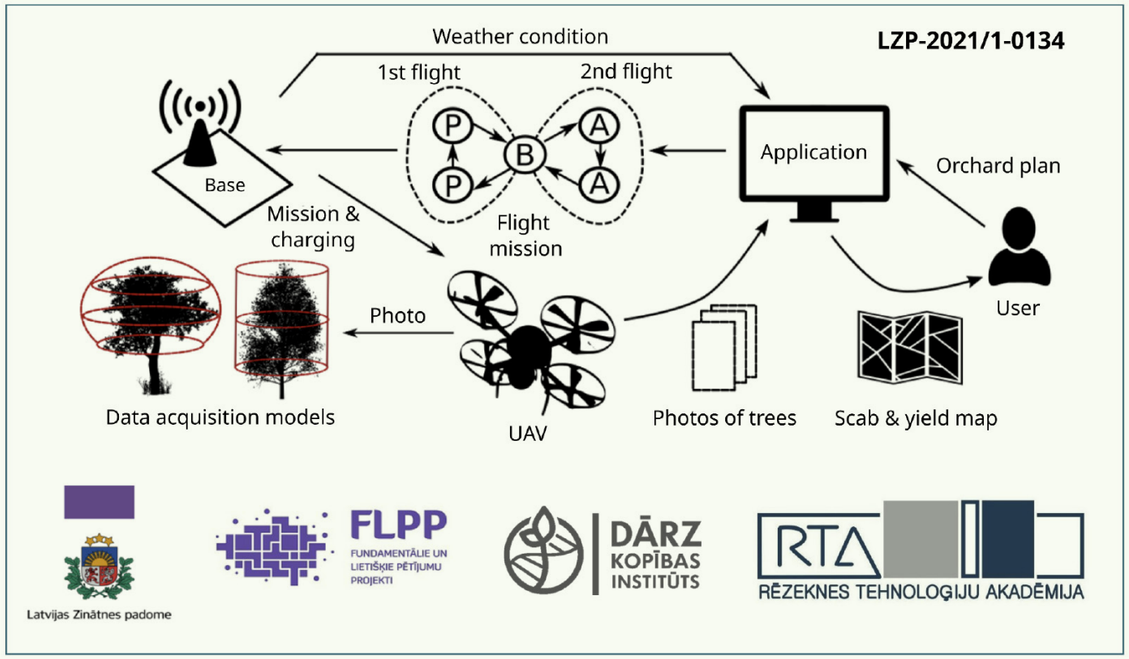

Fig. 1. The concept of Autonomous Orchard Monitoring System (I.Zarembo).

AUTONOMOUS ORCHARD MONITORING SYSTEM

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Key words: *artificial intelligence; digital horticulture; digital twin; smart fruit growing; UAV.*

Flowering intensity, yield and disease symptoms are basic parameters used to characterise apple, pear and cherry trees and make orchard management decisions. Traditionally, flowering intensity and yield estimation has been performed by manual counting, weighting and visual evaluation. However, it is an expensive, time-consuming and possibly subjective process. Therefore, subsequent decision making becomes a challenging task for the fruit-growers; the data obtained usually is late to estimate the amount of harvest (to predict yield). There is a need for an intelligent flowering, fruitlets and fruits (yield) estimation and disease monitoring system (the last one for apple trees) that overcomes the aforementioned problems.

The proposed Autonomous orchard management system (Fig. 1) is based on the digital twin paradigm and unmanned aerial vehicle (UAV) application to monitor orchards automatically and is aimed at commercial fruit-growers. With the introduction of autonomous monitoring systems, evaluation can be performed at repeated intervals, receiving the obtained evaluation promptly for operative decision-making, ensuring data objectivity and independence from the evaluator. Automatic data collection allows creating a data bank for process analysis and improvement of orchard management systems.

The system is based on web technologies and has a user-centred design to complete decision-making using dashboard and geospatial information about yield and scab. The system allows to: 1) enter an orchard's geospatial information and generate flight missions of orchard monitoring; 2) manage connected UAVs, mobile devices, weather stations and fruit tree details. The flight missions are calculated using predefined mathematical models taking into account obstacle avoidance, no-fly zones and orchard boundaries. During a flight mission an UAV autonomously traverses the designated area and takes a series of photographs of trees in specific angles. The captured images are exchanged between drone and server using a mobile application; Android mobile serves as a drone base.

The system is designed to have an artificial intelligence (AI) solution that is able to analyse the captured images to detect flowers, fruitlets, fruits and disease symptoms in the canopy of fruit trees. The existing scab detection module[1] is integrated into the system. Meanwhile, our current studies are directed to develop fruit yield prediction AI module. At this moment we collected a dataset of images, annotated it and developed a data model compatible with AI.

The yield prediction module will be based on an intelligent workflow, which combines image preprocessing methods, object detection neural networks and regression models.

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