

Doctoral Study Programme HORTICULTURE - 2023/2024

The influence of agrotechnical measures on increasing the bioactive potential of extracts from selected aromatic plants

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Workplace: Institute of Horticulture
Field of study: Agriculture and landscaping
Study program: Horticulture
Form of study: daily

Thesis: Plant extracts are concentrated, natural and multi-component products that can be used to produce valuable and useful bioproducts (e. g. food, cosmetics, medicines, biostimulants, biopesticides and feed). They have antifungal, antimicrobial, antiparasitic, antiprotozoal, antioxidant, medicinal, aromatic, and anti-inflammatory properties. Many modern medicines have been developed using clues obtained from the study of phytochemicals. Extracts as a group of natural products have the potential to become a new generation of bioproducts suitable for use in modern sustainable agriculture, as well as in the food and pharmaceutical industries.

Due to the high content of various bioactive compounds, aromatic plants are an interesting raw material for the potential production of extracts. Different parts of plants can be used for their production, such as seeds, fruits, flowers, stems, leaves and roots.

During cultivation, plants must cope with various environmental stresses. Under the influence of abiotic stresses such as drought, mineral nutrition disorders or temperature stress, the synthesis of protective plant compounds occurs in plants as a physiological response to stress. Many of them, produced within the primary or secondary metabolism of plants, act as functional compounds not only in plants but also in other organisms. They are metabolites or intermediates that can affect the nutritional quality of the edible parts of the plant as well as the biological activity of the extract itself.

Rationale: The bioactive potential of aromatic plant extracts can be increased in various ways. The species, variety, cultivation technique and, finally, the extraction method itself have a fundamental influence.

The dissertation of an experimental nature will be focused on growing plant material in a model field experiment according to proven technology and with detailed mapping of inputs in the framework of nutrition and protection, as well as climatic characteristics in the place of the experiment. Procedures suitable for increasing biologically active substances will be chosen, such as use of selected biostimulants. When choosing species (varieties), we will focus on less well-known aromatic plants in our conditions with potential use in the pharmaceutical and food industry, such as Fenugreek (*Trigonella foenum-graecum*) etc.

Subsequently, extracts will be obtained from these plants. As part of the experiments, the most suitable processing of the samples will be investigated in terms of the preservation of biologically valuable substances by extraction with different extraction agents under different physical conditions. In the obtained samples, biologically valuable components will be evaluated from a qualitative and quantitative point of view using OES-ICP and CV-AAS, and changes in the content of biologically active substances will be monitored using UV/Vis spectrophotometry (antioxidant parameters - DPPH, ABTS, FRAP), HPLC-DAD (phenolic substances, biogenic amines, vitamins D, E), or GC-FID / GC-MS (FAME and volatile aromatic substances).

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The effect of biostimulants on the quantitative and qualitative parameters of grapes and must of Slovak must varieties of grape vine (*Vitis vinifera*).

Supervisor: doc. Ing. Ján Mezey, PhD.
Workplace: Institute of Horticulture
Field of study: Agriculture and landscaping
Study program: Horticulture
Form of study: daily

Thesis: The wealth of the country lies in many aspects, and one of them is the natural wealth, or the legacy. Agriculture can also be included in these spheres, which also includes special plant production in the form of viticulture and winemaking. The cultivation of vines and the production of wine and cider has a long history and tradition in our territory. Mainly proven world varieties are grown, but in the last 30 years we have witnessed the establishment of Slovak varieties in our vineyards. These varieties are directly bred for our conditions, thus providing a prerequisite for high-quality growth, fertility, as well as optimal quantitative and qualitative indicators of grapes, must and wine. Various purposes were used during breeding to improve the external and internal quality of grapes, including the increase of health-promoting, bioactive substances, such as phenolic substances, such as polyphenols, anthocyanins, resveratrol, but also, for example, antioxidant activity.

Biostimulants are substances that can directly stimulate plant metabolism. They contain biostimulating substances such as humic, humic and fulvic acids, protein hydrolyzates, extracts from seaweed and various plants, chitosan and biopolymers. We can also include useful fungi with the ability to produce metabolites with a biostimulating effect, other mycorrhizal fungi, as well as some bacteria. Biostimulants improve plant metabolism, stabilize crops, increase plant tolerance to abiotic stresses, increase nutrient intake from fertilizers and their subsequent translocation in the plant, improve quality parameters of crops such as sugar and protein content, improve fruit color, help better water intake and its use by weeds, improve soil fertility by supporting the development of useful soil microflora.

Rationale: By applying biostimulants to plants, or to the soil in the form of a dressing, or by spraying on a leaf, we can potentially stimulate the metabolism of the plant itself, increase the efficiency of nutrient intake, thereby directly influencing many quantitative and qualitative properties of plants. The application of a complex group of biostimulants in different stages of development and in different forms of application to Slovak new breeders of grape must varieties has not yet been implemented. It is therefore important to understand how individual varieties will react to specific types of biostimulants in terms of quantity and quality of grapes, or cider. One group of biostimulants can potentially increase quantitative indicators, while another can affect the content of fermentable sugars, the content of malic acid, or the pH of the must. We also assume stimulation of the synthesis of a wider group of polyphenols, especially in the case of blue varieties. All these assumptions will need to be confirmed by several years of observation and multiple analyses.

Financial coverage: EIP-PRV SR 2014-2022, „Protection of fruit from damage caused by frost“.

Effect of plant essential oils *in vitro*, *in vivo* and *in situ* conditions against bacterial pathogens on fruit model

Supervisor: prof. Ing. Miroslava Kačániová, PhD.
Workplace: Institute of Horticulture
Field of study: Agriculture and landscaping
Study program: Horticulture
Form of study: external

Thesis: An increasing number of EO has shown an interesting activity from an agricultural consideration, against a broad spectrum of micro-organisms *in vitro* and *in planta* and against weeds and bioindicator plants. Bacteria causing diseases on plants may have a considerable economic impact. As an example, bacterial diseases caused by *Xanthomonas* spp. affect a wide range of host plants, causing considerable damages on plants and hence a loss in terms of yield and crop quality. The response and susceptibility of pathogens to EO or EO major compounds are diverse. It has for instance been demonstrated that the effect of basil EO on different bacteria induced various responses in terms of inhibition, against a wide range of pathogens. It has been shown particularly efficient against *Pseudomonas tolaasii*, whereas *Brenneria nigrifluens* was barely affected by the EO. Additionally, *Xanthomonas citri* and *Rhodococcus fascians* were also inhibited but at higher EO concentrations in comparison with *P. tolaasii*. Another study has shown a mitigated success of the *Tanacetum* species EO, being ineffective against *Erwinia amylovora* or *Xanthomonas* spp. *Origanum onites* has on the contrary proven itself efficient against *Clavibacter michiganensis* and *Xanthomonas* spp. with consistent inhibition zones. Considering that the EOs are perceived as an alternative eco-friendly food preservative, the interest in EOs application in the food industry and packaging has grown in recent years. EOs play significant roles in the food sector with a wide range of applications, mainly to prolong shelf-life and prevent oxidation. For this purpose, they are valorized by the addition to food products. Several EOs have GRAS status (Generally Recognized as Safe), including basil, cinnamon, clove, coriander, ginger, lavender, menthol, nutmeg, oregano, rose, sage, and thyme EOs. The tests revealed positive results of the essential oils, showing a stronger biocide efficacy. EOs are used as biopreservatives in all food types with various applications in the food segment for meat, fish, seafood, bread, grains, milk, dairy products, fruits, and vegetables (especially cut products) to enhance the quality and safety of products. The aim of the dissertation will be the monitoring of plant essential oils *in vitro*, *in vivo* and *in situ* conditions against plant bacterial pathogens on fruit model.

Rationale: In the dissertation, the chemical composition of plant essential oils EOs and their influence *in vitro*, *in vivo* and *in situ* conditions on selected types of bacterial pathogens will be monitored. *In vitro*, the effect of EOs will be monitored using the disc diffusion method and the minimum inhibitory concentration method. Under *in vivo* conditions, plant essential oils will be used to monitor the inhibition of the growth of bacterial pathogens directly on selected types of fruit during ripening. *In situ* conditions, plant essential oils are used in the gas phase for 7 days on selected types of fruit. Monitoring the effect of different concentrations of plant essential oils will also be an important factor. Despite the importance of fresh fruit safety, there are not many results on the effectiveness of plant essential oils to control bacterial populations on fruit, indicating the need for research in this area. For long-term research on the impact of biochar on N₂O emissions, soil properties and crop yields, a field experiment was established in 2014 and continues up to now.

Financial coverage: VEGA 1/0180/20 Study of properties and biological activity of plant essential oils in a cell model", KEGA 010SPU-4/2021 Internationalization of education and

creation of new teaching texts in English for the accredited study program "International Master of Horticulture Science (IMHS)" and for Erasmus program", **APVV-20-0058** Potential of herbal essential oils from aromatic plants for medicinal use and food preservation".

Assessment of effect of ecological biostimulants on quantitative and qualitative parameters of horticultural crops with emphasis on maintaining of soil health

Supervisor: doc. Ing. Alena Andrejiová, PhD.
Workplace: Institute of Horticulture
Field of study: Agriculture and landscaping
Study program: Horticulture
Form of study: external

Thesis: The use of plant biostimulants in practice is currently considered a current and innovative approach to increase agricultural production in a sustainable and ecological way. One of the best ways to successfully combat various adverse abiotic and biotic environmental conditions is to support the cultivated plants themselves. Plant biostimulants based on humic substances; amino acids; protein hydrolysates; chitosan; algae and plant extracts; of beneficial microorganisms (fungi or bacteria) are usually used in the cultivation of high value crops (fast crops in greenhouses, fruit trees, vegetables in field conditions, flowers and ornamentals). These biological preparations were originally used only in organic agricultural production, but nowadays they are increasingly being introduced into conventional plant production. Their application activates several physiological processes that increase the efficiency of the use of nutrients, stimulate plant development and enable the reduction of fertilizer consumption. The application of humic substances to plants leads to an increase in their production and an improvement in the quality of the soil; the ability of the soil to retain water increases, aeration of the soil is promoted, a better water regime is created and a suitable environment is created for the development of beneficial soil microorganisms. Many biostimulants are also capable of counteracting the effect of biotic and abiotic stresses and thereby increasing the quality and yield of crops. The research focus of the work will be to verify the biostimulating effect of selected ecological preparations based on humic substances and soil microorganisms - bacteria when growing cauliflower and strawberries in field conditions. By solving the work, we expect to confirm the impact of applied biostimulants on the improvement of yield and quality parameters of edible parts of model crops included in field trials and to quantify this impact, as well as to evaluate the economic efficiency of the application of verified ecological biostimulants.

Rationale: Use biostimulants in agricultural practice is not always a simple solution when looking for alternative ecological approaches. Their effectiveness and the significance of their use depends on many factors, such as the crops used, the nutrient content of the soil and the physical properties of the soil. On the other hand, the correct form of application, their correct combination, which leads to a significant synergistic effect, significantly increases their effectiveness. The knowledge gained will make it possible to design procedures for the effective

use of selected soil biostimulants based on humic substances, amino acids and soil bacteria with regard to improving the quantitative and qualitative parameters of the production of monitored model crops of horticultural crops while simultaneously having a beneficial effect on the properties of the soil, which are a prerequisite for maintaining or increasing its fertility. Such practices are in line with the philosophy of sustainable agricultural production and minimization of the negative impacts of agricultural land use on the environment. Solving the topic will be part of the activities of the projects currently being solved within research programs with a horticultural focus. The evaluation of selected quantitative and qualitative parameters will take place at the Institute of Horticulture, while the necessary analyzes will be carried out in cooperation with the specialized workplaces of the SUA in Nitra. We assume that the obtained results of the implemented applied research will find wide application in horticultural primary production.

Financial coverage: the topic addressed as part of the external doctoral study will be financially covered by the doctoral student or his workplace and VEGA 1/0406/23 (Ecologization of Horticultural Production via Use of Soil Biostimulants).

Biological and technological conditions of intensification of Persian walnut (*Juglans regia* L.) production.

Supervisor: doc. Ing. Oleg Paulen, PhD.
Workplace: Institute of Horticulture
Field of study: Agriculture and landscaping
Study program: Horticulture
Form of study: external

Theses of the solution: Similarly to the cultivation of other agricultural and horticultural crops in Persian walnut cultivation, not only environmental factors (soil, climate, etc.) play a fundamental role in ensuring production, but also internal factors related to the characteristics of the varieties – growth, habitus, relationships acting in the initiation of generative organs, pollination characteristics, relationships acting in the formation of fruits and their quality, characteristics of fruits, susceptibility to abiotic and biotic environmental factors. An important factor is also the applied cultivation technology aimed at adjusting environmental conditions, as well as the effective use of the production potential of varieties, accelerating the onset of fruiting and extending the production period. The work will focus on the study of the internal prerequisites for the formation of the fruiting capacity of Persian walnut and their use in the modern system of walnut production to increase its efficiency, as well as on the study of environmentally friendly practices to reduce the adverse effects of monocultural walnut cultivation in the orchard system. The output will also include a scientifically justified proposal for cultivation technology elements aimed at achieving a high intensity of Persian walnut cultivation.

Rationale: Persian walnut is a fruit species that has historically been an extensive fruit species in our conditions, and much of the production still comes from plantings of a non-commercial

nature with a large share of subsistence and small-scale sales, which means a lower and less stable level of production, an uneven quality of fruit, and a conservative varietal assortment not corresponding to the growing demands of the market and the requirements for economic indicators of production. Due to the nutritional values of Persian walnut kernels and the growing interest in the consumption of nuts, a significant part of their consumption in the Slovak Republic is covered by imports. In recent years, we have observed an increase in the area of commercial plantings of Persian walnut in Slovakia, so that it has become the fruit species with the largest area of plantings after apple trees. In the case of commercial plantings, the indicator of success is the efficiency of cultivation, which is also a sign of their intensity. The results achieved so far by the little satisfactory cultivation of nuts are the result of little attention paid to this fruit species, minimal use of scientific knowledge in the application of cultivation technology. At the same time, they indicate an under-utilization of the potential of Persian walnut. At the same time, the domestic production of nuts from intensive orchards can contribute to guaranteeing the quality of nuts on the domestic market and to the variety of nut products. Compared to the past, new technological problems are emerging (new pests and pathogens), without the solution of which the effective cultivation of Persian walnut is now inconceivable. In addition to the output in the form of a dissertation, it will provide the education of a specialist in the issue of the production of royal walnut, which is currently absent in the Slovak Republic and growers have to search a qualified advice abroad or, in the worst case, improvise, which does not guarantee good results and effective use of subsidies.

Financial aspects: the topic addressed within the framework of external doctoral studies will be covered financially by the doctoral student or his workplace, which is interested in improving the cultivation technology of Persian walnut.