International Scientific Conference

BioProtection

Global Plant Health And Product Safety

International Scientific Conference

BIOPROTECTION - GLOBAL PLANT HEALTH AND PRODUCT SAFETY

UNIWERSYTET PRZYRODNICZY w Lublinie

Minister of Education and Science

September, 22-24, 2021 Lublin

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PROGRAMME

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Agro II - Lecture room No. 101 (first floor) (Akademicka 15 street, Lublin)			
Hours	Presentation title	Speaker	Institution
14.00–14.30	Opening ceremony	Agnieszka Jamiołkowska	University of Life Sciences in Lublin, Poland
	Speech of Magnificence Rector of the Life Sciences University in Lublin, Poland	Krzysztof Kowalczyk	University of Life Sciences in Lublin, Poland
	Presentation of conference sponsors	Beata Zimowska	University of Life Sciences in Lublin, Poland
14.30–15.00	Mycotoxins: new strategies for old enemies. Aflatox® Project	Francesca Degola	University of Parma, Parma, Italy
15.00–15.30	Food safety in the aspect of agriculture pollution	Elvyra Jariene	Vytautas Magnus University Agricultural Academy, Kaunas, Lithuania
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16.00–16.30	Strategic management of phytopathogens by nanotech	Mahendra Rai	Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
16.30–17.00	Global plant health and natural protection tools	Iryna Matsiakh	Ukrainian National Forestry University, Lviv, Ukraine; National Forestry Agency of Georgia, Tbilisi, Georgia; Ukrainian National Forestry University (Lviv, Ukraine); National Forestry Agency of Georgia (Tbilisi, Georgia)
17.00–17.30	Development and perspectives of biopesticides sector	Damian Strukowicz	Koppert Sp. z o.o., Poland
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10.15–10.30	Antinematicidal potential of *Actinobacteria* isolated from moroccan ecosystems towards *Meloidogyne javanica*	Mustapha Barakate	Cadi Ayyad University – Faculty of Sciences Semlalia, Morocco
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12.00–12.15	Pest Warning System and the E-dwin Project – IT tools for the implementation of decision support systems for plant protection	Magdalena Jakubowska	Institute of Plant Protection – NRI, Poznań, Poland
12.15–12.30	The use of low-temperature plasma to reduce pathogenic fungi inhabiting crops	Marek Kopacki	University of Life Sciences in Lublin, Poland

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Hours	Activity
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10.00–10.30	Coffee break (Agro II – hall ground floor)
10.30–12.00	Visiting of Central Research Laboratory (Głęboka 5 street, Lublin)
12.00–12.30	Summary of the conference (Sale No. 101)
12.30	Lunch
13.00	Departure

SPECIAL GUESTS

Dr Francesca Degola, Associated Professor from Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma (Parma, Italy).

After a master degree in Molecular Biology I earned my PhD in Plant Science and I obtained the title of associated professor of Botany and Plant Science at University of Parma. My scientific research covers different aspects concerning the plant protection: in particular, abiotic stresses such as heavy metal and new generation drug response, and biotic issues linked to phytopathogenic microorganisms. Main topics are connected to mycotoxigenic fungi contaminating agricultural commodities: the study of mycotoxins biosynthesis and metabolism, the characterization of the Aspergillus population colonizing maize fields (including its mycovirome), the development of intraspecific bio-competition strategies to contain aflatoxins contamination, the design and validation of new generation antifungal compounds (both plant-derived and newly synthesized) and the study of their effects on plants growth and development.

Professor Elvyra Jariene from Institute of Agriculture and Food Sciences of Vytautas Magnus University Agricultural Academy (Kaunas, Lithuania).

I completed my PhD from Vytautas Magnus University Agricultural Academy (VMU AA, Kaunas) in Agronomy Science. I'm the director of the Institute of Agriculture and Food Sciences of VMU AA. My scientific research covers safety and quality plant food raw materials. Main topics are related with organic and biodynamic plant food raw materials, the development of functional food products.

Dr Iryna Matsiakh, Associated Professor from Ukrainian National Forestry University (Lviv, Ukraine), National Forestry Agency of Georgia (Tbilisi, Georgia).

My research range is related to forest pathology (tree diseases), partly forest entomology, and forest protection (prevention and control of tree diseases). Research activities are mostly concentrated on epidemiology, biological and ecological features of the tree pathogens, their interactions with tree-hosts. I am curious about studying invasive pests and diseases in the forests and green areas, to learn new diagnostic tools for the detection and investigation of forest tree diseases (molecular techniques) with practical activities in the field (using biological control treatment) to ensure the sustainable development of forests for future generations. I am also in an ideal position to transfer the knowledge related to plant protection to students and forestry specialists. One of the major goals of my career is to develop and promote forest protection science based on my own positive experience and development as a scientist who may inspire and support young people not only in my country.

Professor Mahendra Rai from Sant Gadge Baba Amravati University (Amravati, Maharashtra, India).

I am a professor at UGC – Basic Science Research Faculty and former head of the Department of Biotechnology, Sant Gadge Baba Amravati University (India). Currently, I am visiting scientist at the Department of Microbiology, Nicolaus Copernicus University in Toruń (Poland). My main research interest is green synthesis of metal nanoparticles particularly using fungi and their applications as nanoantimicrobials against pathogenic microbes. My research is highly interdisciplinary and combines microbial biotechnology with nanotechnology. Recently, I was included in the Stanford's list of the top 2% of Indian scientists in nanoscience and nanotechnology.

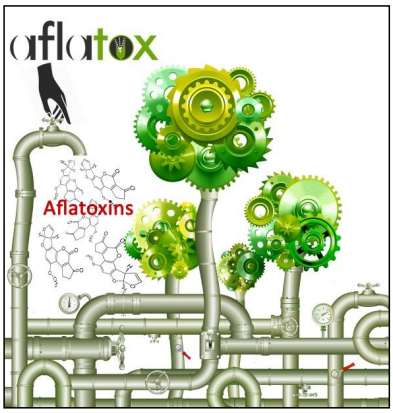
PLENARY PAPERS

MYCOTOXINS: NEW STRATEGIES FOR OLD ENEMIES. AFLATOX® PROJECT

Francesca Degola

Department of Chemistry, Life Sciences and Environmental Sustainability, Parma University, Italy

The control of the fungal contamination on crops is considered a priority by the sanitary authorities of an increasing number of countries, and this is also due to the fact that the geographic areas interested in mycotoxin outbreaks are widening. Among the different pre-and post-harvest strategies that may be applied to prevent fungal and/or aflatoxin contamination, fungicides still play a prominent role; however, despite of countless efforts, to date the problem of food and feed contamination remains unsolved, since the essential factors that affect aflatoxins production are various and hardly to handle as a whole. In this scenario, the exploitation of bioactive natural sources to obtain new agents presenting novel mechanisms of action may represent a successful strategy to minimize, at the same time, aflatoxin contamination and the use of toxic pesticides. The Aflatox® Project was aimed at the development of new-generation inhibitors of aflatoxigenic *Aspergillus* spp. proliferation and toxin production, through the modification of naturally occurring molecules: a panel of 177 compounds, belonging to the thiosemicarbazones class, have been synthesized and screened for their antifungal and anti-aflatoxigenic potential. The most effective compounds, selected as the best candidates as aflatoxin containment agents, were also evaluated in terms of cytotoxicity, genotoxicity and epi-genotoxicity to exclude potential harmful effect on the human health, the plants on which fungi grow and the whole ecosystem.



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FOOD SAFETY IN THE ASPECT OF AGRICULTURE POLLUTION

Elvyra Jariene[1], Honorata Danilcenko[1], Jurgita Kulaitiene[1], Nijole Vaitkeviciene[1], Sonata Trumbeckaite[2]

[1] Vytautas Magnus University Agricultural Academy,
[2] Lithuanian University of Life Sciences, Lithuania

Nowadays, many dedicated agronomy, technology, medical, ecology scientists are looking for ways to grow plants for food in order to obtain a high quality and environmentally friendly crop without harming the soil and man. The link between plant growing system (organic or biodynamic), accumulation of the biologically active compounds in plants and the effect of these active compounds on cellular functions might be important for prevention and treatment of diseases.

The aim of the research to examine the effects of farming systems on the accumulation of biologically active and anticancer compounds of potato tubers with coloured flesh. Specific tasks: i) to investigate the effect of farming systems on biological and agrochemical soil properties; ii) to determine the influence of farming systems on the development of potato plants of different genotypes as well as the yield and quality (including bioactive compounds content and antioxidant properties) of tuber; iii) to investigate the link between farming system-dependent accumulation of biologically active compounds in potatoes and their influence on viability, proliferation and energy metabolism of gastric cancer cells.

The field experiment was conducted in 2018 and 2019 on conventional, organic and biodynamic farms (Lithuania). The effect of farming systems on the accumulation of biologically active compounds of 5 potato cultivars (*Solanum tuberosum* L.) with different coloured flesh was investigated. The fertilization, growing technologies, etc., were used according to the agronomic practices. The standard methods were used to quantify the biological and agrochemical properties of the soil, biochemical compounds in the potato tuber and testing cell viability and proliferation assay.

Different farming systems have different effects on the biological and agrochemical properties of the soil. According to the results (comparing quite different years 2018–2019), the biomass accumulations of microorganisms in the soil in vegetation stages and farming systems fluctuated. As the biomass of microorganisms, the increase or decrease of minerals in the soil reflects the activity of the microorganisms and the ability to decompose organic matter. Apparently, in different climatic conditions, compost had different effects on the activity of microorganisms and enzymes in the soil by promoting nutrient accumulation, therefore the amounts of soil microbiological biomass and soil dehydrogenase activity and other processes had some fundamentally positive different trends. Results demonstrates variation in the content of polyphenols and carotenoids between potato cultivars grown in conventional, organic, and biodynamic farming systems. Higher but not significant

contents of polyphenols (sum), phenolic acids (sum), chlorogenic acid, p-coumaric acid, caffeic acid, carotenoids (sum), lutein, and carotene were determined in the biodynamic potato tubers compared to the conventional ones. Moreover, organically and biodynamically cultivated potatoes (except the Salad Blue cultivar) were essentially richer in flavonoids and anthocyanins. When comparing the cultivars, higher contents of polyphenols (sum), phenolic acids (sum), chlorogenic acid, and p-coumaric acid were found in Tornado tubers. Violetta contained significantly more of flavonoids (sum), anthocyanins (sum), and individual compounds, such as petunidin-3,5-di-O-glucoside, pelargonidin-3,5-di-O-glucoside, and peonidin-3,5-di-O-glucoside. Data reveal the potential inhibiting effect of Tornado (organic) and Laura (biodynamic) on cellular energetic on gastric adenocarcinoma (AGS) cells as well as dose-dependent effect on cell viability and survival.

Funding: This research was funded by Ekhagastiftelsen Grant Foundation Program (Sweden) for application "Effect of farming systems on the accumulation of biologically active and anticancer compounds of potato tubers with coloured flesh" (No. 2017-33).

GLOBAL PLANT HEALTH AND NATURAL PROTECTION TOOLS

Iryna Matsiakh

Ukrainian National Forestry University, Lviv, Ukraine; National Forestry Agency of Georgia, Tbilisi, Georgia

"As the complexity of plant health challenges requires knowledge and specialized expertise that cannot be found in a single country alone, diplomacy for science triggers international multi-disciplinary collaborations to tackle these challenges", said Dr Baldissera Giovani, Euphresco coordinator. "Global phytosanitary research coordination will speed-up harmonization of approaches and reconcile national views to move from the lowest common denominator compromise to a more ambitious vision of international plant health", he added.

Plant health can be described as a broad term that covers a range of variable affects including facing with environmental conditions, mitigating the adverse effects of climate change on plants' ecosystems, fighting with pests and disease, and, importantly, producing food the world's growing population. Humans are strange creatures that care about plants health of primarily because of getting food, raw and building materials from them and interested in obtaining of these products in the largest possible volume and quality, rather than sharing them with insects, snails and fungi. Its known that every day, many ports and airports handle commodities arriving from all over the world or being shipped from there around the world. Thousands of trucks and freight trains cross the borders daily transporting ornamental and forest plants, fruit and vegetables or products made of wood like wood packaging or delivered on millions of wood pallets. There is a lot of private travel and no matter whether increasing awareness and putting information at the airports, train or bus stations, people still bring plants and plant products from abroad home involving the risk of the introduction and spread of plant diseases and pests. The worldwide global trade and tourism may significantly affect economy and ecology of plant ecosystems once plants become a welcome feast for pests or colonized by local or invasive pathogens.

No matter what the actual problem is, importance of plant health is vital to sustainable and profitable crop production, human's food, horticulture and forestry as well as animal feed. To protect future crops or forests, humans mainly use chemicals that not only kill pests but also harm other components of ecosystems and human health. But due to the increased awareness of the impacts of pesticide influencing the environment and human health in the last decades, many countries instituted more resulted efforts to reduce reliance on chemical controls of pesticide, thereby increasing the cost, and decreasing the availability of these tools. The International Year of Plant Health 2020, declared by the United Nations, increased the importance to defend countries against invasive or local plant pests and diseases helping to sustain a vibrant, biologically diverse natural environment.

The biologically or naturally based technologies such as biological control could be more widely used to solve pressing needs in pest management and, in fact, has a long history. Taking about natural protection tools means relies on benefits of nature itself including various natural antagonists against pests and diseases of plants as well as bacteria, fungi, viruses, insects, mites and nematodes that may help to grow healthy plants with ecological balance of plant ecosystems. Nowadays, it is designed about 80 commercially produced beneficial insects and 20 approved biological agents that are available to control diseases and pests.

Plants pests and diseases can interact with natural antagonists in different ways and levels, e.g. molecular, cellular, population and evolutionary level. Many experiments done under controlling conditions in the laboratories and greenhouses or field experiments in many counties and institutions are good examples of human's tries of deeper understanding these interactions in the long term that accelerate development of biological control strategies.

Beneficial insects and mites can parasitize other pests as prey or host and overcome their defense reactions. To use natural enemies to regulate pest populations is one of the famous biological method of plant protection. Such natural enemies of insects that damage trees during their feeding and development are parasitoids, predators and pathogens that that can be easily mass-reared and released. Parasitoids and insect predators are called entomophagous. Insects of Hymenoptera family are mostly parasitoids whose larvae develop on variety of hosts killing and completely consuming them. Insects of Bethylidae, Braconidae, and Pteromalidae families can paralyze and feed on the before laying eggs on it. Several Hemiptera and Coleoptera species are predators which feed on other hosts or their parts while they are still alive. In the process of natural selection, the evolution of the victims was always aimed to avoid to become a lunch for predator. The victim could escape, hide, disguise, gather in large groups. Due to the victim's resist, predators usually prey on old, young or sick individuals, e.g. those whose death will not significantly affect the dynamics of victim populations. But artificial introduction of predators to new habitats for biological plant protection sometimes may have unexpected impact on environmental conditions.

Other microorganisms such as viruses, bacteria and fungi can be used as important plant diseases natural enemies. Well-known bacteria *Bacillus thuringiensis* that can be bought as a commercial product and applied as a spray may kill many types of caterpillar. Unfortunately, this environmentally friendly method to control the spread of box tree moth *Cydalima perspectalis* population in Georgia was failed because of specific climatic conditions of the region and fast development of this invasive pest in a new habitat. Many fungal species so-called endophytes living in plants without pathogenic symptoms are known as natural antagonists of plants pathogens that may control insects and pathogenic fungi development. In forestry, fungus *Phlebiopsis gigantean* that grows on dead wood and old timber rolls is used as biological control agent (commercial product Rotstop) to reduce attacks by root

rot fungus *Heterobasidion annosum* that cause root rot in spruce and pine forests in many European countries with losses in forestry of EUR 50-100 million annually. Dutch Trig® commercial product that contains spores of the fungus *Verticillium albo-atrum* (isolate WCS850) produced in the Netherlands and used as bio-agent for injection of elm trees (30,000 elms in the Netherlands every spring) to protect them from Dutch Elm Disease (*Ophiostoma ulmi* and *Ophiostoma novo-ulmi*). It has also demonstrated its effectiveness as bio-agent in Germany, Sweden, the USA and Canada.

Viruses are organisms that among others the most specific and most environmentally friendly plant protection products at all. They are fully harmless to humans and the environment, effective against certain caterpillars and pathogenic fungi. For example, a mycovirus (*Cryphonectria hypovirus* 1, CHV-1) is used as a successful biological control agent of chestnut blight (ascomycete fungus *Cryphonectria parasitica*) in several chestnut growing regions of Europe. The artificial release of hypovirus by therapeutically treating individual virulent cankers with hypovirus-infected *C. parasitica* strains have started recently in Caucasus region with a big hope for conservation of natural sweet chestnut forests in Georgia (personal experience).

Three basic type strategies (classical biological control, augmentative biological control, conservation biological control) with intentional introduce of the natural enemies and antagonists or strengthen an already existing populations and promoting of natural enemies or antagonists to pests are the main parts of biological control methods used in agriculture, forestry and horticulture. In addition, biological control of pest organisms as natural protection tool is one of the component of integrated pest management in many countries. Despite of having an advantages and disadvantages itself, with a combination of many biological, chemical and physical plant protection approaches it plays a crucial role nowadays, especially when we are facing increasing of global worldwide plant trade, climate changes and looking for any possible eco-friendly solutions to grow healthy crops and plants for horticulture and forestry. Moreover, environmentally friendly plant protection tools may be used on the areas where treatments with synthetic chemical are not allowed like natural forests, protected areas and reserves with high protective status.

STRATEGIC MANAGEMENT OF PHYTOPATHOGENS BY NANOTECHNOLOGY

Mahendra Rai

Department of Biotechnology, Sant Gadge Baba Amravati University, India;
Visiting Professor, Department of Microbiology, Nicolaus Copernicus University in Toruń, Poland

The plant pathogens are known for much percentage of crop loss globally and the global population is increasing with the fast rate. The current global population is estimated to be 7.8 billion which will be 9.6 billion by the end of 2050. To feed such a big population, we need to think of enhanced food production and safer technologies to save the food crops from plant pathogens. The excessive use of agrochemicals as fungicides have generated huge environmental and health problems. Moreover, several fungicides have been ineffective/ less effective as many of the fungal pathogens have developed resistance to these pesticides. In this context, there is a pressing need to search for effective, eco-friendly bio-based alternative technologies for plant protection. In this case, Integrated Disease Management (IDM) is considered to be of the most importance for the management of diseases as it includes biological, physical, chemical and cultural strategies. However, it requires proper technical knowledge and time consuming. Considering these facts, alternative technologies including nanotechnology may provide strategic management of the plant diseases.

Nanotechnology is emerging as a key area in every sphere of life including agriculture. The nanomaterials of size range between 1-100 nm plays vital role in the management of plant pathogens. The plant pathogens such as fungi, bacteria and viruses can be inhibited by the use of nanoparticles. The nanotechnology is enabling technology and have tailor-made controllable activities depending on shape, size, surface charge and site-specific delivery. The nanotechnology can be used for the rapid detection of disease, delivery of fungicides/pesticides and also protection or therapy of crop plants. There are pros and cons of every technology and nanotechnology also has some toxicity issues which needs greater attention before its use.

PARTNERS WITH NATURE

Damian Strukowicz

Koppert Polska Sp. z o.o., Dąbrówka, Poland

The primary purpose of using plant protection products (pesticides) in agriculture is to improve the quality of agricultural crops. These products move in the natural environment. Therefore, not only to protect plants against pests and pathogens, but also to protect the environment and human health, products of natural origin should be used.

The use of natural compounds to control pathogens has great potential. New applications and techniques open up new possibilities in the approach to plant protection. Plant-based extracts/ biostimulants represent a new generation of products and are an environmentally friendly complement to widely used chemicals. Biostimulants and bio-fertilizers allow the maximum use of the potential of plants and increase the resistance of crops.

The enormous potential of using biopreparations is confirmed not only by the research conducted so far, but also by the increase in popularity, and thus the use of biostimulants. Koppert Polska sp.z o.o. provide an integrated system of specialist knowledge and natural, safe solutions that improves crop health, resilience and production. Koppert Biological Systems uses the solutions from nature itself. Together with growers and in partnership with nature, we work to make agriculture and horticulture healthier, safer, more productive and resilient. We achieve this by using natural enemies and micro-organisms to combat pests and plant diseases, bumblebees for natural pollination, and biostimulants that support and strengthen the crops both above and underground.

We firmly believe in the power of nature. Working with nature requires a holistic approach that makes the cultivation of food crops environmentally friendly and free of chemical residue.

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BIOLOGICAL SYSTEMS

ORAL PRESENTATIONS

THE ANTAGONISTIC ACTIVITY OF ENDOPHYTIC DIAPORTHE ERES FROM PRUNUS DOMESTICA AGAINST COMMON PHYTOPATHOGENS

Barbara Abramczyk[1], Anna Marzec-Grządziel[1], Ewa Król[2], Wiesław Oleszek[1]

[1] Institute of Soil Science and Plant Cultivation – State Research Institute, Poland
[2] Department of Plant Protection, University of Life Sciences in Lublin, Poland

Diaporthe Nitschke, and its asexual state *Phomopsis* (Sacc.) Bubak, commonly described as plant pathogens have been reported as one of the most frequently isolated genera of endophytic fungi with worldwide distribution and a wide range of host plants associations. Endophytic *Diaporthe eres* strain was isolated from healthy *P. domestica* shoots during previous studies conducted on fungi from fruit plants in Poland. In present study the antagonistic activity of endophytic *D. eres* against *Alternaria alternata*, *Botrytis cinerea*, pathogenic *D. eres*, *Fusarium avenaceum*, *F. sporotrichioides*, *Trichothecium roseum*, *Verticillium dahliae* was tested using in vitro dual culture assays. After 16 days of incubation the percentage inhibition of radial growth for each pathogen-endophyte combination was calculated.

Dual culture test assay revealed the inhibition percentage of endophytic strain against all tested plant pathogens ranging between 20% (*V. dahliae)* and 40% (*T. roseum*). Although the tests did not show complete growth inhibition of any of the phytopathogens tested, the results obtained indicate the ability of the endophytic *D. eres* to limit the growth of pathogens. There is therefore a need to investigate more isolates of this species for their biocontrol potential as endophytic *D. eres* could be considered as promising option for plant disease management in the future.

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THE EFFECT OF CADMIUM ON CALRETININ EXPRESSION IN THE CLAUSTRUM OF THE RAT AFTER CONSUMPTION THE BEETROOT/CARROT JUICE

Ewa Baranowska[2], Małgorzata Matysek[1], Radosław Szalak[1], Dominik Szwajgier[2], Edyta Kowalczuk-Vasilev[3], Roman Lalak[1]

[1] Department of Animal Anatomy and Histology, University of Life Science in Lublin, Poland
[2] Department of Biotechnology, Microbiology and Human Nutrition, University of Life Sciences in Lublin, Poland
[3] Institute of Animal Nutrition and Bromatology, University of Life Sciences in Lublin, Poland

Cadmium (Cd) is a heavy metal, abundantly present in the environment, which causes toxic effect due to its accumulation in a variety of tissues, including the central nervous system (CNS). The study aimed to assess whether the exposure to cadmium affected the expression of calretinin (Cr) in neurons of the *claustrum* in the rat after the consumption of the freshly pressed beetroot/carrot juice (80:20 v/v, pH 4.0). The juice exerted antiradical, antioxidant, and anti-inflammatory activity due to the presence of polyphenols and betalains.

The *claustrum* is the telencephalic structure that consists of two parts: the *claustrum proper* (Cl) and the *endopiriform nucleus* (EN), which is an important transmitter between many brain structures of almost all mammals and is involved in the cognitive processes. 8-week-old Wistar rats (n = 32) were divided into four equal groups A–D (n = 8). Group A (control) received tap water *ad libitum*; group B – Cd dissolved in 100 ml tap water/day (5 mg/kg bw); group C – beetroot/carrot juice (100 ml/day), whereas group D – Cd dissolved in 100 ml juice/day (5 mg/kg bw). The diet supplemented with Cd and juice was continued for 12 weeks. After the euthanasia, formalin-fixed, paraffin-embedded slides of the brain were made. The sections were immunohistochemically stained with primary polyclonal antibody to Cr (1:1000; Biorbyt, UK) according to the peroxidase-antiperoxidase method (PAP). The obtained results were subjected to statistical analysis (ANOVA).

In groups A and C numerous CR-immunoreactivity (CR-ir) neurons were found in both the Cl and EN. In group B the level of Cr-ir neurons was statistical significantly reduced to 32.4 ±1.2 %. Additionally, in group D, the level of Cr-ir neurons was slightly higher when compared with group B (by approx. 6%). Current research may suggest that main bioactive components from beetroot/carrot juice (polyphenols and betalains) may reduce the toxic effects of cadmium on CNS neurons.

All the procedures involving the use of animals are in accordance with the ethical principles approved by IInd Local Ethical Committee at the University of Life Sciences in Lublin, Poland.

INVESTIGATION OF A HIGH-ALTITUDE ALPINE GRASSLAND: AN AGROECOSYSTEM THREATENED BY CLIMATE CHANGE

Giorgio Chiari[1], Marica Simoni[2], Federico Righi[2], Alessandro Petraglia[1]

[1] Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy
[2] Department of Veterinary Science, University of Parma, Italy

In the Alpine arc, the 25% of territory is occupied by grasslands, that provide both ecological (carbon sequestration) and socio-economic (agriculture, tourism) services, and host many typical quality productions. In high-altitude Alpine areas, grazing is the main form of livestock management. Despite only few data are currently available in the literature regarding the nutritional value and production of high altitude alpine pastures, the realization of comparative studies on such features in these environments is necessary in the perspective of the ongoing climate change. It is well acknowledged that cold ecosystems are the most affected by alterations due to the global warming; modification of climatic variables proved to alter the composition of plant community and could alter the nutritional value of the derived forages.

The purpose of this work is the evaluation of the composition and nutritional value of a high altitude (2600–2700 m asl) grassland dominated by *Carex curvula* All., located in the central Alps, in the Stelvio National Park, under current conditions and in response to the simulation of the conditions foreseen for the near future (reduction of precipitations and increase in temperature). We evaluated the composition of the plant community, the nutritional value and fiber fraction, the protein content, and we calculated their bovine net energy of lactation (NEl).

The latter parameter ranged from 0.82 to 1.64 Mcal/kg (average: 1.23 Mcal/kg) under current conditions while under the simulation for a reduction of precipitations and higher temperature, the NEl ranged from 1.30 to 2.48 Mcal/kg (average: 1.87 Mcal/kg), indicating a positive effect of these conditions on plants nutritional value.

SELECTED RHIZOBACTERIA WITH PLANT GROWTH-PROMOTING CHARACTERISTICS INCREASE *ARABIDOPSIS THALIANA* GROWTH AND ACT AS POTENTIAL BIOCONTROL AGENTS AGAINST PHYTOPATHOGENIC FUNGAL SPECIES

Gianluigi Giannelli, Franco Bisceglie, Beatrice Bonati, Giorgio Pelosi, Francesca Degola, Giovanna Visioli

Department of Chemistry, Life Sciences and Environmental Sustainability, Parma University, Italy

Plant growth-promoting rhizobacteria (PGPR) are commonly indigenous to soil and rhizosphere, and can play a major role in promoting plant growth through both the production of phytohormones and the biocontrol of plant pathogens (thanks to the biosynthesis of antimicrobial compounds). In this work, a selection of 5 culturable PGPRS over a collection of 40 present in our laboratory, that were isolated by different soil environments, have been investigated for their IAA production and ACC deaminase and siderophore activity, as well as for their capacity to stimulate *Arabidopsis thaliana* primary and secondary root growth and increase aerial biomass. In addition, they have been tested *in vitro* for their ability to contain the fungal growth of some phytopathogenic species.

Analytical approaches have been adopted for the identification of the siderophores produced by bacterial strains under iron-limiting conditions, as the presence of siderophores produced by PGPR have shown to alter the microbial communities, contributing to the selection of also several unculturable microorganisms useful for the plant growth; they could enhance the action of plant siderophore in mineral nutrition, and can limit the growth of possible plant pathogens. Results of our study underline significant beneficial effects of two strains, namely NCR_1 and PVR_9, on *A. thaliana* root growth and fresh weight biomass production, while other strains showed an effect on the promotion of secondary roots but have no effect on aerial tissues. In addition, only PVR_5 and PVR_9 were able to suppress fungal growth.

Different molecules were identified by analytical techniques which could be important for plant mineral nutrition and antimicrobial potential in the root-soil interface. Overall, these are promising results for the application of new PGPRS for agricultural purposes, both for biocontrol strategies against plant pathogens and plant biofertilization protocols.

PLATFORM PEST WARNING SYSTEM AND THE E-DWIN PROJECT – AN IT TOOL FOR THE IMPLEMENTATION OF DECISION SUPPORT SYSTEMS IN PLANT PROTECTION

Magdalena Jakubowska[1], Maciej Zacharczuk[2]

[1] Institute of Plant Protection – NRI, Poznań, Poland
[2] Wielkopolska Agricultural Advisory Center, Poznań, Poland

Effective use of information systems in farm management brings a number of benefits, ranging from the most general, in the form of management of the farm as a whole and improvement of information flow, through measurable benefits reflected in the improvement of economic indicators on the farm. The necessary condition for achieving the above-mentioned benefits is the effective implementation of IT decision support systems as an innovative source of knowledge that will serve many interested entities, not only the agricultural producer. The subject of the project with the acronym E-dwin will be the creation of a national IT system for plant protection, which will significantly affect the quality and quantity of food produced in Poland. The system will be a work tool for farmers, support for other food producers and consumers.

The main strategic goal of the project is the implementation on the market of 4 public e-services in the agricultural production, agricultural processing and food sectors, addressed to users of plant protection products, agricultural advisors, food consumers and agro-processing enterprises, local government units, public institutions operating in the field of plant protection. The project responds to the needs related to production efficiency and the quality of plant protection. This article presents the results of two-year research on the implementation of the system in five voivodeship agricultural advisory centers and connection of knowledge and collected field observations posted on the Platform of Pest Warning System

NON-THERMAL PLASMA IN PLANT PROTECTION

Marek Kopacki[1], Joanna Pawłat[2], Piotr Terebun[2], Michał Kwiatkowski[2], Barbara Skwaryło-Bednarz[1], Agnieszka Jamiołkowska[1]

[1] Department of Plant Protection, University of Life Sciences in Lublin, Poland
[2] Institute of Electrical Engineering and Electrotechnologies, Lublin University of Technology, Lublin, Poland

Due to the limitation of the chemical method of plant protection, the physical method is increasingly used. One of the new methods of protecting and supporting plant growth is the use of low temperature plasma. The aim of this study is to evaluate the feasibility of using plasma produced in an atmospheric pressure gliding arc reactor for health and rooting process of 3 plant species.

In the years 2017–2019, experiments were carried out on the effect of low-temperature plasma on fungi and on the effect of plasma on the rooting of *Salix caprea*, semi-woody shoots of *Forsythia* sp., as well as herbaceous shoots of *Chrysanthemum grandiflorum* cuttings. After the application of the plasma with a low-temperature plasma generator produced at the Lublin University of Technology using a combination of two working gases: air and nitrogen at three times: 60 s, 120 s and 300 s. The following morphological features were determined: the weight of seedlings before and after plasma application, the difference the weight of the cuttings, the number and total length of the resulting roots, and the number and total length of the resulting shoots.

The analysis of the tested features showed a difference between the combinations and the greatest impact was in most applications of plasma with air as the working gas at a 300-second application time. The effect of plasma application on the weight gain of seedlings and the rooting process was observed. Another experience was related to the effect of plasma on harmful fungi inhabiting ornamental plants seedlings. It was observed that the most numerous occurrences on the examined willows were *Alternaria alternata*, *Botrytis cinerea* and *Epicoccum nigrum*. In most cases, the longer application time reduced the fungus. Fungal decontamination effect was relatively weaker than with the use of the chemical method with sodium hypochlorite.

DISTRIBUTION AND HARMFULNESS OF *CYDALIMA PERSPECTALIS* (WALKER) IN EUROPE

Izabela Kot, Katarzyna Kmieć, Katarzyna Golan, Edyta Górska-Drabik, Anna Kieruzel

Department of Plant Protection, University of Life Sciences in Lublin, Poland

The box-tree moth (*Cydalima perspectalis* Walker) (Lepidoptera: Crambidae) is an alien, invasive species, which causes damage to horticultural box trees (*Buxus* spp.) in parks and gardens through Europe. The aim of the study was to analyse the course of *C. perspectalis* distribution in Europe and in Poland in particularly, and to assess its harmfulness. The analysis of the expansion of this species in Europe was made after an extensive online search of insect occurrence literature contained in Google Scholar platform that was published between 2005 and 2020. To test distribution of *C. perspectalis* in Poland, we conducted online questionnaire survey and questionnaire experiment (n = 588) to create a map of the pest spread in time. There is no exact information how *C. perspectalis* was introduced from Asia onto Europe. However, it is commonly accepted that it is associated with the international trade in its host plants – box trees.

First occurrence of *C. perspectalis* in Europe was confirmed in Germany in 2007. The analysis of the questionnaire survey indicates that this species could have appeared in Poland as early as 2009. However, the literature data indicate for 2012. First records of *C. perspectalis* occurrence have been established in south Poland and next its range has been expanding northward. Since 2018, there has been sudden spread of this species, which often causing serious hazards for box-trees. Feeding larvae were observed on host plants from March to September. The presence of the pest is usually noticed when the shrubs are visibly damaged (defoliation). According to the literature data, the box-tree moth is a monophagous species inhabiting plants from the genus Buxus. In the regions of origin (China, Japan) larvae also inhabit *Ilex purpurea*, *Euonymus japonicus* and *E. alata*.

POSSIBILITIES OF CEREAL CROPS PROTECTION UNDER ORGANIC RULES

Jolanta Kowalska[1], Joanna Krzymińska[1], Magdalena Jakubowska[2], Jan Bocianowski[3]

[1] Department of Organic Farming and Environmental Protection, Institute of Plant Protection – NRI, Poznań, Poland
[2] Department of Monitoring and Signalling of Agrophages, Institute of Plant Protection – NRI, Poznań, Poland
[3] Department of Mathematical and Statistical Methods, Poznań University of Life Sciences, Poland

In 2021, experiments were beginning toward develop a program for the protection of winter wheat varieties in the organic production system, taking into account varietal suitability and different protection strategies. Causing the changing environmental conditions, field experiments with varieties ('Emil', 'Jantarka', 'Arkadia', 'Torpeda', 'Tytanika', 'Euforia' and 'Kilimanjaro') were established in three different locations. Three protection strategies have been applied, mainly aimed at protection against cereal pathogens. Plants were sprayed with microbiological preparations based on beneficial fungi *Pythium oligandrum*, *Trichoderma harzianum* and bacteria *Paenibacullus polymyxa* DCF B/00052 in three development plants stages – T1 tillering, T2 shooting to the stem and T3 flowering beginning. The strategies included combinations of treatments based on a single microorganism or complex of them.

After performing two protective treatments T1 and T2, observations of plant health were carried out on the basis of the stem as well as flag and under-flag leaves. Symptoms of disease on the leaves were evaluated – the occurrence of brown leaf spot of wheat (*Drechslera tritici-repentis*), leaf rust of wheat (*Puccinia recondita*), septoria leaf spot (*Septoria tritici*). Also symptoms on the base of the stalk were caused by *Fusarium* spp. were assessed. All evaluations were made in accordance with the methodology of the EPPO. Ear health – presence of symptoms of fusarium ear blight (*Fusarium* spp.) and septoria leaf blotch (*Stagonospora nodorum*) were assessed after the T3 treatment. Harvested yield and its quality were verified depending on the applied protective strategies and the variety.

The research was carried out for the Ministry of Agriculture and Rural Development in Poland, financed as part of an earmarked subsidy from the state budget for 2021, for the implementation of the task entitled "Plant protection to ensure the country's food security and food safety", task 2.1. (Badania wykonywane na rzecz Ministerstwa Rolnictwa i Rozwoju Wsi, finansowane w ramach dotacji celowej z budżetu państwa na rok 2021, na realizację zadania pn. „Ochrona roślin dla zapewnienia bezpieczeństwa żywnościowego kraju oraz bezpieczeństwa żywności", zadanie 2.1.)

RELATIONSHIP AMONG GALL MIDGES (*ASPHONDYLIA* SPP.) AND MICROFUNGI

Beata Zimowska[1], Rosario Nicoletti[2,3], Andrea Becchimanzi[3], Ewa Dorota Król[1]

[1] Department of Plant Protection, University of Life Sciences in Lublin, Poland
[2] Council for Agricultural Research and Economics, Research Centre for Olive, Fruit and Citrus Crops, Caserta, Italy
[3] Department of Agricultural Sciences, University of Naples Federico II, Portici, Italy

Relationships between gall midges of the genus *Asphondylia* (Diptera: Cecidomyiidae) and fungi developing on the internal walls of the galls is known since long time. Apart from a trophic hypothesis, it is presumed that the development of the fungus have the function of thickening of the gall wall, ensuring midge protection against biotic and abiotic adversities. Recent joint activities carried out by Polish and Italian research groups concerning *Asphondylia* gall midges and associated fungi on several species belonging to the Lamiaceae yielded the discovery for the first time in Poland of *Asphondylia serpylli* associated with *Thymus vulgaris* and the description of the new species *Asphondylia nepetae* on *Clinopodium nepeta* in Italy. The constant occurrence of *Botryosphaeria dothidea* as the fungal symbiont of midges was confirmed both in Poland and in Italy. It is a cosmopolitan endophytic and serious plant pathogenic fungus mainly known from forest plants, and is listed in many countries as a quarantine organism. The possibility that symbiotic *B. dothidea* strains may belong to a distinct phylogenetic lineage specifically adapted to the gall condition has been considered, but no evidence resulted in this sense till now. Moreover, results of our investigation showed full identity with *B. dothidea* of isolates from galls collected from Lamiaceae, while strains recovered from different plant species worldwide grouped in separated lineages, indicating that population structure is shaped by geographical distance rather than host-plant preference.

During the course of the last few decades, *B. dothidea* has been recognized primarily as an endophyte in dozens of studies, mainly in woody plants where it remains dormant until the onset of stress conditions. Climate change ongoing currently is expected to increase stress on many plant communities, including woody ecosystems and agriculture. Thus, it is possible that symbiotic strains of *B. dothidea* inhabiting inner wall of galls could become a source of infection for woody hosts. Besides this ecological jeopardy, the prolonged saprotrophic or endophytic phase is of particular importance, as it implies that the fungus can easily pass undetected by quarantine systems in galled living plants or other plant parts.

Isolations from galls, as well as from normal flowers of Lamiaceae, also yielded *Cladosporium* spp. in high frequencies. In the past, these fungi were reported as the main inquilines in A*sphondylia* galls on plants belonging to different botanical families. The finding of these fungi in both normal and galled flowers was taken as an indication that they do not have a definite relationship with the midges. Moreover,

identification based on DNA sequencing showed that these isolates are taxonomically heterogeneous and belong to several species which are classified in two different species complexes. Two new species, *Cladosporium polonicum* and *Cladosporium neapolitanum*, were characterized within the *Cladosporium cladosporioides* species complex based on strains from Poland and Italy respectively.

POSTERS

THE IMPACT OF NITROGEN FERTILIZATION ON YIELD AND THE CONCENTRATION OF MACROELEMENTS IN ROOT CHICORY *Cichorium intybus* L. var. *sativum* BISCH.

Bożena Cwalina-Ambroziak[1], Jadwiga Wierzbowska[2], Bożena Bogucka[3]

[1] Department of Entomology, Phytopathology and Molecular Diagnostics, University of Warmia and Mazury in Olsztyn, Poland
[2] Department of Agricultural and Environmental Chemistry, University of Warmia and Mazury in Olsztyn, Poland
[3] Department of Agrotechnology and Agribusiness, University of Warmia and Mazury in Olsztyn, Poland

High quality of vegetables, a group of plants produced intensively, particularly depends on appropriate selection of varieties and suitable mineral fertilization. Root chicory, a dietetic vegetable with nutritional and health-promoting qualities, is a rich source of carbohydrates, fibre vitamins (A, C and group B), lutein (carotenoids), anthocyanins (flavonoids) and minerals. The effect of N fertilization on yield and content of macronutrients in chicory roots was assessed.

In a plot experiment, conducted at the Agricultural Experiment Station in Tomaszkowo near Olsztyn, (in 2016–2018), three root chicory varieties were grown: 'Polanowicka' (Poland), 'Orchies' and 'Chrysolite' (France). Seeds were sown in the last ten days of April, on plots 3.6 m^2 (3 × 1.2 m) in area each, in 3 rows, 15 cm apart in each row, and rows spaced at 40 cm. The experiment was laid out in a randomized subblock design (blocks – levels of fertilization; varieties – subblocks) with three replications. Three levels of topsoil N fertilization were applied (46% urea, single application) before sowing: 0, 80 and 120 kg ha^{-1}. Fertilization also included 73 kg P_2O_5 (46% granulated triple superphosphate) and 115 kg K_2O (60% potash salt) per ha^{-1}. Roots were harvested between 10 and 20 of October. 5 roots were picked at random from each plot. They were washed and cut into 1 × 1 × 1 cm cubes, after which they were freeze-dried and ground in a mill. The content of N, P, K, Ca, Mg and Na was determined in the material mineralized in concentrated H_2SO_4 with added H_2O_2 (N by the Kjeldahl method, P – by colorimetry with the vanadate-molybdate method, K, Ca and Na – by atomic emission spectrophotometry, and Mg – by atomic absorption spectrophotometry), while the S content was determined by nephelometry, following the mineralization of material in a mixture of $HClO_4$ and HNO_3.

The analyzed experimental factors, variety and dose of N fertilization, as well as the weather conditions had an effect on the yield of chicory roots and concentrations of macronutrients contained in roots. Higher root yield produced by the three chicory varieties was obtained in warm and moderately humid growing season of 2018 (57.25 Mg ha^{-1} on average) than in the other years. The highest yield was harvested in 2017 from 'Chrysolite' not fertilized with nitrogen (83 Mg ha^{-1}). The average

mass of roots of this variety was 62.25 Mg ha^{-1}. Roots of the variety 'Polanowicka' were found to have the highest content of N and K (in the fertilization variant 120 kg N ha^{-1}), Ca and Mg (80 kg N ha^{-1}) and S (0 kg N ha^{-1}). The variety 'Chrysolite' accumulated most P (80 kg N ha^{-1}), while 'Orchies' accumulated most Na (120 kg N ha^{-1}). Higher concentration of macronutrients was determined in roots harvested from the plots fertilized with 80 and 120 kg N ha^{-1} than ones with 0 kg N ha^{-1} (no fertilization). The above data confirm the average concentrations determined for the varieties and N fertilization doses.

The weather and genetic component mostly shaped the qualitative yield of chicory roots; the highest yield was obtained in 2018 from the variety 'Chrysolite'. An increase of the N dose above 80 kg ha^{-1} did not increase root yield/ Roots of the 'Polanowicka' variety had better quality, i.e. higher content of macronutrients, except Na. N fertilization improved nutritive value of roots.

A RESPONSE OF *ALTERNARIA ALTERNATA* TO BIOTECHNICAL PREPARATIONS

Joanna Dłużniewska

Department of Microbiology and Biomonitoring, University of Agriculture in Kraków, Poland

Alternaria alternata (Fr. Keissl.) is a fungal pathogen causing leaf spot, rots and blights on many plant parts on over 380 host species of plants. It caused serious losses in the yield. Disease management strategies including rotation with non-host crops and sanitation are not entirely satisfactory since the fungus is primarily airborne, has long survival ability in plant debris, and has a wide host range. Fungicide treatments are the most effective way to control the disease to a non- damaging level. Typically, fungicides are applied starting from two weeks after transplanting until two weeks before harvest at two to three week intervals. Such heavy use of chemicals is not economically feasible for the generally resources-limited growers. However, the widespread use of chemicals in agriculture has been a subject of public concern and scrutiny due to their potential harmful effects on the environment, their undesirable effects on non-target organisms, development of resistant races of pathogens and possible carcinogenicity of some chemicals. For this reason, recent efforts have focused on developing environmentally safe, long lasting and effective biocontrol methods for the management of plant disease.

The aim of the present study was to examine the effect of natural substances such as garlic extract, grapefruit extract, vermicompost extract, and chitosan on mycelial growth, conidia germination, and biological activity of *A. alternata*. The effect of the substances on *A. alternata* linear growth was examined *in vitro* with the poisoned medium method. To investigate the effect of the natural substances on conidia germination of *A. alternata* were each placed microscope slide with the addition of respective substances. The biotic correlations between *A. alternata* pathogen and *Trichoderma viride* antagonistic fungus were defined with the biotic series method.

It was found that the tested substances inhibited mycelial growth and conidia germination of *A. alternata*. Among the tested natural substances, vermicompost extract and grapefruit extract showed the strongest inhibitory effect. At the all experimental concentration, all biological substances, contrary to the fungicide, had a positive effect on the relationship between *A. alternata* and *T. viride*.

NEW DATA ON DISTRIBUTION AND LIFE CYCLE OF *COMSTOCASPIS PERNICIOSA* COMST. (HEMIPTERA; COCCOMORPHA; DIASPIDIDAE)

Katarzyna Golan, Izabela Kot, Katarzyna Kmieć, Edyta Górska-Drabik

Department of Plant Protection, University of Life Sciences in Lublin, Poland

San José scale is a key pest of orchards almost all over the world, found on the list of quarantine pests in many countries. In a short time, it can lead to the death of plants on which it feeds. In Poland, the first outbreaks of *C. perniciosa* were detected in the years 1948–49 in several towns near Wadowice. In 2015 San José scale was found near Opole Lubelskie in the Lublin Voivodeship. Since then, the pest has significantly increased their population. It was observed in many orchards in Mazovia and Sandomierz region. Currently, there is still no San José scale management in Poland.

The most important factor to control *C. perniciosa* population is to determine an optimum date of pesticide application because the only stage that is sensitive to treatments is first-instar nymph (crawler). This pest species may undergo from one to five generations per year depend on the climate. Our observations conducted in 2016–2021 in the Lublin Voivodeship have shown the occurrence of two complete generations during the year. Theses generations overlap so all stages of the pest occur at the same time during the summer. The first generation of crawlers appears between early and mid-June and the second in mid-August. A second generation of adults appears during the beginning of August. Usually San José scale individuals overwinters in the black cap stage, however different stages may entered hibernation. Our study also showed if warmer temperatures continue into the fall, a third generation of San José scale can begin late September.

The obtained results creates a database for the San José scale management not only in Poland, but also in countries with similar climatic conditions.

MULTIFUNCTIONAL LIVING MULCHES FOR WEEDS CONTROL IN ORGANIC APPLE ORCHARDS

Joanna Golian, Zbigniew Anyszka, Joanna Kwiatkowska

National Institute of Horticultural Research, Skierniewice, Poland

The studies were carried out in the years of 2019–2020 at the National Institute of Horticultural Research in Skierniewice. The suitability of various multifunctional living mulching species grown in the rows of an organic apple orchard to control weed infestation was assessed for two years. Living mulch species included herbs (*Alchemilla vulgaris, Mentha piperita, Tropaeolum majus*), fruits and vegetables (*Fragaria vesca, Cucurbita maxima*), which, besides weed control, can provide additional income as second cash crop and ecosystem services such as pollination, soil phytoremediation and improved soil biodiversity.

All living mulch species limited weed infestation, but to a different extent and with a diverse seasonal efficacy. Two perennial living mulch species, mint and wild strawberry, as well as the annual nasturtium were most strongly limiting weeds growth during the whole growth season. Even though soil cover by weeds was dominated by few perennial (e.g. *Equisetum arvense* and *Taraxacum officinale*) and annual weeds (e.g. *Lamium purpureum, Stellaria media, Galinsoga parviflora, Capsella bursa-pastoris* and *Poa annua*), irrespective of the living mulch species, a certain modification of weed population was noticed after two years of living mulches establishment. Results are discussed in view of the different mechanisms of weed control that could be used by the different living mulch species considering also their usefulness for a functional weed management strategy.

EFFECT OF *SINAPIS ALBA* L. AS AN INSECTARY PLANT ON THE OCCURRENCE OF *APHIS FABAE* SCOP., COCCINELLIDAE AND SYRPHIDAE IN BROAD BEAN

Janina Gospodarek, Elżbieta Boligłowa

Department of Microbiology and Biomonitoring, University of Agriculture in Kraków, Poland

Introducing insectary plants along with principal crops is an effective way to increase the biological diversity of beneficial insects and improve the stability of ecological equilibrium in agrocenoses and could be an alternative to chemical plant protection, particularly in organic farming. The goal of this study was to determine the effect of white mustard as a companion plant in broad bean cultivation on the occurrence of *Aphis fabae* Scop., Syrphidae, and Coccinellidae. The study also aimed at finding the optimum row separation of broad bean plants. It also evaluated the effectiveness of the thinning of mustard in a specific time to eliminate excessive competition with the main crop.

Field experiments were conducted in 2014–2017 in the Experimental Stations of the Agricultural University in Prusy near Kraków. Broad bean of the Bartek variety was cultivated in companion planting with white mustard of the Bardena variety with different row spacing. In 2014 (in which preliminary experiment was conducted), the shortest distance between the rows of broad bean plants in companion planting measured to 50 cm, the moderate distance between the rows was 65 cm, and the highest distance was 80 cm. White mustard was sown as a row in the midway between two broad bean rows. As it was observed in 2014 that white mustard was competitive toward broad bean, in the following years (2015–2017), in which main experiment was conducted, the shortest distance (50 cm) was eliminated and only row spacing of 65 and 80 cm was applied. Additionally, when the broad bean plants reached the phase of flower bud formation, half of the plots in which mustard was cultivated as a companion plant were thinned (every other mustard plant was uprooted).

The results showed that white mustard contributed to significant suppresion of *A. fabae* abundance on broad bean (to the level similar as with the use of chemical protection). *S. alba* contributed to an increased abundance of hoverflies and lady beetles on broad bean despite the relatively low abundance of their prey, i.e. aphids. The most appropriate distance between broad bean rows when white mustard was introduced was 65 cm, with the concomitant conduct of mustard thinning when the broad bean plants reached flower bud formation.

EFFECT OF *ACHILLEA MILLEFOLIUM* L. ESSENTIAL OILS ON *ACROBASIS ADVENELLA* (ZINCK.) CATERPILLARS

Edyta Górska-Drabik[1], Katarzyna Golan[1], Cezary Sempruch[2], Michał P. Dybowski[3], Izabela Kot[1], Katarzyna Kmieć[1], Katarzyna Dzida[1], Paweł Czerniewicz[2]

[1] Department of Plant Protection, University of Life Sciences in Lublin, Poland
[2] Department of Biochemistry and Molecular Biology, University of Natural Sciences and Humanities in Siedlce, Poland
[3] Department of Chromatography, Institute of Chemical Sciences, Maria Curie Sklodowska University in Lublin, Poland

The solutions of essential oil (0.5%, 0.8% and 1.0% w/v) derived from *Achillea millefoilum* L. were evaluated for their repellent and insecticidal activity towards *Acrobasis advenella* (Zinck.) and for their effects on the activity of selected enzymes of larvae tissues.

The chemical composition of the EO was determined by GC–MS analysis. The main compounds in this oil were β-pinene, chamazulene, eucalyptol and β-caryophyllene. The choice tests showed that larvae avoided inflorescences treated of 0.8% i 1.0% EO. Our study also showed an increased mortality of larvae and a decrease in the percentage of pupation of *A. advenella*. The mortality of larvae increased with concentration and time of exposure to the EO. The highest mortality observed after 72 hours (57,8%).

In addition, the effects of the yarrow EO on the activity of catalase (CAT), polyphenol oxidase (PPO), peroxidase (POX), and α- and β-glucosidases, which are important antioxidants, detoxification enzymes and digestive enzymes, were examined. The activity of enzymes varied depending on the applied concentrations of tested oil and exposure time. We found a significant increase in CAT activity in larvae feeding on inflorescences treated with 0.8% and 1% *A. milifolium* EO both after 24 and 48 hours. Treatment of larvae 0,5% EO decreased in β-glucosidase activity and at the same time increased in α- glucosidase. The present results also showed that the 0.8% EO inhibited the activity of the POX.

The obtained results suggest that *A. millefoilum* EO can affect important biochemical processes within tissues of *A. advenella* larvae and can be useful in protecting crops of black chokeberry.

EFFECT OF METHODS OF WEED CONTROL ON THE CONTENT OF TOTAL AND PROTEIN NITROGEN IN POTATO TUBERS

Marek Gugała[1], Krystyna Zarzecka[1], Anna Sikorska[2], Iwona Mystkowska[3]

[1] Institute of Agriculture and Horticulture, University of Natural Sciences and Humanities in Siedlce, Poland
[2] Department of Agriculture, Vocational State School of Ignacy Mościcki in Ciechanów, Poland
[3] Faculty of Health Sciences, Pope John Paul II State School of Higher Education in Biała Podlaska, Poland

Modern agriculture poses new challenges for farmers, one of which is the need to produce ”safe” and ”organic” food. The idea of protecting biodiversity, the natural environment and the consumer is becoming more and more popular and leads to the search for various methods of growing plants while reducing the pressure on the surrounding natural environment. The objective of the research was to determine the effect of herbicides and biostimulants on the content of total nitrogen, protein nitrogen and nitrogen uptake by tubers of three edible potato cultivars.

Research results were obtained in a three-year (2012–2014) field experiment carried out in central-eastern Poland. The experiment was set up as a split-plot arrangement with three replicates. The factors were as follows: factor I – three medium-early table potato cultivars – Bartek, Gawin, Honorata, factor II – five methods of application of herbicides and biostimulants: (1) control object – mechanical weeding – without herbicides and biostimulants, (2) mechanical-chemical weeding and 7–10 days after planting the tubers Harrier 295 ZC (linuron + clomazone) herbicide – 2.0 dm^3 ha^{-1}, (3) mechanical-chemical weeding and 7–10 days after planting the tubers Harrier 295 ZC (linuron+ clomazone) herbicide – 2.0 dm^3 ha^{-1} + at the end of plant emergence Kelpak SL biostimulant – 2.0 dm^3 ha^{-1}, (4) mechanical-chemical weeding and just before emergence Sencor 70 WG (metribuzin) herbicide – 1.0 kg ha^{-1}, (5) mechanical-chemical weeding and just before emergence Sencor 70 WG (metribuzin) herbicide – 1.0 kg ha^{-1} + Asahi SL biostimulant 1.0 dm^3. Total nitrogen content was determined in the dry weight of tubers using the Kjeldahl method on a 2300 Kjeltec Analyzer Unit. The results of the three-year study were subjected to the variance analysis and the significance of the differences between the mean was determined by the Tukey's test method at the significance level of $p \leq 0.05$.

Chemical analyzes have shown and statistical calculations have confirmed a significant effect of cultivars, biostimulants and weather conditions in the years of the research on the content of total and protein nitrogen in tubers and on nitrogen uptake by potato tubers. The cultivars grown in the field experiment differed in terms of the accumulation of the discussed components. The Bartek variety was characterized by the highest content of total and protein nitrogen, and the Honorata variety was characterized by the highest nitrogen uptake by potato

tubers. Tubers of plants sprayed with herbicides in combination with biostimulants were characterized by higher nitrogen and total and protein content. The weather conditions in the years of the research were the factor shaping the content of the discussed components.

ASSESSMENT OF TOXICITY IMPACTS OF CHEMICAL PROTECTION OF WINTER WHEAT IN DIFFERENT TILLAGE SYSTEMS

Małgorzata Holka, Jerzy Bieńkowski

Institute for Agricultural and Forest Environment, Polish Academy of Sciences, Poland

The aim of the study was to assess the potential toxicity impacts of the application of plant protection products on aquatic ecosystems and humans. The analysis was based on the data on chemical protection of winter wheat (*Triticum aestivum* L.) in the following soil tillage systems: conventional tillage, reduced tillage and no-tillage. The study was conducted in 2015–2017 on 15 farms, located in the Wielkopolska region, Poland. Routes and amounts of environmental emissions were determined using the model PestLCI 2.08. These results constituted inventory data in the studies by the life cycle assessment (LCA) method. The characterization model USEtox 2.02 was used to assess the freshwater ecotoxicity potential (FETP) and the human toxicity potential (HTP), including carcinogenic and non-carcinogenic effects.

Assessment of environmental emissions from plant protection showed that the largest amounts of active substances were available for leaching and surface runoff. Emissions to the air and groundwater were smaller. The results showed that the total freshwater ecotoxicity and human toxicity impacts were associated with physico-chemical properties and toxicity of individual active substances.

The study was carried out in the frame of the research project funded by the National Science Centre, Poland. Project no 2015/19/N/HS4/03031.

LABORATORY EFFECT OF FUNGISTATIC ACTIVITY OF SOME PLANT EXTRACTS ON PHYTOPATHOGENIC FUNGI

Agnieszka Jamiołkowska[1], Weronika Kursa[1], Barbara Skwaryło-Bednarz[1], Radosław Kowalski[2], Jakub Wyrostek[2], Elżbieta Patkowska[1], Elżbieta Mielniczuk[1], Marek Kopacki[1]

[1] Department of Plant Protection, University of Life Sciences in Lublin, Poland
[2] Department of Analysis and Food Quality Assessment, University of Life Sciences in Lublin, Poland

The aim of the research was the laboratory evaluation of fungistatic effect of alcohol extract of some herbal plants on the growth of selected phytopathogenic fungi. The research material consisted of above-ground part of horseradish (*Armoracia rusticana* L.), yarrow (*Achillea millefolium* L.) and tansy (*Tanacetum vulgare* L.) collected before flowering, from natural sites located in Lublin (Lublin Province, Poland). In the experiment, various concentrations of plant extracts (5%, 10%, 20%) were tested for the growth of *Alternaria alternata* (strain PCL10), *Botrytis cinerea* (strain CH10), *Colletotrichum coccodes* (strain P74/2) and *Fusarium oxysporum* (strain ECR4).

Alcohol extracts from tansy and yarrow leaves had a higher concentration of flavonoids (in conversion to epicatechin equivalent EE, 22.3 mg/ml; 23.1 mg/ml), polyphenols (in conversion to gallic acid equivalent GAE, 36.9 mg/ml; 37.4 mg/ml) and were characterized by higher antioxidant activity (in conversion to mM of Trolox; 59.4 mM; 63.1 mM) than the corresponding horseradish extract (sequentially 1.2 mg/ml; 20.8 mg/ml; 3.1 mM). Plant extracts limited the growth of fungi to a varying degree, depending on the fungus species, the type of extract, its concentration and duration of activity. The strongest fungistatic effect of alcohol extracts was recorded on the 4th day of the experiment against *Alternaria alternata* and *Botrytis cinerea* in the case of 20% tansy extract (Aa – 39.1%, Bc – 37.1%) and 20% yarrow extract (Aa – 23.1%, Bc – 59.6%). The weakest fungistatic effect was shown after application of horseradish leaves extract for all fungal strains. The fungistatic activity of the extracts decreased with time. The weakest fungistatic effect of the extracts was recorded against *Botrytis cinerea*, where the extracts inhibited the linear growth of the fungus only in the first days of the experiment. The fungistatic activity of the herbal plant extracts depended on the content of biologically active compounds.

ROLE OF MYCORRHIZAE IN SUSTAINABLE AGRICULTURE

Agnieszka Jamiołkowska, Weronika Kursa, Barbara Skwaryło-Bednarz

Department of Plant Protection, University of Life Sciences in Lublin, Poland

Xenobiotic pollutants accumulate in the environment as a result of agriculture chemicalization. Uncontrolled leakage of contaminants into food poses a great threat to consumer health. Chemicals in agriculture are one of the significant ecological stresses also faced by plants, as they can block their enzymatic systems, contribute to physiological changes, which is often associated with tissue and cell death. One of the strategies is to promote and implement sustainable or organic farming. Biological control (BC) has become one of the most widely applied alternatives to pesticides for pest and disease control in agriculture production. It reduces the risks posed by chemicals to the environment and human health and increasing development of resistance by plant pests to these chemicals (Elliott et al. 2009). BC has become one of the most widely applied alternatives to pesticides for pest and disease control in agriculture production. Antagonistic microorganisms and mycorrhizal fungi (MF) are of great importance among biological protection agents, and their application in sustainable and organic agriculture is becoming increasingly popular (Mahmood and Rizvi 2010). Mycorrhiza plays a significant role especially as a factor limiting biotic and abiotic plant stresses, thereby indirectly contributing to reducing the consumption of agrochemicals, e.g. pesticides (Wang et al. 2012, Jamiołkowska et al. 2018). Mycorrhiza is an old and ubiquitous symbiosis formed between a relatively small group of soil fungi and higher plant roots and affects host plants in several aspects of their growth (physiology, phytopathology, biochemistry). MF have the potential to influence the economic benefits of agricultural systems through both direct and indirect processes related to plant nutrition (Smith and Smith 2012). MF provide plants with access to soil nutrients, protect against diseases and toxicities and play other roles such as soil aggregation, plant protection against drought stress and soil pathogens, as well as increasing plant diversity. MF interact with most crop plants, including cereals, vegetables and fruit trees, and are therefore receiving increasing attention due to their potential use in sustainable agriculture. Not only can MF improve soil and plant health, but it can also alter the accumulation of contaminants in plants. The benefits and mechanisms behind MF's role in ameliorating organic contaminant residues in crops can be summarized as follows: (1) increased biomass through improved mineral nutrition and water availability, (2) alleviation of oxidative stress induced by contaminants, (3) enhanced activity of contaminant degradation-related enzymes, (4) accumulation and sequestration of contaminants by AMF structures, (5) stimulation of contaminant-degrading microorganisms in soil, (6) improved soil structure, and (7) reduced pesticide application due to increased crop resistance to pathogens and improved competition with weeds.

Finally, future challenges and perspectives regarding MF's contribution to crop safety are proposed (Wang et al. 2012).

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THE RESISTANCE OF THE SELECTED SOYBEAN CULTIVARS TO THE OCCURRENCE OF CHOSEN FUNGAL DISEASES

Agnieszka Klimek-Kopyra[1], Anna Ślizowska[1], Andrzej Oleksy[1], Elżbieta Boligłowa[2]

[1] Department of Agroecology and Plant Production, Agricultural University of H. Kołłątaj in Kraków, Poland
[2] Department of Microbiology and Biomonitoring, Agricultural University of H. Kołłątaj in Kraków, Poland

More than 300 species of pathogens attack soybean worldwide, although relatively few cause significant economic damage. It is believed that soybean diseases are not a major threat in Poland. Nevertheless, diseases that mostly occur on soybean plants include: root-rot, ascochytosis, anthracnose, septoriosis – brown spot, fusariosis (root and wilting), cercospora leaf blight, purple seed stain and fusary browning of pods. The current goal of Polish scientists is to best adapt soybean varieties to the climatic conditions of Poland, while obtaining and maintaining high fertility and good disease resistance. To choose the right variety for cultivation, it is needed to use the Description List of Varieties, which is available on the Research Centre for Cultivar Testing (COBORU) website. Currently, 32 cultivars are registered in it. The aim of this study was to assess the resistance of the selected soybean cultivars of various maturity groups to the occurrence of chosen fungal diseases on soybean plants.

Two-years (2017–2018) field experiment was carried out at the Experimental Station in Prusy of the Agricultural University of H. Kołłątaj in Krakow. The research analysed one-factorial experiment in a randomized block system. 8 varieties of soybean (Abelina, Aligator, Augusta, Erica, Lissabon, Mavka, Merlin and Sultana) was used to verified plant health and plant productivity. The severity of disease was evaluated on 25 randomly taken plants from the plot. Diseases such as root-rot (*Fusarium* spp.), pustular bacteriosis (*Xanthomonas campestris* pv. *glycines*), leaf ascochytosis (*Ascochyta* spp.), leaf fusariosis (*Fusarium oxysporum*), fusary browning of pods (*Fusarium* spp.) and bacterial blight of soybean (*Pseudomonas syringae* pv. *glycinea*) were evaluated. Plant health status was assessed on a 9-point scale, according to the COBORU methodology. Based on the research, it was found that soybean plants were infected by: pustular bacteriosis, ascochytosis, root-rot, fusariosis, fusary browning of pods and bacterial blight of soybean. Tested plants of soybean cultivars showed significant differences in the severity of ascochytosis and fusary browning of pods. The development of ascochytosis varied significantly in 2017. The most affected cultivars were Lissabon (7.95°) and Augusta (7.98°). Significant differences in the infection of plants with fusary browning of pods were noted in both years of research in all cultivars. The largest infection (7.70°) was noted in 2018 for Erica cultivar. Very-early and early maturing cultivars tend to give scientifically significantly smaller yields than cultivars from mid-early and

mid-late group, regardless the weather conditions. Cultivar Merlin gives high, stable yields regardless the temperature and precipitation conditions. Cultivar Merlin is more resistant to the infection by *Fusarium* spp., causing a root rot disease, in conditions of warm and wet weather (2017), when compared to dry and warm conditions (2018).

THE KEY METHODS SUPPORTING TIMING DECISIONS FOR *COMSTOCASPIS PERNICIOSA* COMST. MANAGEMENT

Katarzyna Kmieć[1], Katarzyna Golan[1], Izabela Kot[1], Edyta Górska-Drabik[1], Hubert Sytykiewicz[2]

[1] Department of Plant Protection, University of Life Sciences in Lublin, Poland,
[2]Institute of Biological Sciences, Siedlce University of Natural Sciences and Humanities, Poland

San José Scale (SJS), *Comstocaspis perniciosa* (Comstock) syn. *Quadraspidiotus perniciosus* (Hemiptera: Diaspididae) is a cosmopolitan invasive species, recognized in many countries of the world as one of the most dangerous pests of fruit crops. It can injure fruit directly and can also reduce tree vigour by removing sap, eventually killing the tree. SJS female produce crawlers which are mobile and actively move around the plant, finally settle on the bark, leaves and fruit. A single female produces up to 500 crawlers. The most important problem in SJS management is determining the appropriate date of control, because timing of sprays against crawlers is not always successful.

The objectives of the study were to: 1) assess the life cycle of SJS in Poland, 2) test the effectiveness of various methods of SJS monitoring to assist key management timing decisions for this pest. The experimental work was carried on for two years 2019–2020 in an untreated apple orchard situated in Wojciechów near Opole Lubelskie (Poland). SJS male flight activity was monitored using pheromone traps. Crawlers were sampled using sticky tape traps. All life stages were also identified and counted on branches gathered once a week from March to October each year. Temperature data were collected from a weather station located near the orchard. First and peak adult and crawlers appearance were plotted over seasonal degree-day (DD) accumulations above a base of 10.6ºC.

Insect activity was changed each year according to the course of weather conditions, thus the treatments effectiveness depends upon timing of sprays based on adult male flight and monitoring of crawler activity. In order to precise determine the time of spraying it is necessary to know the male date flight period starts and the time period of crawlers activity. These periods can be accurately predicted on the basis of the daily temperature readings. The key methods supporting timing decisions were pheromone traps for *C. perniciosa* males and searching for crawlers directly on the shoots. Sticky traps were of little use, especially with less frequent occurrence of the first generation larvae.

EFFECT OF PREPARATIONS BIOSAR AND BETA-CHIKOL ON GROWTH AND SPORULATION OF *BOTRYTIS CINEREA* AND *FUSARIUM* SPP.

Ewa Dorota Król, Beata Zimowska

Department of Plant Protection, Subdepartment of Phytopathology University of Life Sciences in Lublin, Poland

Botrytis cinerea and fungi of the genus *Fusarium* belong to dangerous pathogens of many plant species. The aim of studies was investigate the effect of plant growth stimulants Biosar (based on grapefruit extract) and Beta-Chikol (based on chitosan) on *in vitro* growth of *Botrytis cinerea, Fusarium culmorum, F. oxysporum* and *Neocosmospora solani*. Commercial preparations were added to malt extrat agar (MEA) to obtain the suitable concentrations within the ranges recommended by the producers, which were 0.05%; 0.075%; 0.1% for Biosar and 1%; 2%; 2.5% for Beta-Chikol. Such prepared substrate was poured into 85 mm Petri dishes and inoculated with 3 mm mycelial disk of appropriate fungus species. Measurements of the growth of fungal colonies were taken after 4 and 8 days of incubation. Antifungal activity was determined by comparing the fungal growth on the substrates containing preparations with the control one (without the addition of preparations).

The results showed that influence of the studied compounds was differentiated and depended on the preparation, its concentration, time and fungal species. Generally, the diameters of the *B. cinerea, F. culmorum, F. oxysporum* and *N. solani* colonies decreased with increasing concentration of the preparation. After 4 days of the experiment, higher antifungal activity against these fungi was observed for Biosar than for Beta-Chikol, as indicated by higher percentages of colony growth inhibition of 3 species of fungi, i.e. *B. cinerea, F. oxysporum* and *N. solani*. Only in the case of *F. culmorum* stronger growth inhibition by Beta-Chikol than by Biosar was showed. However, the opposite situation was observed after 8 days of culture. The former preparation reduced the growth of colonies of all tested fungi less than the latter one. Simultaneously negative changes in the macroscopic appearance of the colony as well as in the morphological structures of fungi growing at higher concentrations of Biosar and Beta-Chikol was observed. All species of examined fungi formed poorer aerial mycelium, their hyphae were usually deformed and sporulation weaker compared to the control. The fact that Biosar and Beta-Chikol preparations are safe for environment, stimulate plant growth and simultaneously to a greater or lesser extent inhibit the growth and sporulation of the tested plant pathogens *in vitro*, proves that they may be an effective alternative to synthetic fungicides and may be useful in Integrated Disease Management.

INFLUENCE OF VARIETY AND CLIMATIC FACTORS ON THE HEALTH OF TULIPS

Barbara Marcinek[1], Marek Kopacki[2], Barbara Skwaryło-Bednarz[2], Mariusz Szmagara[1], Agnieszka Jamiołkowska[2]

[1] Institute of Horticultural Production, Subdepartment of Ornamental Plants and Dendrology, University of Life Sciences in Lublin, Poland
[2] Department of Plant Protection, University of Life Sciences in Lublin, Poland

The three-year studies (2014–2016) was conducted in the conditions of Lublin (south-eastern Poland). They included 9 varieties of tulip from different groups: 'Jan Reus', 'Findel', 'Maja', 'Winter Gold', 'Belica', 'Mount Tacoma', 'Golden Age', 'Mrs Moon', and 'Claudia'. The tests were carried out at the beginning of flowering (end of April) from above-ground and underground parts of plants, in the form of leaves and bulbs showing symptoms of disease, and after flowering (beginning of July) in the form of bulbs showing symptoms of disease. Symptoms of infection in the plots concerned from 12 to 42% of plants. Each year, plants with disease symptoms of stem and leaves and root rot were subjected to mycological analysis.

Tulip stems, leaves and bulbs were colonized to a large extent by *Penicillium verrucosum* var. *cyclopium*, *Alternata alternaria*, *Fusarium avenaceum* and *Fusarium oxysporum*. The number of *Botrytis tulipae* colonies from tulip bulbs was much greater than that from above-ground parts of plants. Soil and air temperature as well as the amount of rainfall can significantly affect the health of tulips. This is especially important when the soil is not frozen during the winter months. This was recorded in the 2013/2014 season, when the soil froze at the beginning of the 3rd decade of January and thawed already in mid-February, and the snow cover lasted only 11 days. In this season, very high amounts of rainfall were recorded in November and January, and in May the amount of rainfall was tripled. exceeded the perennial average, which had a large impact on the infestation of shoots and leaves by *Botrytis tulipae*. In the 2013/14 and 2015/16 season, tulips bloomed very early and were low, they also produced the lowest yield of daughter bulbs. In the 2015/16 season air temperatures in the autumn, winter and spring months significantly exceeded the long-term average (in November by 2.9°C, in February by 6.2 °C in March by 3.0°C), with a simultaneous high amount of rainfall from November to the end of December on non-frozen soil, as well as in February (the soil thawed at the end of the first decade of this month) and March it limited the access of air to the root system and could have the effect of significant infection of bulbs by fungal pathogens, as well as root rot. The most susceptible to infection by fungi were the 'Maja' and 'Belica' tulip cultivars, while the least 'Winter Gold' and 'Mrs Moon', which should be included in plantings in urban areas.

PATHOGENICITY OF *FUSARIUM* SPP. TO SELECTED TURFGRASS SPECIES

Elżbieta Mielniczuk, Elżbieta Patkowska, Agnieszka Jamiołkowska

Department of Plant Protection, University of Life Sciences in Lublin, Poland

Diseases caused by fungi are one of the factors reducing the quality of lawns. *Fusarium* spp. are important pathogens damaging turfgrasses, which are often carried with the sowing material.

The research included mycological analysis of the sowing material of eight turfgrass cultivars belonging to four species: *Festuca rubra* L., *Festuca ovina* L., *Lolium perenne* L. and *Poa pratensis* L. One hundred kernels randomly chosen from 40 g samples were analyzed for each cultivar. The plate method was applied to isolate the fungi colonizing the sowing material. Fungi isolates belonging to 24 species and non-sporulating forms were obtained as a result of the mycological analysis of turfgrass kernels. Among pathogenic fungi, the following species were obtained: *Fusarium avenaceum, F. culmorum, F. crookwellense, F. equiseti, F. poae, F. sporotrichioides*, *Microdochium nivale, Botrytis cinerea, Bipolaris sorokiniana, Pyrenophora biseptata, Pyrenophora lolii* and *Rhizoctonia solani*.

The studies on the harmfulness of three *Fusarium* species (*F. avenaceum* No 70*, F. crookwellense* No 74 and *F. sporotrichioides* No 24) in relation to seedlings of eight grass cultivars were carried out in a growth chamber, at the temperature of 22–23°C and with relative humidity of the air of 85%.

Results obtained from this experiment confirmed considerable harmfulness of *Fusarium* spp. towards the seedlings of turfgrasses, which can be reduced introducing less susceptible varieties to the cultivation. The statistical analysis of disease indexes for plants obtained from the experimental combination with artificial infection of the subsoil with above mentioned strains as compared to the control indicated significant differences in all studied cultivars and in the case of all analyzed *Fusarium* strains. Significantly, the lowest value of the disease index of cultivar Pinia (*Lolium perenne* L.) allows to accept that cultivar as the least susceptible to infestation by *Fusarium* spp. under conditions of controlled temperature and humidity.

THE CAROTENOID CONTENT IN THREE EDIBLE POTATO CULTIVARS DEPENDING ON THE BIOSTIMULANTS USED

Iwona Mystkowska[1], Krystyna Zarzecka[2], Marek Gugała[2], Anna Sikorska[3]

[1] Department of Dieteties, Pope John Paul II State School of Higher Education in Biała Podlaska, Poland
[2] Institute of Agriculture and Horticulture, University of Natural Sciences and Humanities in Siedlce, Poland
[3] Department of Agriculture, Vocational State School of Ignacy Mościcki in Ciechanów, Poland

The aim of the study was to assess the carotenoid content in tubers of three edible potato cultivars depending on the biostimulants used.The research was based on a 3-year field experiment carried out in eastern Poland, in 2015–2017, on brown, slightly acidic soil. The experiment was led by means of a split-plot method. The impact of two factors was tested. The first order factor were the three cultivars of edible potato: 'Honorata', 'Jelly', 'Tajfun', while of the second order - four variants of applying biostimulans: Kelpak SL, Titanit, GreenOk, BrunatneBio Złoto and a control variant (potato plants sprayed with distilled water). Potato plants were treated with biostimulators three times (beginning of flowering, full flowering and after plant flowering). The carotenoid content was determined by spectrophotometric method reagent in fresh potato tuber mass. The principle of the method is based on the extraction of carotenoids from the test sample with petroleum ether and their determination in the obtained extract using the colorimetric method at the wavelength = 450 nm.

The content of carotenoids in tubers depended on the cultivars, biostimulants used and weather conditions prevailing during vegetation. Among the studied cultivars, Jelly accumulated the most carotenoids, and 'Tajfun' the least. Biostimulants increased the concentration of carotenoids compared to tubers from the control object. The interaction of biostimulants used during the years of research has been demonstrated. The largest amounts of carotenoids were obtained in the year with the least rainfall – 2016, and the lowest in the coldest 2017 with the highest amount of precipitation.

ROLE CHEMISTRY IN FEEDING GROWING WORLD POPULATION

Anil B. Naik

Department of Chemical Technology, Sant Gadge Baba Amravati University, India

Mineral nutrients are essential for growth and proper development of plants. Theyarebasicallytwotypes;macronutrientsandmicronutrients.Thelackofmineralscanlead to deficiency symptoms in plants. About 70% growth in agricultural production can b attributed to increase fertilizer application. However, it is practically difficult to provide sufficient manures and fertilizers in all parts of world. The plant growth regulators (PGR) play an significant role in the task of increasing productivity. Moreover, the growing rate of antimicrobial resistance is a major concern these days. The N-heterocyclic compound are most commonly found in nature and are involved several biological functions in plants an animals. The development of structurally new class of antimicrobials which is less toxic and safe is known as Pyrazole. Substituted pyrazoles are the largest and most significant group of systemic compounds developed for the control of fungal diseases in fruits, vegetables, legumes and grain crops, both as pre- and postharvest applications.

The metal ion Pr(III) solution of in the form of nitrate (Sigma-Aldrich) of the concentration of 0.01M was prepared using doubly distilled water. Ligand; 3-(2-hydroxy-4-methylphenyl)-5-methyl pyrazole (HMPMPZOLE) were synthesized in laboratory by known literature method. Healthy seeds of Chickpea of equal size were selected for germination were taken and thoroughly washed using doubly distilled water. Healthy seeds of equal size were immersed in tested solution of different pH values. These seeds soaked were taken out of each solution and were sowed in the experimental trays and kept under the atmosphere pressure at room temperature. The effect of the ligand, metal ion and complex solution on growth of plants was studied and compared with control (water) system at different pH values. Plant growth is decided on the basis of measured average value of parameters such as percentage of germinations, shoot length, root length and leaf area of young leaves.

The percent germination in all treatments showed increase than that of control (distilled water). Greshon and coworkers reported the activity of metal chelates is considerably increased as compared to that of free metal and ligand alone on their complexation. It is seen that in Pr(III)-complex with PHMPMPZOLE showed decrease in shoot length but increase as compared to control. Zielinski et al. showed that lanthanide ion could substitute the calcium ion to produce active enzyme system.

The chemistry find ample role in feeding growing world population in various field of human-interest e.g. biological, medicinal, pharmaceutical etc. There are a number of chemicals which help in increasing food production to keep pace with growing population of India. Plant physiological investigations have revealed that plants need various nutrients for healthy growth. Essential nutrients include

number of metals such as iron, Manganese, copper, zinc etc. Iron in the form +3 oxidation state in the soil is mostly hydrolyze to form insoluble iron hydroxide which cannot be taken up by plants known as Iron Chlorosis which affects the yield of crops. The supply of water soluble Fe(II)-EDTA complex readily enters the roots of plants to fulfill deficiency.

APPLICATION OF NEXT-GENERATION SEQUENCING IN THE STUDY OF VARIOUS FORMS OF *BLUMERIA GRAMINIS*

Tomasz Ociepa, Sylwia Okoń

Institute of Plant Genetics, Breeding and Biotechnology, University of Life Sciences in Lublin, Poland

Detailed knowledge of the sequence of, genetic information is the basis for explaining the specific mechanisms occurring in a given organism. Despite the dynamic development in the field of sequencing methods, relatively little is known about the mechanisms of virulence, evolution or genetic diversity of cereal pathogens.

The biotrophic fungus *Blumeria graminis* causing powdery mildew of cereals and grasses has evolved into nine special forms constituting subspecies infecting one species of the host plant (1). So far, the genomes of 3 special forms have been known or studied, i.e. *hordei* (2), *tritici* (3) and *triticale* (4). The rest of the special forms have not been sequenced, including f. sp. *avenae*, which attacks oats. Genetic and evolutionary studies of *Bga* have shown that it different from the other subspecies. Sequencing of the known genomes of *Blumeria graminis* showed that this genome is larger than that of other fungal pathogens (*B.g. tritici* 180 Mb; *B.g. triticale* 140 Mb; *B.g. hordei* 120 Mb) and contains 60 to 90% of evenly distributed repeat elements. The presence of a large number of repetitive sequences in the genome makes it difficult to read, assemble and annotate. Consequently, first assemblies of the barley and wheat powdery mildew genomes were highly fragmented. Recent advances in long-read sequencing technology (i.e. Pacific Biosciences and Oxford Nanopore Technologies), along with new scaffolding methods, have enabled resolution of chromosome-scale assemblies of an increasing number of plant pathogens genomes. Only genomes of high contiguity allow the addressing of topics such as gene space organization and copy number variation (CNV). These analyses are essential to be able to cover the entire diversity of the candidate effector complement of a pathogen.

Understanding the structure and sequence of the pathogen genome allows to conduct accurate evolutionary studies and pathogen population structure analysis, and thus more effectively control the spread of diseases. The development of the reference genome is the basis for many molecular studies, including the structure of genes, their function and evolution. However, re-sequencing of different isolates allows to determine the dynamics of changes occurring in *B. graminis* population and analysis of genetic diversity between pathogen isolates.

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PRODUCTIONAL AND DEVELOPMENTAL REACTION OF WINTER OILSEED RAPE TO AN AUTUMN APPLICATION OF SELECTED AGROCHEMICALS UNDER MILD TEMPERATE CLIMATE

Andrzej Oleksy, Bogdan Kulig, Agnieszka Klimek-Kopyra, Marek Kołodziejczyk

Department of Agroecology and Crop Production, University of Agriculture in Krakow, Poland

The aim of this study was to verify the action of selected agrochemicals applied in the autumn, on the health, growth, yield and chemical composition of seeds of varieties of winter oilseed rape (Jumper and Belleuve). The study tested the following active ingredients and combinations thereof: prothioconazole, tebuconazole, difenoconazole, metconazole, paclobutrazol, mepiquat chloride and chlormequat chloride. In years with mild winters 2009–2012, field experiments were conducted at the Experimental Station (Modzurów, Poland), in the area with fertile soils and mild temperate climate. Moreover plants were provided with a very good agrotechnology, which led to a record yield more than 8 t of seeds per hectare.

Most of the agrochemicals tested reduced fungal infestation, but this did not translate into an increase in yield. Shorter stems (7–9%) were observed after plant spraying in the 4-leaf stage with a combination of difenoconazole + paclobutrazol. The oil content in the seeds increased (4.2 – 5%) after application of a mixture in the 4-leaf stage (prothioconazole + tebuconazole) plus (difenoconazole + paclobutrazol), and a combination of chloromequat chloride in 4-leaf stage plus (prothioconazole + tebuconazole) at the 8-leaf stage. Three combinations of agrochemicals can be recommended for use in similar weather conditions and agricultural practices, due to the fact that they presented more than one important function: difenoconazole + paclobutrazol – fungicide effect and retard effect, (prothioconazole + tebuconazole) + (difenoconazole + paclobutrazol) – fungicide effect and increase in oil content and chloromequat chloride + (prothioconazole + tebuconazole) – fungicide effect and increase in oil content.

PATHOGENICITY OF *FUSARIUM* ISOLATES OBTAINED FROM SOYBEAN

Hanna Olszak-Przybyś[1], Grażyna Korbecka-Glinka[1], Elżbieta Patkowska[2]

[1] Institute of Soil Science and Plant Cultivation – State Research Institute, Puławy, Poland
[2] University of Life Sciences in Lublin, Poland

The diverse species of *Fusarium* infect soybean (*Glycine max* (L.) Merr.) plants at almost every growth stage causing diseases such as: seedling blight, seed decay and *Fusarium* root rot. Previous research has shown that diseases caused by a complex of *Fusarium* species (mainly dominated by *F. oxysporum* and *F. graminearum*) lead to reduced seed quality, lower emergence and abnormal seedlings growth of soybean in the field. The aim of this study was to compare the pathogenicity among different isolates belonging to *Fusarium* genus. Nineteen fungal isolates were evaluated in *in vitro* pathogenicity assay including: 9 isolates *F. oxysporum*, 4 isolates *F. culmorum* and 6 isolates *F. graminearum*. These isolates were obtained in 2019 from soybean plants with disease symptoms growing in the experimental field located in Makowisko (south-east Poland). Species identification of the selected *Fusarium* isolates was performed by means of microscopic methods, available taxonomic descriptions and polymerase chain reaction (PCR) using species-specific primers.

The pathogenicity test was conducted on healthy soybean seeds of three cultivars: Mavka, Atlanta and Abelina in three replicates, 100 seeds each. Seeds were surface disinfected using 1.4% sodium hypochlorite solution. Then they were subjected to fungal inoculation by soaking in the spore suspension in PDA medium (1×10^6 spores/ml) for 5 min. Inoculated seeds were placed in Petri dishes with sterile filter paper moistened with water. The seeds soaked in PDA medium without fungal spores constituted a negative control. The pathogenicity assay was carried out under controlled conditions (25 ±2°C in the dark with 70% humidity) in plant growth chambers (Snijders, Holand). Seven days after inoculation the symptoms of infection were observed and experimental seed/seedlings were assigned to 5-grade scale where 0° – healthy seed germination without necrotic spots, 1° – 0% to10% necrotic spots, 2° – 10% to 25% necrotic spots, 3° – 25% to 50% necrotic spots, 4° – 50% to 75% and 5° – 75% to 100% necrotic spots, respectively. Disease index (DI) was calculated using the formula of McKinney (1923).

Pathogenicity assay showed that all the isolates tested in current study were able to infect soybean seeds. After seven-day of inoculation soybean seeds were covered with the mycelia of the *Fusarium* isolates and showed typical symptoms of rotting and browning, visible on radicle and cotyledons. For negative control seeds, there were no significant disease symptoms. Our results demonstrated that one isolate of *F. oxysporum* had the highest aggressiveness manifested by DI ranging between 95.9%–97.6% depending on cultivar. On the other hand, the least pathogenic was *F. culmorum* isolate with disease index 34.4%–37.8%. The disease index averaged over all tested isolates equalled 70%, 66.6%, 59.8% for *F. oxysporum, F. graminearum* and

F. culmorum, respectively. This research allowed to create the collection of *Fusarium* isolates with a known aggressiveness level. Selected isolates will be used in future studies to test antifungal substances and for pathogenicity testing in the greenhouse.

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BIODIVERSITY OF FUNGI COLONIZING SCORZONERA *(Scorzonera hispanica* L.) CULTIVATED WITH THE USE OF BIOSTIMULANTS

Elżbieta Patkowska, Agnieszka Jamiołkowska, Elżbieta Mielniczuk, Barbara Skwaryło-Bednarz

Department of Plant Protection, University of Life Sciences in Lublin, Poland

The necessity of environmental protection and reduction of crop production costs requires modern sustainable agriculture to provide proper methods of plant protection. In modern agriculture, it is possible to use biostimulants that protect the soil against degradation and plants against phytopathogens and stress. Biostimulants increasing the tolerance of plants to abiotic and biotic stress also include microorganisms that induce plant resistance to pathogens and modify the composition of soil microorganisms and microorganisms colonizing under-ground plant organs. Biostimulants are friendly to the soil environment and can effectively improve the plant growth and yielding. The aim of field and laboratory studies was to establish the effect of biostimulants on the growth and on the health status of *Scorzonera hispanica* L. plants.

The field experiment was carried out in south-eastern Poland on Haplic Luvisol. The biostimulants Asahi SL (active components: nitroguaiacolate and nitrophenolates), Beta-Chikol (a.s. – chitosan) and Bio-Algeen S90 (extract from seaweed *Ascophyllum nodosum*) were applied for the pre-sowing seed dressing of scorzonera cv. 'Duplex'. For comparison, the fungicide Zaprawa Nasienna T 75 DS/WS (a.s. – tiuram 75%) was used. Untreated seeds served as control. Moreover, the biodiversity of soil-borne fungi colonizing the roots of this vegetable was determined. The number of seedlings and the health status of scorzonera plants were determined during three growing seasons. In each year of the study, both scorzonera seedlings with necrosis symptoms on the roots and the infected roots obtained after scorzonera harvest were subjected to laboratory mycological analysis.

The experiments showed that, the emergence and health status of scorzonera seedlings after the application of biostimulants, especially after Beta-Chikol, were significantly better than in the control. The indicator of the protective effect of the applied biostimulants against plant infection by soil-borne pathogens was the value of the disease index of scorzonera seedlings. Biostimulants and a fungicide significantly reduced the occurrence of diseased scorzonera plants. The health status of scorzonera plants was differentiated and it depended on the type of biostimulant. The highest number of infected seedlings was found in control, and the lowest after the application of Beta-Chikol and Zaprawa Nasienna T 75 DS/WS. The mean proportion of diseased seedlings after Asahi SL and Bio-Algeen S90 application was slightly higher, but differed significantly from control. Asahi SL and Beta-Chikol were more effective than Bio-Algeen S90 in limiting the occurrence of

fungi pathogenic towards scorzonera plants. Diseased scorzonera roots were most frequently colonized by *Alternaria scorzonerae*, *Alternaria alternata*, *Rhizoctonia solani*, *Sclerotinia sclerotiorum* and *Fusarium* spp., especially by *Fusarium oxysporum*.

The biostimulants used in the field experiment limited scorzonera roots colonization by polyphagic fungi. Asahi SL, Beta-Chikol and Bio-Algeen S90 can be recommended as effective biostimulants in field cultivation of *Scorzonera hispanica*.

PRODUCTION AND ECONOMIC EFFICIENCY IN THE CULTIVATION OF STRAWBERRY (FRAGARIA × ANANASSA DUCH.) DEPENDING ON THE METHOD OF PROTECTION

Joanna Pawlak, Wioletta Wróblewska, Dariusz Paszko

Department of Management and Marketing, University of Life Sciences in Lublin, Poland

The research was conducted in the years 2018–2020 in 8 specialistic horticultural farms, growing strawberries for processing, in the Podkarpackie Voivodeship. Organic cultivation methods have been used in 4 of them, whereas the others have used conventional ways of cultivation. The examined horticultural farms ranged in surface area from 6 to 14 ha, and strawberry plantations ranged from 2 to 6 ha. The analysis was focused on comparison of yielding of 3 strawberry cultivars: 'Honeoye', 'Aprica', and 'Dipred', obtained by applying either ecological or conventional methods of plant protection. Furthermore, depending on the method of plant protection, a comparative analysis of the economic efficiency of the previously stated strawberry cultivars was conducted. For both conventional and ecological plantations, the same cultivation methods were applied. Strawberries were grown in two rows on high beds, covered with non-voven black polypropylene. On a 1 ha surface area, 33 thousand seedlings were planted. Plantations were watered with a drip irrigation system and fertilized with a fertigation method. Organic and conventional fruit were sold to the same customer.

According to the findings, the costs of ecological protection were nearly twice as high as those of conventional protection. It was concluded that strawberry yields varied depending on the method of protection in different years and within cultivars under examination. Moreover, the research results indicate that the yields of strawberries grown in an ecological plantation differed only slightly from those grown in a conventional plantation. Despite the higher costs of ecological protection, economic efficiency of these plantations were comparable to or greater than that of the conventional ones, due to higher sales price of ecological fruit.

EFFECT OF LIVING MULCHING IN ORGANIC APPLE ORCHARD ON PEST AND BENEFICIAL ARTHROPODS

Wojciech Piotrowski, Małgorzata Sekrecka, Eligio Malusa

Department of Plant Protection, National Institute of Horticultural Research in Skierniewice, Poland

In Poland, organic fruit production system is characterized by monoculture management method, which largely contributes to the problems with plant pests control and beneficial insects effectiveness.

Our study, conducted between 2019–2020 in Poland aimed to assess the effect of cover plants e.g. *Satureja* sp.*, Tropaeolum adpressum, Alchemilla vulgaris, Viola odorata, Mentha longifolia, Galium odoratum + Stachys officinalis, Veronica officinalis, Pulmonaria officinalis + Tagetes, Cucurbita pepo, Fragaria vesca* grown under apple trees, on pest and beneficial insects populations on the trees. Each year, from May to September pests occurrence were assessed (one time/month) in the orchard separately for 'Gala' and 'Golden Delicious' cvs. The focus was the assessment of shoots colonized by aphids i.e. *Dysaphis plantaginea* and *Aphis pomi*, number of phytophagous mites (Tetranychidae, Eriophyidae), and phytoseiid mites. The damage fruits caused by *Cydia pomonella* and leafrollers was examined too. 50 shoots and 50 leaves per replicate were evaluated for the presence of aphids and mites, and 100 fruits were evaluated for pest damage by *C. pomonella* and leafrollers. Each evaluation was done in 4 replicates.

Less number of shoots colonized by two species of aphids was noticed on the apple trees 'Gala' cv., where cover plant such as: *Satureja sp.*, *Tropaeolum adpressum* and *Cucurbita pepo* were growing in the rows. Furthermore, less number of leaf rosettes damaged by leafrollers where found on the apple trees growing with *Satureja* sp., *Viola odorata*, *Cucurbita pepo* plants. On the apple trees 'Golden Delicious' cv., on the plots with cover plants such: *Pulmonaria officinalis + Tagetes*, *Cucurbita pepo*, *Fragaria vesca* less shoots with aphids and less leaf rosettes damaged by leafrollers were archived.

On both apple cultivars, regardless of the plants cover (including control plots) used, there were not any differences in the matter of fruits damaged by *Cydia pomonella* and number of mite. The seasonal differences involved also the species present in the beneficial mites populations: four species were identified in 2019 (*Typhlodromus pyri*, *Amblyseius (Amblyseius) andersoni*, *Euseius finlandicus* and *Phytoseius echinus*), while only two species were observed in 2020 (*Typhlodromus pyri* and *Amblyseius (Amblyseius) andersoni)*.

The effect of the living mulch was visible for both 2019 and 2020, even though, overall, the number of beneficial mites was higher in the first season than in the second. Mint resulted among the species that favored the presence of predatory mites in 2019, but in the following season this was no more observed. On the other

hand, wild strawberry and *Pulmonaria officinalis* resulted to support the presence of the beneficial mites in both seasons. It should also be mentioned that in both seasons, the number of phytophagous mites was very low, which could possibly be derived from the activity of the predatory species as well as by a direct effect of the living mulches.

PROSPECTS FOR THE USE OF PESTICIDES IN AGRICULTURE

Barbara Sawicka[1], Hakiye Aslan[2], Imran Aslan[3], Chukwuebuka Egbuna[4], Olutosin A. Otekunrin[6], Piotr Barbaś[5]

[1] Department of Plant Production Technology and Commodities Science, University of Life Science in Lublin, Poland
[2] Vocational School of Food, Agriculture and Livestock, Bingöl University, Turkey
[3] Faculty of Health Sciences, Bingöl University, Turkey
[4] Department of Biochemistry, Faculty of Natural Sciences, Chukwuemeka Odumegwu Ojukwu University, Nigeria
[5] Department of Potato Agronomy, Institute of Plant Breeding and Acclimatization–National Research Institute, Jadwisin Branch, Serock, Poland
[6] Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Nigeria

The problems of food safety through the prism of pesticide residues in food were presented. Their widespread use and considerable durability made them ubiquitous in the natural environment. Some of them take a long time to decompose, even those that were discontinued even 40 years ago, such as DDT and its breakdown products, are still found in agricultural crops. Due to the significant persistence of pesticides, as well as their potential threat to the environment, the incidence of the society has increased, and the contamination of water and soil with their decomposition products has increased. In recent years, consumers have been paying increasing attention to the potential health effects of synthetic chemicals in food production. The concern about food safety issues has created significant pressure on pesticide producers in Europe and around the world, exerted not only by consumers but also by various committees and social organizations in the USA,

Europe, to reduce pesticide residue levels in food from farms, which synthetic plant protection products are used. The attention was paid to the existence of very strong correlations between exposure to pesticides and the incidence of leukemia, skin cancer, prostate cancer, lung cancer and neurodegenerative diseases. Attention was also paid to the prohibition of the use of carcinogenic, mutagenic, toxic, and especially endocrine disrupting substances as pesticides for reproduction and the possibility of using biopesticides that decompose quite quickly and constitute a special group of active substances in plant protection. Their use in plant protection can lead to many positive changes, such as: reducing pesticide residues in food and in the environment, and thus reducing the risk to consumers. The current legal requirements for risk assessment of combined exposure to chemicals have also been reviewed. The aim is therefore to identify regulatory needs and approaches to risk assessment, as well as challenges related to the implementation of harmonized guidelines at European and international level. The work was based on a systematic review during which the research problem was defined, primary sources were selected and critically assessed, complete data were collected, analysed, meta-analyses were

performed and conclusions were drawn up. As a result of the analysis, it was found that pesticides replacing banned chemical compounds should undergo appropriate comparative assessment procedures. The factor influencing the search for new tools for pest control is the growing evolution of the resistance of the pest population to the currently used pesticides. Another factor supporting the development of the biopesticides market is the growing demand for so-called eco-products. Various alternatives to phased out synthetic pesticides in the form of natural products, i.e., biopesticides, are also being developed.

EFFICIENCY OF SELECTED POTATO CULTIVARS UNDER VARIOUS PROTECTION PROGRAMS AGAINST *PHYTOPHTHORA INFESTANS* MONT DE BARY

Barbara Sawicka[1], Piotr Pszczółkowski[2], Dominika Skiba[1], Piotr Barbaś[3], Farhood Yeganehpoor[4], Bernadetta Bienia[5], Barbara Krochmal-Marczak[5]

[1] Department of Plant Production Technology and Commodity Science, University of Life Sciences in Lublin, Poland
[2] Experimental Station for Cultivar Assessment of Central Crop Research Centre, Dębowa Kłoda, Poland
[3] Department of Potato Agronomy, Institute of Plant Breeding and Acclimatization – National Research Institute, Jadwisin Branch, Serock, Poland
[4] Department of Plant Eco-Physiology, University of Tabriz, Tabriz, Iraq
[5] Department of Plant Production and Food Safety, Carpathian State University in Krosno, Poland

Poland is one of the largest potato producers in the world and it is here one of the key food and industrial plants. Unfortunately, its yields are almost twice lower than those obtained in the EU countries. Late blight caused by the oomycete *Phytophthora infestans*, is one of the most harmfulness plant disease which affects solanaceous plants [1–3]. The main reasons for this are: high susceptibility of genetically homogeneous varieties to *Phytophthora infestans* and imperfect protection of plantations against this pathogen. The experiments were carried out using the subblock method randomly selected in a dependent split-plot design, in three repetitions. The overriding factors were the strategies of protection against *Phytophthora infestans* Mont de Bary, with different frequency of fungicide application (three to nine treatments) and the control object, without protection. The second-order factor consisted of four potato cultivars with different resistance to *Ph. infestans* and a mixture of these varieties.

In the experiment, constant mineral fertilization was applied in the amount of: 90 kg N, 42 kg P, 106 kg K ha^{-1}, determined on the basis of the abundance of these components in the soil. The experiment was carried out with a spacing of 67.5 × 37 cm in the last decade of April each year. Propagation material was C / A grade. Nursing treatments and other protective treatments were applied in accordance with good agricultural practice. The aim of the research was to determine the effectiveness of comprehensive strategies (programs) for potato protection against *Ph. infestans* in the conditions of Central and Eastern Poland. The criterion for assessing the effectiveness of the protection strategy was the rate of potato blight spreading, increase in total and marketable tuber yield, dry matter, starch, and protein. The strategy with sixfold protection turned out to be the most effective in terms of the overall yield of tubers, dry matter and starch, and the strategy with protection against potato blight was the most effective in terms of protein yield. Moreover, it was proved that the resistance of varieties to *Ph. infestans* was a priority factor and should primarily determine the choice of a strategy for protection against potato blight. The extended period of plant vegetation, and thus the reduction of yield

losses, were resulted from: a combined strategy for the application of protection programs against *Ph. infestans* and using selected potato varieties resistant to stem blight. Danusia variety turned out to be the variety with the slowest spreading rate of early blight, while potato blight was the slowest to spread on the Ania variety. The impact of late blight strategies is especially valuable when plants are exposed to the stress of heat and moisture.

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THE IMPACT OF FOLIAR APPLICATION OF BIOSTIMULATORS ON THE MORPHOLOGICAL CHARACTERISTICS OF THE LEAF ROSETTE OF WINTER RAPE PLANTS

Anna Sikorska[1], Marek Gugała[2], Krystyna Zarzecka[2], Iwona Mystkowska[3]

[1] Department of Agriculture, Vocational State School of Ignacy Mościcki in Ciechanów, Poland
[2] Faculty of Agrobioengineering and Animal Husbandry, University of Natural Sciences and Humanities in Siedlce, Poland
[3] Department of Dieteties, Pope John Paul II State School of Higher Education, Poland

The field experiment was caried out in three growing seasons (2013–2016) at the Agricultural Experimental Station – Zawady (52°03'N and 22°33'E) belonging to the University of Natural Sciences and Humanities in Siedlce, Poland. The experiment was set up in a split-plot configuration with three replications. The examined factors were: morphotypes of winter oilseed rape: population ('Poznaniak'), hybrid restored with a semi-dwarf type of growth (PX104), hybrid restored with a traditional type of growth (Konkret), II – four types of biostimulators: 1. control variant – without the use of biostimulators, sprayed with distilled water, 2. biostimulator Tytanit® (titan), 3. biostimulator Asahi®SL (sodium ortho-nitrophenol, sodium para-nitrophenol, sodium 5-nitroguaiacol), 4. biostimulator Silvit® (active silicon, potassium oxide, boron – form of pure element , zinc – form of pure element). The aim of the study was to evaluate the effect of biostimulators containing various active substances on the morphological features of the leaf rosette (number of rosette leaves, tap root length, height of the growth cone) and on the fresh and dry mass of the above-ground rosette and the root system of traditional and semi-dwarf winter oilseed rape morphotypes type of growth under changing climatic conditions.

The genetic factor significantly influenced the morphological features of plants, marked in autumn by inhibition of vegetation. The population variety 'Poznaniak' developed more rosette leaves, greater length of the tap root, and fresh and dry mass of the rosette and the root system as compared to the restored hybrids. The applied biostimulators significantly influenced plant parameters determined in the fall before the vegetation inhibition. After the use of a biostimulator containing the active substance in the form of sodium o-nitrophenol, sodium para-nitrophenol and sodium 5-nitroguajakol, a significantly higher value of the tested features was obtained compared to the control variant. Regardless of the type of biostimulator used, the height of the growth cone was the same as in the control object. The most favorable parameters of the leaf rosette were obtained in the first and second periods of summer-autumn vegetation and winter dormancy, while in extreme drought conditions during sowing and a fairy dry period of emergence, its weakest features were obtained.

PATHOGEN ELIMINATION USING MERISTEMS IN VITRO CULTURE – THE STRATEGY OF HOP PROTECTION AGAINST VIRUSES AND VIROIDS

Urszula Skomra, Grażyna Korbecka-Glinka, Hanna Olszak-Przybyś, Diana Czarnecka, Karolina Kursa

Institute of Soil Science and Plant Cultivation State Research Institute, Department of Plant Breeding and Biotechnology in Puławy, Poland

Hop plants in Poland are commonly infected by *Hop mosaic virus* (HpMV), *Apple mosaic virus* (ApMV) and *Hop latent viroid* (HLVd). Infection is usually symptomless but in many cases it can have a deleterious effect on cone yield, bitter acids content and composition of hop essential oils. The response of individual hop cultivars to infection is different. One of the most effective methods of hop protection against virus and viroids is the use of planting material free from these pathogens for establishing hop gardens. This material has to be propagated in suitable greenhouse conditions starting from virus- and viroid-free mother plants obtained by elimination of these pathogens using apical meristems in vitro cultures. Apical meristems about 0.1–0.2 mm long were excised from suitable donor plants and transferred to three different regeneration media for growing, shoots development and rooting. Regenerated plantlets were tested for the presence of viruses and viroid using ELISA and RT-PCR methods, respectively. Meristem culture have been successful in eliminating both viruses, but it was less effective against viroid. All plantlets regenerated from meristems were free of the HpMV and ApMV, whereas only from 2.2% to 36.4%, depending of hop cultivar, were free of HLVd. The highest percentage of completely healthy plants was obtained for the 'Puławski' cultivar, while the lowest for the 'Magnat' cultivar.

Healthy plantlets were multiplied *in vitro* to the requirement number, then transferred into the pots and placed in the greenhouse where they adapted to the outside growing conditions. These mother plants, after retesting for HpMV, ApMV and HLVd and confirming their health status, were propagated by single-node cuttings. Currently, in the Institute of Soil Science and Plant Cultivation State Research Institute in Puławy, the healthy mother plants of seven most important hop cultivars grown in Poland, i.e. 'Iunga', 'Lubelski', 'Magnat', 'Magnum', 'Marynka', 'Puławski', 'Sybilla', are maintained and propagated. Every year 10-20 thousands hop seedlings of high health status is produced, depending on the hop growers demand.

Elimination of viruses and viroids doesn't protect hop plants against reinfection. The frequency of reinfection with HpMV, ApMV and HLVd was studied in 26 hop plantations five years after establishing them using healthy planting material. From 10 to 20 plants were tested from each plantation, depending on its size (totally 360 plants of five hop cultivars were tested). Reinfection with HLVd, ApMV and HpMV was observed in 2.8%, 1.4% and 0.8% of tested plants, respectively. On

the average, 5.0% of samples were positive for at least one pathogen. The highest rate of reinfection was found in cultivar ‘Marynka’ (11.4% of the tested plants were infected), and the lowest in cultivar ‘Lubelski’ (1.4% of the tested plants were infected).

HpMV, ApMV and HLVd were successfully eliminated from hop plants using apical meristems in vitro cultures. Elimination effectiveness depended on pathogen and was much greater in case of viruses. Plants free of viruses and viroid were propagated to produce high-quality hop planting material. The rate of reinfection during first five years after planting was low, thus the hop gardens established using healthy planting material remained for long time with high health status.

Results were developed under task 4.0 “Maintaining high-quality elite hop seedling material” from the budget subsidy allocated to the tasks of the Ministry of Agriculture and Rural Development in 2021.

THE EFFECT OF AMARANTH GROWING WITH THE USE NON-CHEMICAL PROTECTION METHODS ON THE CATALASE ACTIVITY IN THE SOIL

Barbara Skwaryło-Bednarz[1], Agnieszka Jamiołkowska[1], Marek Kopacki[1], Elżbieta Patkowska[1], Katarzyna Golan[1], Hanna Klikocka[2]

[1] Department of Plant Protection, University of Life Sciences in Lublin, Poland
[2] Department of Economics and Agribusiness, University of Life Sciences in Lublin, Poland

The aim of the study was to determine the influence of habitat, cultivar and development growth stage on the catalase activity in soil under two amaranth cultivars – 'Rawa' and 'Aztek'. In a 3-year field experiment (2013–2015), amaranth was grown as a test plant in wide-row spacing on the soil of the good wheat complex in the South-Eastern Poland (N50°71′, E23°04′). The field experiment included 4 variable factors: weather conditions; selected growth stages of amaranth (the 5-leaf phase, full flowering and seed maturity); NPK doses combinations (I – 40 kg N ha^{-1}, 30 kg P ha^{-1}, 30 kg K ha^{-1}, II – 60 kg N ha^{-1}, 40 kg P ha^{-1}, 40 kg K ha^{-1}, III – 80 kg N ha^{-1}, 50 kg P ha^{-1}, 50 kg K ha^{-1}, IV – 120 kg N ha^{-1}, 70 kg P ha^{-1}, 70 kg K ha^{-1}) and two cultivars ('Rawa' and 'Aztek'). In the cultivation of amaranth, due to the absence of pathogens and pests, no pesticides were used. Plant protection was limited only to the reduction of weed infestation twice. The conducted research shows that the main factor differentiate the catalase activity in the soil under amaranth was weather conditions, and then other factors such fertilization, cultivar and growth stage.

All analyzed factors had a significant impact on the organic matter in the soil, and only the applied NPK fertilization on the value of sorption capacity. Moreover, it was found that the 'Aztek' cv. positively influenced the activity of catalase and the accumulation of humus in the soil than the 'Rawa' cv. Beneficial effect of amaranth on the soil environment and its enzymatic activity could be related to the lack of introduced pesticides.

SUPPRESSION OF PHYTOPATHOGENIC FUNGI BY *PSEUDOMONAS* SSP. STRAINS

Wojciech Sokołowski, Magdalena Karaś, Sylwia Wdowiak-Wróbel, Monika Marek-Kozaczuk, Michał Kalita, Karolina Włodarczyk

Department of Genetics and Microbiology, Maria Curie-Sklodowska University in Lublin, Poland

Bacteria of the *Pseudomonas* genus are ubiquitously found in the internal tissues of plants and recognized as a members of various endophytic microbiomes. Because of their broad metabolic activity, which is necessary to adapt to plant endosphere, *Pseudomonas* strains isolated from plant material are rich source of many novel bioactive compounds (include antimicrobial molecules) which make them an important candidate to use in sustainable and organic agriculture as biological agents against phytopathogens (Sheorana et al. 2015).

Four bacterial strains, isolated from root nodules of various legume plants and classified on the basis of comparative analysis of 16S rRNA gene sequences to *Pseudomonas* genus (data not presented) were tested. To evaluate *in vitro* antagonistic activity of bacterial strains against *Botrytis cinerea*, *Diaporthe rudis*, *Fusarium equiseti*, *Fusarium oxysporum* and *Sclerotinia sclerotiorum* the disc diffusion method was conducted (Balouiri et al. 2016). Moreover, siderophore and salicylic acid production assay (Arnow 1937) as well hydrogen cyanide (HCN) production assay (Lorck, 1948) were carried out.

Though, all tested strains had potential to inhibit the growth of some phytopathogenic fungi, only one appeared to be active against all phytopathogens used in this investigation. Among factors produced by tested bacterial isolates of plausible antagonistic activity against pathogenic fungi were: siderophores, salicylic acid and hydrogen cyanide. Since, all tested strains have capacity to produce antimicrobial molecules they seem to have the potential as biocontrol agents, especially against phytopathogenic fungi. However, further investigations are required to confirm above conclusions.

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FUNGAL ENDOPHYTES OF GRASSES – OUR ENEMIES OR ALLIES?

Aleksandra Jagienka Stach

Department of Plant Taxonomy, Adam Mickiewicz University, Poland

Fungi of the genus *Epichloë* are so-called facultative endosymbionts of many grasses species. However, in the sexual stage fungus parasitizes on the plant; it creates specific structures, called stromata, on the blades of the grass inhibiting its flowering and seed production. Additionally, stromata formed on vegetative shoots diminish intensity of photosynthesis. In the asexual stage, *Epichloë* is an endophyte and its presence in the plants' tissues does not give any visible symptoms of the disease. Still, it involves production of alkaloids which have toxic effect on herbivores – it is particularly important from an economic point of view in the case of pasture grasses and livestock. Mycotoxins cause to cattle such conditions as diarrhea, respiratory problems, lack of appetite, tissue necrosis or miscarriages.

This leads to large economic losses. Intensification of research on the endophytes has started at the turn of the 80's and 90's. Knowing details of the biology of these organisms, scientists began to be more aware of their properties. On the one hand, beneficial for the host (at least in certain circumstances): grasses with the fungus in the endophytic stage often have greater biomass, produce more seeds, cope better in extreme environmental conditions (e.g. during drought) and are more resistant to herbivores (thanks to alkaloids) than uninfected plants.

On the other hand, the risk that endophytes can be dangerous for farm animals has become more evident. From that moment the studies on the possible practical deployment of these microorganisms and the substances they produce have been intensified and some of the results obtained found application in medicine, biotechnology and in plant's protection. At the same time researchers try to redress the adverse effects of fungi presence in the pasture grasses. By selection and genetic manipulation they search for nonpathogenic strains that neither cause disease to cattle, nor inhibit plant growth.

INFLUENCE OF PATHOGENS ON THE PHOTOSYNTHESIS PARAMETERS OF VARIOUS CANNA CULTIVARS

Mariusz Szmagara[1], Marek Kopacki[2], Barbara Marcinek[1], Barbara Skwaryło-Bednarz[2], Agnieszka Jamiołkowska[2]

[1] Institute of Horticultural Production, Subdepartment of Ornamental Plants and Dendrology, University of Life Sciences in Lublin, Poland
[2] Department of Plant Protection, University of Life Sciences in Lublin, Poland

The three-year studies was conducted in the conditions of south-eastern Poland. They included 10 varieties of canna: 'Aida', 'America', 'Botanica', 'Cherry Red', 'La Boheme', 'Lucifer', 'Picasso', 'Robert Kemp', 'President' and 'Wyoming'. In every year, the plant health assessment was performed two times, i.e. in June and in September, however in June (three weeks after the transplanting in target location) the plants haven't indicated the disease symptoms so due to that the disease index was not calculated. Each year in October, plants with disease symptoms of stem and root rot, leaves yellowing and wilt were subjected to mycological analysis. The photosynthetic activity of plants was measured during two growing seasons. In each season, measurements were carried out twice, i.e. in the first ten days of July and the first ten days of September.

The Disease Index measurements of plants conducted in the vegetation period showed index values depending on the study year, weather conditions and variety of cannas. However, no significant statistical differences were noticed. The highest disease index was noticed in the first year of research ('Aida' cv.) and the lowest in the third year of research ('Botanica', 'Lucifer' and 'President' cvs.). The results of mycological analysis showed that canna plants were colonized by *Fusarium* spp., *Sclerotinia* spp. and *Alternaria* spp. *Alternaria alternata*, *Fusarium oxysporum, Fusarium avenaceum* and *Sclerotinia sclerotiorum* predominated among pathogenic species. The best health status and the lowest number of colonies were noticed for plants of cv. 'Botanica'.

The infection of canna leaves by pathogenic fungi has negatively affected the intensity of photosynthesis, transpiration, stomatal conductance and substomatal CO_2 concentration, but it was largely related to the degree of infestation of specified varieties of canna. The photosynthesis process was limited especially in 'Picasso', 'Cherry Red', 'President' and 'La Boheme' cultivars, which were the most infected by pathogenic fungi, in particular the leaves. In the least infested varieties, such as 'Botanica' 'Wyoming' and 'Lucifer', these values were much higher. The damage to the photosystem was more severe than external disease symptoms indicated, which suggest that intensity and gas exchange measurements might be helpful in early evaluation of diseases severity.

MODIFICATIONS OF VITAMIN C AND TOTAL PROTEIN CONTENT IN EDIBLE POTATO TUBERS UNDER THE INFLUENCE OF HERBICIDE AND BIOSTIMULANTS

Krystyna Zarzecka[1], Marek Gugała[1], Iwona Mystkowska[2], Anna Sikorska[3]

[1] Institute of Agriculture and Horticulture, University of Natural Sciences and Humanities in Siedlce, Poland
[2] Faculty of Health Sciences, Pope John Paul II State School of Higher Education in Biała Podlaska, Poland
[3] Department of Agriculture, Vocational State School of Ignacy Mościcki in Ciechanów, Poland

The research material consisted of potato tubers from a three-year field experiment, which was carried out in the fields belonging to the University of Natural Sciences and Humanities in Siedlce, in Poland. The experiment was established by method split-plot pattern, in triplicate. The first factor was the two edible potato cultivars 'Malaga' and 'Oberon', and the second factor was the five methods of weeds regulation with the use of herbicide and biostimulants:

1) control object − without chemical protection,
2) herbicide Avatar 293 ZC – 1.5 L ha^{-1} before potato emergence,
3) herbicide Avatar 293 ZC – 1.5 L ha^{-1} before potato emergence and biostimulant PlonoStart 2 L ha^{-1} after potato emergence,
4) herbicide Avatar 293 ZC – 1.5 L ha^{-1} before potato emergence and biostimulant Aminoplant 1,5 L ha^{-1} after emergence,
5) herbicide Avatar 293 ZC – 1.5 L ha^{-1} before potato emergence and biostimulant Agro-Sorb Folium 4 L ha^{-1} after emergence.

Vitamin C content in fresh tubers was determined using the Tilman's method modified by Pijanowski. Content of total protein was calculated from the content of nitrogen multiplied by 6.25, assayed with the Kjeldahl method. The research results of this experiment was statistically analysed using with analysis of variance.

The conducted research showed that the vitamin C content significantly depended on the methods of herbicide and herbicide application with biostimulants and research years. The content of total protein significantly depended on the application of herbicide and herbicide with biostimulants, cultivated cultivars and weather conditions in the years of research.

The highest vitamin C accumulation followed an application of the herbicide Avatar 293 ZC + the biostimulant Aminoplant whereas total protein content was the highest after spraying with the same herbicide + the biostimulant PlonoStart. Cv. Oberon displayed a higher potential for an accumulation of chemical components in tubers compared with cv. Malaga. The analyses conducted in the study demonstrated a significant effect of meteorological conditions throughout the study years on the concentration of the chemical components of potato tubers examined in the research.

BIOLOGICAL TREATMENT WITH *DEBARYOMYCES HANSENII* REDUCES THE CONTENT OF DEOXYNIVALENOL AND CULMORIN IN DURUM WHEAT GRAIN

Urszula Wachowska[1], Marian Wiwart[1], Elżbieta Suchowilska[1], Michael Sulok[2], Wolfgang Kandler[2], Rudolf Krska[2], Dariusz Gontarz[3]

[1] Faculty of Agriculture and Forestry, University of Warmia and Mazury in Olsztyn, Poland
[2] Department IFA-Tulln, University of Natural Resources and Life Sciences in Vienna
[3] PZZ Lubella GMW, Sp. z o.o. Sp. k. in Lublin, Poland

Fungi of the genus *Fusarium* cause *Fusarium* head blight (FHB) and produce numerous secondary metabolites, thus decreasing the quality of durum wheat grain. Trichothecenes, including deoxynivalenol (DON), are the most commonly occurring and the most toxicologically important mycotoxins. Culmorin (CUL, a tricyclic sesquiterpene diol), which remains weakly researched, enhances the phytotoxic effects of DON on wheat seedlings.

Field experiments were conducted to evaluate the applicability of a *Debaryomyces hansenii* isolate (NCBI GenBank accession number KX444668) for reducing the concentrations of DON and CUL in the grain of several spring cultivars of durum wheat grown at two locations in Poland (Bałcyny near Olsztyn and Niedrzwica Kościelna near Lublin). *D. hansenii* cells were applied two times during the flowering stage of wheat. Flowering spikes were inoculated with an aqueous suspension of *F. graminearum* spores. The concentration of fungal cells in the suspension was 10^4 cells in 1 cm^3 of water. Unprotected plants were the control.

DON and DON-3-glucoside (D3G) were detected in 26 out of the 40 examined samples. The DON content of grain was particularly high in the control samples of 'Floradur' and 'Tamadur' cvs. in Niedrzwica Kościelna (2081 and 1113 μg/kg, respectively). In most cases, the inoculation of wheat spikes with *F. graminearum* increased the DON content of grain up to 1519 μg/kg. Biological treatment involving a cell suspension of *D. hansenii* isolate decreased DON concentrations in grain, compared with control samples and grain samples from spikes inoculated with *F. graminearum*. The CUL content of grain was usually higher than DON content. A clear positive correlation was found between CUL and DON concentrations. CUL, 15-hydroxyculmorin and 5-hydroxyculmorin were detected in 35 grain samples, and their content was high (up to 2887.87 μg/kg) in cv. 'Tamadur' and 'Duragol' in Niedrzwica Kościelna. At this location, the biological treatment exerted a particularly high inhibitory effect on CUL production by *Fusarium* fungi. The reduction in the content of the analyzed mycotoxins in grain resulted mainly from the suppressed growth of *Fusarium* fungi on durum wheat spikes and lower severity of FHB.

The results of this study indicate that yeasts colonizing wheat grain can be applied as biological treatments to decrease DON and CUL concentrations in grain. Yeasts have a complex mechanism of action and are sensitive to environmental factors. Yeast biocontrol mechanisms represent unexplored field of research and plentiful opportunities for the development of commercial, yeast-based applications for plant protection.

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