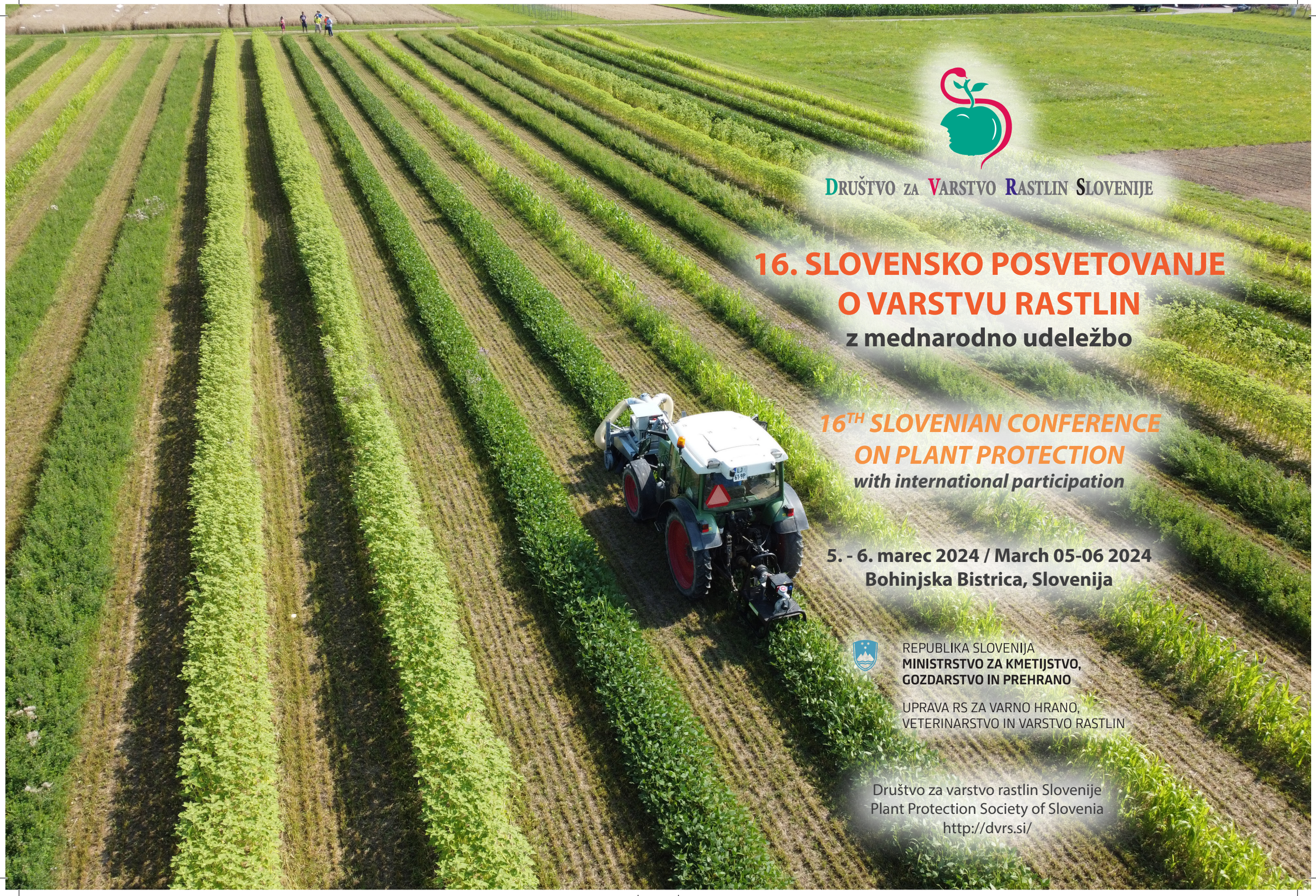

DRUŠTVO ZA VARSTVO RASTLIN SLOVENIJE

16. SLOVENSKO POSVETOVANJE O VARSTVU RASTLIN

z mednarodno udeležbo

16TH SLOVENIAN CONFERENCE ON PLANT PROTECTION

with international participation

5. - 6. marec 2024 / March 05-06 2024
Bohinjska Bistrica, Slovenija

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA KMETIJSTVO, GOZDARSTVO IN PREHRANO

UPRAVA RS ZA VARNO HRANO, VETERINARSTVO IN VARSTVO RASTLIN

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Izvlečki referatov / *Abstract volume*

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Izvlečki referatov 16. Slovenskega posvetovanja o varstvu rastlin z mednarodno udeležbo, Bohinjska Bistrica 2024
Izdajatelj Društvo za varstvo rastlin Slovenije
Urednik prof. dr. Stanislav TRDAN
Tehnični urednik in oblikovalec prof. dr. Stanislav TRDAN
Tisk Cicero, Begunje, d.o.o.
Naklada 250 izvodov
Ljubljana, 2024

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

632(082)

SLOVENSKO posvetovanje o varstvu rastlin z mednarodno udeležbo (16 ; 2024 ; Bohinjska Bistrica)
Izvlečki referatov = Abstract volume : 16. slovenskega posvetovanja o varstvu rastlin z mednarodno udeležbo = 16th Slovenian Conference on Plant Protection with International Participation : 5.-6. marec 2024, Bohinjska Bistrica, Slovenija / [urednik Stanislav Trdan]. - Ljubljana : Društvo za varstvo rastlin Slovenije = Plant Protection Society of Slovenia, 2024

ISBN 978-961-96561-0-5
COBISS.SI-ID 184714499

Pokrovitelj:

Uprava Republike Slovenije za varno hrano, veterinarstvo in varstvo rastlin

Sponzorji:

Corteva Agriscience SLO d.o.o.
Semenarna d.o.o.

Posvetovanje so podprli:

Albaugh Europe Sàrl
Bayer d.o.o.
Efos informacijske rešitve d.o.o.
Iskra PIO d.o.o.
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KAZALO

Uvodni referati

Classical biological control in New Zealand: an overview of the history, its regulatory system, and future prospects

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The threat of non-native invasive species poses a significant risk to global biodiversity and food security, resulting in substantial economic losses every year. This risk has been exacerbated by the growth of global trade, tourism, and climate change. In recent years, there has been a notable rise in the invasion of countries by insect pest species. Many of these insect pests (e.g., brown marmorated stink bug, spotted wing drosophila, spotted lanternfly) are highly polyphagous and pose significant biosecurity risks to agricultural and horticultural industries worldwide. Classical biological control is a recognized and commonly used strategy for managing populations of invasive insect pests and has often proved highly cost effective. It involves introducing a non-native biological control agent to permanently control the target pest. However, the deliberate introduction of an exotic biological control agent is subject to regulatory measures, including a rigorous risk assessment and review process. This process is often time-consuming and may take several years to complete. New Zealand has a long history of classical biological control programmes, with over more than 750 introductions of biological control agents conducted to date against several invasive insect pests. In New Zealand, the Environmental Protection Authority (EPA) is the regulatory agency responsible for regulating, under the Hazardous Substances and New Organisms Act 1996, the importation and development in containment and release of new organisms (incl. biological control agents). A recent notable example of an EPA release approval was the conditional release approval of a pre-emptive application for the release of the *Trissolcus japonicus* (samurai wasp) in the event of a brown marmorated stink bug (BMSB) incursion. This presentation will provide an overview of classical biological control in New Zealand, explain how its regulatory system works, and highlight a recently adopted novel approach to classical biological control (i.e., pre-emptive biocontrol) to enhance current and future preparedness efforts against high-risk insect pests.

IZVLEČEK

Klasično biotično varstvo na Novi Zelandiji: pregled zgodovine, zakonodaje in obeti za prihodnost

Tujerodne invazivne vrste predstavljajo veliko tveganje za svetovno biotsko raznovrstnost in prehransko varnost, kar vsako leto povzroči znatne gospodarske izgube. To tveganje se je povečalo zaradi rasti svetovne trgovine, turizma in podnebnih sprememb. V zadnjih letih je prišlo do opaznega porasta vdorov škodljivih vrst žuželk v države. Mnoge od teh žuželk (npr. marmorirana smrdljivka, plodova vinska mušica, *Lycorma deliculata*) so zelo polifagne in predstavljajo veliko tveganje za biološko varnost poljedelske in hortikulturne industrije po vsem svetu. Klasično biolotično varstvo je priznana in pogosto uporabljena strategija za obvladovanje populacij invazivnih škodljivih žuželk in se je pogosto izkazala za zelo stroškovno učinkovito. Vključuje uvedbo tujerodnega koristnega organizma za trajno zatiranje ciljnega škodljivca. Vendar pa je namerna uvedba tujerodnega koristnega organizma za zatiranje škodljivega organizma predmet regulativnih ukrepov, vključno s strogim postopkom ocene tveganja in pregleda. Ta postopek je pogosto dolgotrajen in lahko traja več let. Nova Zelandija ima dolgo zgodovino klasičnih programov biotičnega

varstva, z več kot 750 vnosi koristnih organizmov, izvedenih do danes proti več invazivnim škodljivim žuželkam. Na Novi Zelandiji je Agencija za varstvo okolja (ang.: Environmental Protection Authority (EPA)) regulativna agencija, ki je v skladu z Zakonom o nevarnih snoveh in novih organizmih iz leta 1996 odgovorna za urejanje uvoza in razvoja pri zadrževanju in izpustu novih organizmov (vključno s koristnimi organizmi). Nedavni pomemben zgled odobritve Agencije za varstvo okolja za sprostitev koristnega organizma je bila pogojna odobritev preventivne (predhodne) vloge za izpustitev jajčnega parazitoida *Trissolcus japonicus* v primeru pojava marmorirane smrdljivke (BMSB). Ta predstavitev bo zagotovila pregled klasičnega biotičnega varstva na Novi Zelandiji, razložila, kako deluje njen regulativni sistem, in poudarila nedavno sprejet nov pristop k klasičnemu biotičnemu varstvu (tj. preventivno biotično varstvo), da bi izboljšali sedanja in prihodnja prizadevanja za pripravljenost na visoke na visoko tvegane škodljivce.

Let's talk about mass trapping: is it simply a tool for control?

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Mass trapping, based on the use of traps with attractant baits inside, is one of the oldest approaches to direct insect control. The first traps date back to the 17th century in England and were light traps for lepidopterans, while the first papers on the attraction of insects to odours were published in Germany and the United States in the 19th century. The studies on the olfaction in insects increased along the 20th century and German researchers proposed the term "pheromones" in 1959 to describe some compounds utilized by insects to communicate. All this new information aided in the use of traps and attractants for monitoring purposes, as well as in the development of control tactics like mass trapping or attract and kill. Publications on mass trapping studies at the field level for various pests began to increase in the 1970s, and this trend continued in the following decades, peaking in 2020 with 311 papers published on mass trapping or some of its related aspects. These studies deal with the mass trapping of fruit trees, grapevines, olive trees, rice, cotton, citrus fruits, stored products, tea, and forest trees, among others. The majority focused on the use of attractants (pheromonal or food-based) as the system's foundation; however, others have employed alternative stimuli such as light of various wavelengths or colored sticky traps. According to the theoretical premise, mass trapping entails setting a high density of traps in the crop to be protected with the goal of killing a sufficiently large proportion of individuals to keep the pest population at levels that do not cause economic damage. Although, in practice, the application of this method is quite complex because there are several influencing factors, such as the effectiveness of the attractant (pheromonal, food-based, light, chromatic, etc.) and the trap design, the level of pest and its distribution in the field, the cost of the whole equipment, a thorough understanding of the biology of the insect pest and its relationship with the crop, and the proper design of the methodology for each crop species in which it will be used. Furthermore, two other factors must be considered: the first, making the mass trapping system compatible with the control of other pests and diseases, that is, introducing it into an integrated pest management plan; and the second, but not less important, gaining the farmer's trust. To demonstrate the practical application of mass trapping, two case studies will be presented: the development and

implementation of a control system for the medfly (*Ceratitis capitata*) at the orchard and wide-area levels, and the current status of mass trapping for BMSB (*Halyomorpha halys*). Finally, the benefits and drawbacks of using mass trapping are examined considering the legal and social requirements of Europe in the 21st century.

IZVLEČEK

Pogovarjajmo se o metodi masovnega lovljenja: je res le orodje za zatiranje škodljivcev?

Masovno lovljenje, ki temelji na uporabi pasti s privabilnimi vabami v notranjosti, je eden od najstarejših pristopov neposrednega zatiranja žuželk. Prve pasti segajo v 17. stoletje v Anglijo in so bile svetlobne pasti za metulje, medtem ko so bili prvi članki o zanimanju žuželk za vonjave objavljeni v Nemčiji in ZDA v 19. stoletju. Število študij o vonju pri žuželkah se je v 20. stoletju povečalo in nemški raziskovalci so leta 1959 predlagali izraz feromoni, da bi opisali nekatere spojine, ki jih žuželke uporabljajo za komunikacijo. Vse te nove informacije so pomagale pri uporabi pasti in atraktantov za namene spremljanja, pa tudi pri razvoju taktik zatiranja, kot sta masovno lovljenje ali privabi in ubij. Publikacije o študijah masovnega lovljenja na prostem za različne škodljivce so se začele povečevati v sedemdesetih letih prejšnjega stoletja in ta trend se je nadaljeval v naslednjih desetletjih in dosegel vrhunec leta 2020 s 311 članki, objavljenimi o masovnem ulovu ali nekaterimi z njim povezanimi vidiki. Te študije se med drugim ukvarjajo z masovnim lovljenjem na sadnem drevju, vinski trti, oljki, rižu, bombažu, citrusih, skladiščnih proizvodih, čaju in med drugim tudi na gozdnem drevju. Večina objav se je osredotočila na uporabo atraktantov (feromonskih ali živilskih) kot temelj sistema; drugi pa so uporabili alternativne dražljaje, kot je svetloba različnih valovnih dolžin ali barvne lepljive pasti. V skladu s teoretično predpostavko masovno lovljenje pomeni nastavitev visoke gostote pasti v posevku, ki ga je treba zavarovati, s ciljem uničenja dovolj velikega deleža osebkov, da se populacija škodljivcev ohrani na ravneh, ki ne povzročajo gospodarske škode. Vendar je v praksi uporaba te metode precej zapletena, ker obstaja več dejavnikov, ki vplivajo na uspešnost, kot je učinkovitost atraktanta (feromonski, na osnovi hrane, svetloba, barvna lepljiva plošča itd.) in zasnova pasti, številčnost škodljivca in njegove porazdelitve na zemljišču, stroški celotne opreme, temeljito razumevanje bionomije škodljive žuželke in njenega odnosa s pridelkom ter pravilna zasnova metodologije za vsako vrsto pridelka, v kateri se bo metoda uporabljala. Poleg tega je treba upoštevati še dva dejavnika: prvi, da je sistem masovnega lovljenja združljiv z zatiranjem drugih škodljivcev in bolezni, to je, da se ga vključi v celostni načrt zatiranja škodljivcev; in drugi, a nič manj pomemben, pridobivanje zaupanja kmeta. Za prikaz praktične uporabe masovnega lovljenja bosta predstavljeni dve študiji primera: razvoj in uvedba sistema zatiranja breskove muhe (*Ceratitis capitata* Wied.) na ravni sadovnjaka in na širšem območju ter trenutni status masovnega lovljenja za marmorirano smrdljivko (*Halyomorpha halys*). Na koncu bodo predstavljene prednosti in slabosti uporabe masovnega lovljenja glede na pravne in družbene zahteve Evrope v 21. stoletju.

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Varstvo poljščin in krmnih rastlin

Pomembna najdba rumenih krompirjevih ogorčic vrste *Globodera rostochiensis* na Gorenjskem

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Rumena krompirjeva ogorčica *Globodera rostochiensis* je v Sloveniji prisotna že več let. Prvič so jo odkrili leta 1971 v vasi Dobrava pri Dravogradu, kjer je bila ugotovljena prisotnost ene same ciste. Naslednja najdba datira v leto 1999, ko je bil ugotovljen nekoliko večji napad njive krompirja v Libeličah pri Dravogradu. V kasnejših letih je bila omenjena vrsta največkrat potrjena na Gorenjskem, ustaljena pa je na Bovškem in v Trenti. Na Gorenjskem je bila vrsta *G. rostochiensis* v sklopu rednega pregleda krompirišč ponovno najdena letu 2022. Za namen ugotavljanja razširjenosti in preprečevanja širjenja na območju tokratne najdbe smo v letu 2023 izvedli uradni nadzor za ugotavljanje razširjenosti (ang. »delimityng survey«) ogorčic *G. rostochiensis* na njivah lastnika, ki so namenjene pridelavi krompirja. Pregledane površine so zajemale vse njive, na katerih se je načrtovalo sajenje krompirja v letu 2023 in na katerih se je prideloval krompir v letih 2021 in 2022. V letu 2024 bomo vzorčili tudi njive, na katerih je bil krompir posajen vse od leta 2018. Pregledane so bile tudi vse površine v okolici njive s potrjeno prisotnostjo ogorčic *G. rostochiensis*. Analiza vzorcev zemlje je pokazala, da so na večjem številu njiv prisotne nevitalne ciste *G. rostochiensis*, v katerih ni bilo jajčec. Vitalne ciste, ki so vsebovale jajčeca oz. ličinke, so bile prisotne na skupno 3,5 ha pregledanih površin, kjer smo prisotnost živih ogorčic *G. rostochiensis* tudi potrdili z morfološkimi analizami ter analizami PCR. Ker gre za nevarnega zajedavca razhudnikovk, ki z večletnim nenadzorovanem razmnoževanju na obdelovalnih površinah lahko povzroči občutne izpade pridelka krompirja, je potreben stalni zdravstveni nadzor obdelovalnih tal, primeren kolobar z vključenimi odpornimi sortami krompirja ter ustrezna higiena obdelovalne mehanizacije.

ABSTRACT

Impotant detection of the yellow potato cyst nematode *Globodera rostochiensis* in Gorenjska region

The yellow potato cyst nematode *Globodera rostochiensis* has been present in Slovenia for several years. It was first discovered in 1971 in the village of Dobrava near Dravograd, where a single cyst was found. The next record dates back to 1999, when a slightly larger infestation was found in a potato field in Libeliče near Dravograd. In the following years, the species was detected several times in the Gorenjska region, and became established in the area of Bovec and Trenta. In 2022, *G. rostochiensis* was again found in Gorenjska region during a routine survey of potato fields. In order to determine its distribution and prevent it from spreading in the area of this find, an official delimiting survey for *G. rostochiensis* was carried out on the owner's potato fields in 2023. The surveyed areas included all fields intended for potato cultivation in 2023 and potato production in 2021 and 2022. In 2024, fields that have been planted with potatoes since 2018 will also be sampled. All areas around the field where *G. rostochiensis* was detected were also analysed. Analysis of soil the samples revealed the presence of non-vital cysts of *G. rostochiensis,* which did not contain eggs, in a large number of fields. Vital cysts containing eggs or larvae were present on a total of 3.5 ha of the investigated plots, where the presence of live nematodes of *G. rostochiensis* was also confirmed by morphological

and PCR analyses. The yellow potato cyst nematode is a dangerous parasite of Solanaceae plants that can cause significant yield losses in potatoes after years of uncontrolled infestation in the fields. It requires continuous monitoring of soil health, appropriate crop rotation with resistant potato varieties and appropriate hygiene of cultivation machinery.

***Ralstonia solanacearum*: tveganje pri uvozu in vloga laboratorijskega testiranja pri mednarodni trgovini s krompirjem**

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Ralstonia solanacearum (Rs) je karantenska bakterija, ki povzroča rjavo gnilobo krompirja. Uvrščena je v prilogo II, del B Izvedbene uredbe EU 2019/2072. Za preprečevanje širjenja Rs so bistveni ukrepi, kot so pregledi rastlinskega materiala, higiena v kmetijskih praksah in stroge fitosanitarne zahteve za premike in uvoz določenih gostiteljskih rastlin. Uvoz semenskega krompirja v EU je prepovedan iz vseh tretjih držav, razen Švice. Uvoz jedilnega krompirja je prepovedan iz večine tretjih držav, razen nekaterih sredozemskih, pod pogojem, da so izpolnjene posebne fitosanitarne zahteve. Egipt je pomemben pridelovalec krompirja, ki izvaža v različne regije in je največji izvoznik krompirja na trg EU. Pri nadzoru ob uvozu je v pošiljkah občasno ugotovljena prisotnost Rs, kar predstavlja tveganje za njen vnos in širjenje v EU. Luka Koper je v zadnjih letih postala ena izmed največjih vstopnih točk za uvoz krompirja s poreklom iz Egipta na trg EU. Za te pošiljke Inšpekcija za varno hrano, veterinarstvo in varstvo rastlin v skladu s predpisi EU (2011/787/EU) ob uvozu pregleda dokumentacijo in izvaja vizualne preglede z rezanjem gomoljev. V zadnjih petih letih smo v laboratoriju testirali več kot 700 vzorcev po 200 gomoljev. V vsaki uvozni sezoni se po en vzorec krompirja iz vsakega povodja v Egiptu, ki je določeno kot prosto Rs, dodatno laboratorijsko testira na latentno prisotnost Rs. EU predpis, ki določa ukrepe za Rs vključno z laboratorijskim testiranjem, se je leta 2022 spremenil in nam sedaj omogoča uporabo PCR v realnem času kot prvi presejalni test za detekcijo Rs. Vseh 700 vzorcev je bilo v laboratoriju pregledanih tudi vizualno s prerezom vsakega gomolja. Pri nobenem od prerezanih gomoljev nismo opazili simptomov rjave gnilobe, čeprav smo kasneje v dveh vzorcih potrdili latentno prisotnost Rs, kar sproža vprašanje o smiselnosti rezanja gomoljev pri vzorcih, ki se testirajo v laboratoriju.

ABSTRACT

***Ralstonia solanacearum:* import risk and the role of laboratory testing in international trade of potatoes**

Ralstonia solanacearum (Rs) is quarantine bacterium that causes brown rot of potatoes. It is listed in Annex II, part B of Commission Implementing Regulation (EU) 2019/2072. To prevent the spread of Rs, measures are important, such as regular inspections of plant material, hygiene in agricultural practices and strict phytosanitary requirements for the movement and import of certain host plants. Imports of seed potatoes from all third countries except Switzerland in the EU is prohibited. Import of ware potatoes is prohibited from most third countries, except some Mediterranean countries, provided that phytosanitary requirements are met. Egypt is a major potato producer exporting to different regions and is the largest exporter of potatoes to the EU market. At import control, presence of Rs bacterium has been confirmed occasionally in Egyptian potatoes which poses a risk for the introduction and spread of Rs in the EU. In recent years, the Port of Koper has become one of the largest entry points for the EU market. The consignments undergo checks at import by the Inspection for Food Safety, Veterinary Sector and Plant Protection in compliance with EU legislation (2011/787/EU), which includes documentary checks and visual inspections by cutting potato tubers. In the past five years, the laboratory has tested over 700 samples, each containing 200 tubers. During each import season, one sample from each sector or basin in Egypt, recognized as free from Rs, shall be subjected to laboratory testing for the latent presence of Rs. The EU legislation on measures for Rs including laboratory testing, was changed in 2022 and now allows us to use real-time PCR as the first screening test for the detection of Rs. All 700 samples were also visually checked by cutting each tuber. No symptoms had been observed on any of the cut tubers, although the latent presence of the bacterium was later confirmed in two samples, which raises the question of the usefulness of cutting tubers of samples tested in the laboratory.

Preizkušanje transgenih linij krompirja sorte Désirée za odpornost proti koloradskemu hrošču (*Leptinotarsa decemlineata* Say)

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Kljub dolgoletnim izkušnjam z zatiranjem koloradskega hrošča (*Leptinotarsa decemlineata* Say) (Coleoptera, Chrysomelidae), se zaradi zmanjševanja nabora učinkovitih insekticidov in razvoja odpornosti proti aktivnim snovem njegova problematika pri pridelavi krompirja povečuje. Biotehnološki pristopi kot so metode genske transformacije, omogočajo izboljšavo odpornosti rastlin proti škodljivcem in predstavljajo pomembno in okoljsko bolj sprejemljivo alternativo kemičnim insekticidom. Nedavno dokazana specifična učinkovitost proteinskih kompleksov na osnovi egerolizinov iz gliv rodu *Pleurotus* proti koloradskemu hrošču kaže na potencial njihove uporabe pri razvoju odpornih rastlin krompirja. Z metodami genske transformacije smo gene za sintezo egerolizinskih proteinov in pleurotolizina B vnesli v krompir sorte Désirée. Insekticidni učinek na ličinke koloradskega hrošča smo preučevali na rastlinah, ki smo jih gojili v rastlinjaku. Pri eni izmed transformiranih linij smo ugotovili značilno povečanje smrtnosti in slabšo vitalnost ličink, ki je bila posledica izrazitega zmanjšanja prehranjevanja na listih. Ličinke, ki so se

hranile z listnim tkivom transformiranih rastlin posledično niso povzročile omembe vrednih poškodb na rastlinah in so bile v povprečju 6-krat lažje od ličink v kontroli. Poleg tega je le 37 % ličink, ki so se hranile na transformiranih rastlinah dokončalo svoj razvojni krog in se razvilo v odrasle hrošče.

ABSTRACT

Testing transgenic Désirée potato lines for resistance to the Colorado potato beetle (*Leptinotarsa decemlineata* Say)

Despite many years of experience in the Colorado potato beetle (*Leptinotarsa decemlineata* Say) (Coleoptera, Chrysomelidae) control, its problem in potato production is increasing due to the reduction of the range of effective insecticides and the development of resistance to active substances. Biotechnological approaches such as genetic transformation techniques enable the improvement of plant resistance to pests and represent an important and more environmentally friendly alternative to chemical insecticides. The recently demonstrated specific efficacy of the aegerolysin-based protein complexes from fungi of the genus Pleurotus against the Colorado potato beetle shows the potential of their use in the development of resistant potato plants. Genes for the synthesis of aegerolysin protein and pleurotolysin B were introduced into potatoes of the Désirée variety using genetic transformation methods. The insecticidal effect on the Colorado potato beetle larvae was studied on potted plants in greenhouse experiment. In one of the transformed lines, we found a significant increase in mortality and a decrease in vitality of the larvae, which was the result of severely reduced feeding. As a result, the larvae feeding on the leaf tissue of the transformed plants caused insignificant damage to the plants and were on average 6 times lighter than the larvae in the control group. In addition, only 37 % of the larvae that fed on the transformed plants completed their life cycle and developed into adult beetles.

Kombinirana uporaba več sevov entomopatogenih gliv rodu *Metarhizium* za zatiranje strun (Coleoptera: Elateridae) v krompirju

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Različne vrste in sevi gliv se lahko razlikujejo v stopnji virulence, ekoloških prilagoditvah in načinih delovanja, s katerimi lahko ob kombinirani uporabi prispevajo k sinergističnemu učinku in tako potencialno razširijo spekter zatiranja škodljivcev. V okviru projekta ECOBREED (št. pogodbe 771367) in programske skupine Kmetijstvo Naslednje Generacije (ARIS, P4-0431) smo preučevali različne pripravke na osnovi entomopatogenih gliv (EPG), zlasti *Metarhizium brunneum* in *Metarhizium robertsii*, za zatiranje strun (Elateridae) v krompirju. Testirali smo kombinacijo šestih sevov gliv rodu *Metarhizium* iz mikološke zbirke Kmetijskega inštituta Slovenije, in sicer v okviru štirih poljskih poskusov, dveh izvedenih v letu 2020 (A1 in A2) in dveh v letu 2021 (B1 in B2). Uporabljeni sevi so v predhodnih poskusih pokazali visoko virulenco proti rumenemu mokarju (*Tenebrio molitor*). Nanos pripravkov smo preizkušali v obliki treh formulacijah:

(a) namakanje gomoljev krompirja v suspenziji šestih sevov EPG (krompir + EPG), (b) formulacija šestih sevov EPG na rižu (krompir + riž), in (c) kombinacija obeh formulacij (krompir + EPG + riž). Te formulacije smo primerjali s komercialnim bioinsekticidom Attracap (Biocare GmbH, a.u. *M. brunneum* Cb15-III) v priporočenem (30 kg/ha) in polovičnem (15 kg/ha) odmerku. Komercialni insekticid Force 1,5 G (Syngenta, a.u. teflutrin) smo uporabili kot pozitivno kontrolo, netretiran krompir je predstavljal negativno kontrolo. Na lokaciji A1 je polovični odmerek Attracap-a značilno zmanjšal delež poškodovanih gomoljev za 23 %, na lokaciji A2 pa je obravnavanje krompir + EPG + riž značilno zmanjšalo delež poškodovanih gomoljev za 21 %. Na lokaciji B2 nobeno od obravnavanj ni značilno zmanjšalo deleža poškodovanih gomoljev, na lokaciji B1 pa so vsa obravnavanja značilno zmanjšala delež poškodovanih gomoljev, pri čemer je obravnavanje krompir + riž zmanjšalo delež poškodovanih gomoljev za 44 %. Uporaba več sevov gliv potencialno omogoča bolj prilagodljiv odziv na dinamičnost agroekosistema, kar zagotavlja učinkovitejšo strategijo zatiranja, ki je v skladu z načeli integriranega varstva rastlin.

ABSTRACT

Combined application of several strains of entomopathogenic fungi of the genus Metarhizium for wireworm (Coleoptera: Elateridae) control in potato

Fungal strains can have unique virulence factors, ecological adaptations, and modes of action that contribute to a synergistic effect that can broaden the spectrum of pest control when used together. As part of the ECOBREED project (Grant agreement No 771367) and PG Next Generation Agriculture (ARIS, P4-0431), our research focused on assessing various formulations based on entomopathogenic fungi (EPF), specifically *Metarhizium brunneum* and *Metarhizium robertsii*, for wireworm control in potatoes. We tested a combination of six fungal strains from the mycological collection of the Agricultural Institute of Slovenia within two field experiments conducted in 2020 (A1 and A2) and two in 2021 (B1 and B2). The EPF *Metarhizium* isolates used in the study demonstrated high virulence to yellow mealworm (*Tenebrio molitor*) in previous experiments. Our investigations covered three different formulations: (a) immersing potato tubers in a fungal suspension comprising all six isolates (potato + EPF), (b) fungi formulated on rice (potato + rice), and (c) combination of both treatments (potato + EPF + rice). We compared these approaches with the commercial bioinsecticide Attracap (Biocare GmbH, a.i. *M. brunneum* Cb15-III) at full (30 kg/ha) and half (15 kg/ha) dose, while the commercial insecticide Force 1,5 G (Syngenta, a.i. tefluthrin) served as a conventional control treatment alongside an untreated control group. In A1, half dose of Attracap significantly reduced the proportion of damaged tubers by 23 %, while in A2 potato + EPF + rice reduced the proportion of damaged tubers by 21 %. In B2, no treatment led to a significant reduction in the proportion of damaged tubers. In B1, all treatments significantly reduced the proportion of damaged tubers, with potato + rice reducing the proportion of damaged tubers by 44 %. The use of multiple fungal strains therefore allows for a more adaptive response to the dynamic and complex agricultural environment, ensuring a more resilient and adaptable control strategy, that is in line with the principles of integrated pest management.

Napovedovanje pomanjkanja vode z uporabo hiperspektralnega slikanja in globokega učenja

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Na uspešnost pridelave krompirja lahko vplivajo stresni dejavniki, zlasti suša in vročina. Hiperspektralno slikanje in modeli globokega učenja ponujajo obetavno rešitev, saj lahko z njimi na neinvaziven način zaznamo spektralne in prostorske spremembe rastlin. Čeprav modeli globokega učenja učinkovito zaznavajo stresne dejavnike, so izzivi, kot sta "prekletstvo dimenzionalnosti" in pretirano prilagajanje modelov, še vedno prisotni, kar zahteva tehnično znanje za modeliranje. V raziskavi, ki je bila izvedena na Kmetijskem inštitutu Slovenije, smo dve sorti krompirja (KIS Krka - odporna na sušo in KIS Savinja - občutljiva na sušo), izpostavili pomanjkanju vode. Z uporabo sistema dveh hiperspektralnih senzorjev in konvolucijske nevronske mreže (CNN) z mehanizmom pozornosti smo identificirali rastline s pomanjkanjem vode. Pri obravnavanju KIS Krka se je model izkazal za učinkovitega, saj je dosegel AUC-ROC 0,74. Pri obravnavanju KIS Savinja je bila učinkovitost modela manjša, saj je model v povprečju dosegel AUC-ROC 0,64. Točnost, priklic in rezultati F1 so pokazali robustnost modela in možnost zgodnjega zaznavanja pomanjkanja vode. Poleg tega je študija pokazala, da je imelo ključno vlogo več spektralnih območij, npr. 475-580 nm, 660-730 nm, 940-970 nm, 1420-1510 nm, 1875-2040 nm in 2350-2480 nm. Uporabljena metodologija globokega učenja izpostavlja izzive pri razlikovanju obravnavanj zaradi podobnih spektralnih podpisov, pri čemer poudarja pomen spektralno-prostorskih informacij. Spektralne analize poudarjajo vloge klorofila in vsebnosti vode v vidnem in bližnjeinfrardečem ter kratkovalovnem infrardečem spektru, kar pomaga pri oceni fiziološkega stanja rastlin. Ugotovitve raziskave so uporabne pri snovanju natančnega kmetijstva, saj omogočajo optimalno dodeljevanje virov in pospešeno izbiro na sušo odpornih kultivarjev. Poleg tega omogočajo uporabo daljinskega zaznavanja za ciljno usmerjeno upravljanje vode v spreminjajočih se podnebnih razmerah.

ABSTRACT

Lack of water detection by utilization of hyperspectral imaging and deep learning

Potatoes, crucial for global food security, face growth hindrance from stress factors, notably drought and heat. Hyperspectral imaging (HSI) and deep learning models offer a promising solution, capturing spectral and spatial plant variations. While deep learning models effectively detect stressors, challenges such as the "curse of dimensionality" and model overfitting still persist, requiring technical expertise for modeling. Our study at the Agricultural Institute of Slovenia focused on two potato cultivars, KIS Krka (drought-resistant) and KIS Savinja (drought-sensitive), exposed to water-restriction conditions. Employing a HSI dual-sensor setup and a Convolutional Neural Network (CNN) with an attention mechanism, we identified water-deficient plants. KIS Krka demonstrated superior performance, achieving an AUC-ROC of 0.74. In contrast, KIS Savinja showed lower performance, averaging an AUC-ROC of 0.64. Precision, recall, and F1 scores indicated the model's robustness and possiblity for early detection of drought stress. Additionally, the study revealed that sveral spectral spectral regions, e.g. 475 – 580 nm, 660 – 730 nm, 940 – 970 nm, 1420 – 1510 nm, 1875 – 2040 nm, and 2350 – 2480 nm, played key roles. Our novel attention-based deep learning framework underscores challenges in treatment differentiation due to similar spectral signatures, emphasizing spectral-spatial information's significance. Spectral analyses highlight chlorophyll and water content roles in visible to infrared and short-wave infrared spectrum, aiding physiological assessment.

The study's findings contribute to precision agriculture, enabling optimized resource allocation and accelerated selection of drought-tolerant cultivars. Additionally, it advances remote sensing applications for targeted water management amid changing climatic conditions.

Analiza ustreznosti podnebnih značilnosti Slovenije za preživetje ameriške koruzne sovke (*Spodoptera frugiperda* [J.E. Smith]) in njenih parazitoidov

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Ameriška koruzna sovka (*Spodoptera frugiperda* Smith), ki po svetu povzroča veliko gospodarsko škodo na poljščinah, se v zadnjih letih nezadržno širi iz toplejših krajev proti severu, tudi Sloveniji. V letu 2023 so jo že zaznali znotraj držav članic EU, zgodaj jeseni v Grčiji, novembra pa še v Romuniji. Zaradi širokega nabora gostiteljskih rastlin in precejšnje prilagodljivosti obstaja možnost, da se bo s časom razširila tudi v Sloveniji. Za namen lažje razporeditve sredstev za spremljanje pojavnosti in ukrepanje ob pojavu, smo izvedli analizo primernosti okoljskih dejavnikov za preživetje sovke v Sloveniji za trenutne podnebne razmere, pa tudi za več scenarijev, kjer je bil upoštevan vpliv podnebnih sprememb. Kot orodje za napoved smo uporabili računalniški model, ki temelji na podatkih o značilnosti podnebja v krajih, kjer so že zabeležili prisotnost škodljivca. Osnovni model s podatki o podnebnih značilnostih in trenutni dejanski razširjenosti sovke na svetovni ravni, smo dopolnili s podrobnejšimi trenutnimi podnebnimi podatki ARSO za Slovenijo in podnebnimi projekcijami regionalnih podnebnih modelov projekta EURO-CORDEX. Rezultati so nam omogočili izdelavo kart s prikazanimi modeliranimi napovedmi verjetnosti, kje na območju Slovenije obstaja večja verjetnost pojava sovke ob trenutnih podnebnih razmerah in različnih scenarijih podnebnih sprememb za 21. stoletje. Analizo smo v nadaljevanju ponovili še za štiri parazitoide *S. frugiperda*, ki so glede na pregled obstoječe literature potencialno najbolj primerni za podnebne značilnosti v Sloveniji. Tudi zanje so bile izdelane karte, kjer je prikazana ustreznost podnebnih značilnosti za preživetje parazitoidov trenutno in v prihodnosti. Na podlagi rezultatov obeh analiz bo mogoče na območja z večjo verjetnostjo pojavnosti ameriške koruzne sovke preusmeriti več sredstev za spremljanje in ukrepanje ob pojavu, na območjih, potencialno primernih za preživetje parazitoidov pa bi lahko preučili tudi možnost njihove predhodne naselitve.

ABSTRACT

Assessment of Slovenia's Climatic Suitability for the Survival of Fall Armyworm (*Spodoptera frugiperda* [J. E. Smith]) and its Parasitoids: A Scientific Analysis

The fall army worm (FAW) (*Spodoptera frugiperda* Smith), which causes great economic damage to crops around the world, has been spreading unstoppably from warmer places to the north, including Slovenia, in recent years. In 2023, it was already detected within EU member states, in early autumn in Greece, and in November in Romania. Due to the wide range of host plants and considerable adaptability, there is a possibility that it will also spread into Slovenia. In order to facilitate the allocation of funds for monitoring and

acting upon occurrence, we assessed Slovenia's climatic suitability for the survival of FAW for the current climate conditions, as well as for several scenarios where the impact of climate change was considered. As a forecasting tool, we used a computer model based on climate data for places where the presence of the pest has already been recorded. The basic model with data on climate characteristics and the current actual distribution of the FAW at the global level was supplemented with more detailed current climate data for Slovenia and climate change projections for the 21st century based on the regional climate model data of the EURO-CORDEX project. The results enabled us to create maps with modeled predictions of the probability of where in Slovenia there is a higher probability of FAW occurrence given the current and future climate conditions under scenarios RCP4.5 and RCP8.5. After that, we repeated the analysis for four parasitoids of *S. frugiperda*, which, according to the review of the existing literature, are potentially the most suitable for the climate in Slovenia. Maps have also been made, showing the suitability of climatic characteristics for the survival of parasitoids now and in the future. Based on the results of both analyses, it will be possible to divert more resources for monitoring and action upon occurrence to areas with a higher probability of occurrence of the FAW, and in areas potentially suitable for the survival of parasitoids, the possibility of their previous settlement could also be examined.

Preučevanje učinkovitosti traktorskega sesalnika za žuželke pri zmanjševanju številčnosti stenic na privabilnih posevkih soje, lucerne, sirka in sončnic

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V letu 2023 smo izvedli poljski poskus, kjer smo preučevali okoljsko sprejemljivo metodo uporabe traktorskega sesalnika za žuželke, kot alternativo uporabi fitofarmacevtskih sredstev. Gre za mehanski način zatiranja različnih vrst ščitastih stenic (Pentatomidae) na izbranih pridelovanih rastlinskih vrstah. V poskusu smo uporabili štiri vrste poljščin (sirek, lucerno, sojo in sončnice), ki se lahko uporabljajo tudi kot privabilni posevki in s tem privabljajo najrazličnejše žuželčje vrste, tudi stenice omenjene družine. Poskus smo izvajali na laboratorijskem polju biotehniške fakultete v Ljubljani. Razdeljen je bil v 3 bloke. Znotraj posameznega bloka smo posejali po dve vrsti vsake od izbranih pridelovanih rastlin. Posejali smo sončnice (*Helianthus annuus*), sojo (*Glycine max*), sirek (*Sorghum bicolor*) in lucerno (*Medicago sativa*). Tekom rastne dobe smo traktorski sesalnik testirali trikrat. In sicer dne 18.7.2023, 11.8.2023 in 24.8.2023. Učinkovitost smo beležili tako, da smo primerjali pojavnost stenic na specifično izbranih mestih pred ter takoj po sesanju. Za namene popisovanja pojavnosti stenic smo se odločili za uporabo metode vizualnega pregleda rastlin na 10 različnih ratlinah ter 6 različnih lokacijah znotraj posamezne vrste, na vseh izbranih rastlinskih vrstah. Vsaka vrsta z izbranim posevkom je bila nato razdeljena še na 2 dela, saj smo poskušali ugotoviti tudi to ali hitrost sesanja ter pozicija sesalnih cevi sesalnika vplivata na končno učinkovitost izbrane metode zatiranja. V prispevku vam bomo predstavili učinkovitost traktorskega sesalnika ter nadaljne možnosti uporabe naprave za v bodoče.

ABSTRACT

Testing the efficacy of a tractor-mounted insect vacuum in reducing true bugs abundance in soybean, alfalfa, sorghum and sunflower as trap crops

In the year 2023, we conducted a field experiment to explore an environmentally friendly approach utilizing a tractor-mounted insect vacuum as an alternative to the use of chemical pesticides. This method involves mechanical suppression of various species of shield bugs (Pentatomidae) on selected cultivated plant species. Four types of crops (maize, alfalfa, soybeans, and sunflowers) were used in the experiment, chosen for their attractiveness to shield bugs of the mentioned family. The experiment took place on the laboratory field of the biotechnical faculty in Ljubljana, and was divided into three blocks. Within each block, two rows of each selected crop were sown, including sunflowers (*Helianthus annuus*), soybeans (*Glycine max*), sorghum (*Sorghum bicolor*), and alfalfa (*Medicago sativa*). The efficacy of the tractor-mounted vacuum was tested three times during the growing season on July 18, 2023, August 11, 2023, and August 24, 2023. We measured efficacy by comparing the occurrence of shield bugs at specific locations before and immediately after vacuuming. To record the occurrence of shield bugs, we employed a visual inspection method on ten different plants and six different locations within each row, covering all selected plant species. Each row was further divided into two parts to investigate whether vacuuming speed and the position of the vacuum nozzle influenced the overall efficacy of the chosen suppression method. In this contribution, we will present the efficacy of the tractor-mounted vacuum and potential future implementations of the device.

Paritvena aktivnost samičk koruzne vešče (*Ostrinia nubilalis*): pomembna metodika pri integriranemu varstvu rastlin?

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Koruzna vešča (*Ostrinia nubilalis* (Hübner) (Lepidoptera, Crambidae) je v Sloveniji pomembna škodljivka, ki povzroča ekonomsko škodo predvsem na koruzi (*Zea mays* L.) in hmelju (*Humulus lupulus* L.). Zelo pogosto jo najdemo tudi na vrtninah in okrasnih rastlinah. V Sloveniji ima dve generaciji letno. Gosenice prve generacije poškodujejo predvsem stebla, gosenice druge pa tudi koruzne storže in storžke hmelja. Gosenice povzročajo neposredno škodo s prebadanjem različnih delov gostiteljskih rastlin, povzročajo pa tudi posredno škodo. Na območjih, kjer so gosenice aktivne, na primer na koruznih storžih, se lahko naselijo glive, ki potencialno proizvajajo mikotoksine. Za uspešno obvladovanje koruzne vešče je zelo pomembno natančno poznavanje njene biologije, velikost populacije, čas parjenja, čas odlaganja jajčec, pojav prvih gosenic, pogostost parjenja, kar se meri s prisotnostjo spermatoforov pri samici. Najučinkovitejša metoda za spremljanje metuljev koruzne vešče je s pomočjo klasične svetlobne vabe, s katero poleg samcev ujamejo tudi samice. Na hmelju kot tudi na koruzi je na polju težko najti odložena jajčeca koruzne vešče, še posebej v začetku posamezne generacije, ko je populacija še nizka. Dober pokazatelj paritvene aktivnosti koruzne vešče je prisotnost spermatoforov v reproduktivnem organu samic (lat. *bursa copulatrix)*. V laboratoriju smo

uvedli metodo preverjanja paritvene aktivnosti samic koruzne vešče. Osnovni namen raziskave je bil, da bi v prihodnosti paritveno aktivnost samičk koruzne vešče lahko uporabili za napoved odlaganja jajčec in posledično pojava gosenic na gostiteljskih rastlinah.

ABSTRACT

The mating activity of females European Corn Borer, *Ostrinia nubilalis*: Is it an important methodology in integrated plant protection?

The European Corn Borer, ECB, (*Ostrinia nubilalis* (Hübner) (Lepidoptera, Crambidae) is an important pest in Slovenia, causing economic damage primarily to corn (*Zea mays* L.) and hops (*Humulus lupulus* L.). It is very commonly found on vegetables and ornamental plants as well. In Slovenia, the ECB has two generations per year. The larvae of the first generation primarily damage stems, while the larvae of the second generation also affect corn cones and hop cones. The larvae cause direct damage by piercing various parts of the host plants, and they also inflict indirect damage. In areas where the larvae are active, such as on the corn cones, fungi can establish themselves, potentially producing mycotoxins. For successful management of the ECB, precise knowledge of its biology is crucial. Key factors include the population size, mating time, egg-laying period, appearance of the first larvae, and the frequency of mating, which is measured by the presence of spermatophores in the female. The most effective method for monitoring ECB moths is through the use of classical light traps, which capture males and females. In both hops and corn fields, it is challenging to find deposited ECB eggs, especially at the beginning of each generation when the population is still low. A reliable indicator of ECB mating activity is the presence of spermatophores in the reproductive organ of females (lat. *bursa copulatrix*).

Relationship of concentration-time in phosphine fumigation on different species

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The protocols that have been proposed as quick diagnostics for the efficacy of phosphine against stored product insect species have been reported by many research groups. We evaluated different monitoring protocols for phosphine efficacy in adults of several major stored product beetle species. Adults of the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae), the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) and the confused flour beetle, *Tribolium confusum* Jacquelin du Val (Coleoptera: Tenebrionidae) were used in these trials. Different concentrations with exposure time were used here. After the termination of each fumigation, the vials were kept under stable conditions at 25 ºC and 65% relative humidity. Population growth was measured after each exposure interval. Our results show that the worst case scenario has

been proven to be the application of 200 ppm for 5 days, given that the survival was high, in the vast majority of the populations tested here. The most effective combination (concentration x exposure time) was at 300 ppm for 5 days, which can be utilized further in designing a widely adopted standardized protocol. In principle, exposure was found to be more important than the concentration. Acknowledgments: This research has been co-financed by the European Union and Greek national funds through the action "Investment Innovation Plans", in the framework of the Operational Program "Central Macedonia" (project code: KMP6-0077613), as part of the "PrecisionFEEDProtect: Precision protection of stored feed from entomological infestations using innovative technologies" project.

Integrated weed control in maize: sustainable solution to control ALS resistant Johnsongrass in Croatia

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Maize is one of the most important crops in Croatia (300,000 ha) and Johnsongrass is the predominant perennial weed species in some large maize growing areas, which is successfully controlled with ALS herbicides. However, in the Republic of Croatia, target-site resistance of Johnsongrass to ALS inhibitors (MoA HRAC group 2) was confirmed in 2017. The main objective of the work was to develop sustainable control methods against ALS resistant Johnsongrass populations in maize. Multi-year field trials (2018-2022) were established in Novaki Oborovski (45.723551, 16.22972) with the goal of controlling ALS - resistant Johnsongrass. In the five-year trials, different weed control measures were integrated (ploughing, crop rotations, inter-row tillage, use of different MoA) and evaluated how these measures contributed to the reduction of Johnsongrass population in the field and long-term rhizome mass in the soil. The results clearly showed that the integration of different weed control strategies significantly contributed to the reduction of ALS -resistant Johnsongrass (Plots 3-4-5; 2018 no.of shoot/m^2: 139-169-162, rhizome mass g/m^2: 727-1264-1400, 2022 no.of shoot/m^2: 2-0-3, rhizome mass g/m^2: 0). The use of different MoAs significantly reduced ALS-resistant Johnsongrass even in monocultures. The best control of ALS -resistant Johnsongrass was shown when the herbicide Adengo was followed by the herbicide Laudis (MoA HRAC group 27+ 2 fb MoA group 27) in combination with inter-row cultivation (efficacy average 91.9%). Integrated weed managment are the best solution in controlling resistant Johnsongrass, but also ensure long-term sustainable weed control.

Učinkovitost herbicidov za zatiranje plevela užitna ostrica (*Cyperus esculentus* L.) v koruzi

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V tehnoloških poskusih financiranih v okviru Javne službe v poljedelstvu in Javne službe varstva rastlin smo v letih 2022 in 2023 v posevku koruze preučevali učinkovitost herbicidov za zatiranje užitne ostrice (*Cyperus esculentus* L.). Užitna ostrica, je trdovraten plevel, ki se v zadnjih letih vse pogosteje pojavlja na pridelovalnih površinah in povzroča gospodarsko škodo pri pridelavi poljščin in zelenjadnic. Namen te študije je bil oceniti učinkovitost različnih herbicidov za zatiranje užitne ostrice ter hkrati oceniti morebiten vpliv herbicidov na gojeno rastlino. Na lokaciji Jablje smo v obeh letih zasnovali poskusa v bločni zasnovi z 20 obravnavanji, ki so obsegala netretirano kontrolo in pripravke z različnimi aktivnimi snovmi oz. kombinacijo le teh. V letu 2023 smo v poskus vključili aktivno snov halosulfuron, za katero smo pridobili dovoljenje za raziskave in razvoj. Halosulfuron je v tujini registriran za uporabo v različnih kulturah in izkazuje visoko učinkovitost zatiranja užitne ostrice. V obdobju vegetacije smo popisali plevelno floro ter ocenili pokrovnost in biomaso plevelov ter učinkovitost delovanja. Po spravilu koruze smo ovrednotili tudi pridelek. V prispevku so prikazani rezultati učinkovitosti posameznih herbicidov in kombinacij le-teh za zatiranje užitne ostrice.

ABSTRACT

The efficacy of herbicides for the control of yellow nutsedge (*Cyperus esculentus* L.) in maize

In the trials, which were carried out with financial support from the Public Service for Agriculture and the Public Service for Plant Protection, the efficacy of herbicides to control yellow nutsedge (*Cyperus esculentus* L.) in maize was investigated in 2022 and 2023. Yellow nutsedge, a persistent weed, has become increasingly widespread in cultivation areas in recent years, causing economic losses in crop and vegetable crops. The aim of this study was to evaluate the efficacy of different herbicides in controlling yellow nutsedge and at the same time to investigate the possible effects of the herbicides on the cultivated plants. Randomised complete block trials were set up at the Jablje site in both years, consisting of 20 treatments, including untreated controls and formulations with different active substances or their combinations. In 2023, the active substance halosulfuron was introduced into the trial, for which a research and development permit was granted. This active substance is approved abroad for various crops and is highly effective in controlling yellow nutsedge. Throughout the vegetation period, the weed flora was recorded and the coverage and biomass of the weeds as well as the efficacy of the treatments were evaluated. Grain yield was also evaluated after harvest. The results of the efficacy of the individual herbicides and their combinations for controlling yellow nutsedge are presented in this paper.

Razvoj diagnostične metode za terensko določanje viroida razpokanosti skorje agrumov (CBCVd) v hmelju

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Viroid razpokanosti skorje agrumov (CBCVd) povzroča neozdravljivo bolezen hudo viroidno zakrnelost hmelja, ki je v obdobju 2007–2022 v Sloveniji prizadela skoraj 500 ha hmeljišč (od 1500 ha). V predhodnih raziskavah smo razvili občutljive molekularne metode, ki omogočajo sočasno določanje več viroidov, ampak ne omogočajo fleksibilnega in hitrega določanja. Razvoj novih metod je nujen korak k odkrivanju novih žarišč in zajezitvi širjenja. Uporaba CRISPR sistema predstavlja velik potencial v rastlinski diagnostiki. V zadnjih letih je bil sistem razvit za določanje številnih patogenov, zaradi visoke občutljivosti, hitrosti in preproste uporabe. Sistem CRISPR ob predhodni namnožitvi tarče z metodo RPA in uporabi hitrih testov, omogoča določitev viroidov na terenu v manj kot 1 uri. Z namenom razvoja diagnostične metode CRISPR/Cas-RT-RPA za terensko določanje viroida CBCVd smo v raziskavi načrtovali in testirali začetne oligonukleotide za RT-RPA ter dobili prve pozitivne rezultate. Pomemben del razvoja CRISPR sistema predstavlja tudi optimizacija metod »hitre izolacije« za pripravo rastlinskih ekstraktov z namenom, da bomo lahko viroid CBCVd določili brez izolacije RNA. V raziskavi smo zato testirali različne načine za homogenizacijo rastlinskega tkiva. S testiranjem različnih metod »hitre izolacije« smo viroid CBCVd v rastlinskem ekstraktu potrdili z uporabo RT-PCR in RT-qPCR metode. Razvite metode tako kažejo potencial za uporabo na terenu. Razvoj metode, ki bo omogočala hitro določanje, brez predhodne izolacije RNA, hkrati pa bila občutljiva in primerna za uporabo na terenu, bo pomenil velik napredek pri raziskavah hmelja, kot rastlinski diagnostiki nasploh.

ABSTRACT

Development of diagnostic method for field detection of citrus bark cracking viroid (CBCVd) in hops

The citrus bark cracking viroid (CBCVd) causes an incurable severe hop stunt disease, which affected almost 500 ha (out of 1500 ha) of hop fields in Slovenia in the period 2007-2022. In previous research, we have developed sensitive molecular methods that allow multiplex detection of several viroids, but are not flexible and fast. The development of new methods is a necessary step towards detection of new outbreaks and limitation of further spread. A great potenitial in plant diagnostics is the use of CRISPR system. Over the past years, the CRISPR system has been developed to identify a number of pathogens, due to its high sensitivity, speed and ease of use. The CRISPR system, with pre-amplification of the target with RPA and the use of lateral flow assays, allows the detection of viroid in the field in less than 1 hour. With the aim of developing a CRISPR/Cas-RT-RPA diagnostic method for the field detection of the CBCVd viroid, we designed and tested primers for RT-RPA and obtained the first positive results. An important goal of the development of the CRIPSR system ia also the optimization of »fast isolation« methods for the preparation of crude extracts. With the aim to determine CBCVd viroid without RNA isolation. In the research, we therefore tested various methods for homogenization of plant tissue. By testing different »fast isolation« methods, we confirmed the CBCVd viroid in the crude extract using RT-PCR and RT-qPCR. The developed methods thus show potential for field use. The development of a method that

will allow fast detection, without prior RNA isolation, while being sensitive and suitable for field use, will represent a major advance in hop research as well as plant diagnostics in general.

Določanje tveganja za prenos viroida razpokanosti skorje agrumov (CBCVd) na hmelj (*Humulus lupulus* L.) prek kontaminiranih tal in s prepletom korenin

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Viroid razpokanosti skorje agrumov (CBCVd) je krožna RNA molekula velikosti 283–286 nukleotidov, ki povzroča agresivna bolezenska znamenja na hmelju (*Humulus lupulus* L.), kot so zakrnela rast, pokanje trt, vihanje listih robov in odmiranje korenike. Za CBCVd je znano, da se v hmeljiščih prenaša predvsem mehansko s kontaminiranim orodjem in opremo, na daljše razdalje pa z okuženim sadilnim materialom. Z namenom proučevanja ostalih poti prenosa smo v naši raziskavi določali možnost prenosa viroida CBCVd s kontaminiranimi tlemi in prepletom korenin okuženih in zdravih rastlin. V prvem poskusu smo izvedli lončni poskus, v katerem smo v parno sterilizirana tla in ne-sterilna tla posadili rastline, okužene z viroidom CBCVd, ki smo jih gojili 2 meseca. Sledila je odstranitev rastlin in vseh rastlinskih ostankov iz zemlje ter posaditev zdravih rastlin. Rastline smo prvič testirali na prisotnost CBCVd po 4 mesecih rasti in nato ponovno po dormanci v naslednji vegetaciji. V drugem poskusu smo v kontaminiranih hmeljiščih vzorčili tla v neposredni bližini korenin okuženih rastlin in tla uporabili za saditev zdravih rastlin hmelja. Rastline smo prvič testirali na prisotnost CBCVd po 2 mesecih in ponovno po dormanci v naslednji vegetaciji. V primeru obeh poskusov nismo potrdili prisotnosti CBCVd na testiranih rastlinah, kar nakazuje na nično tveganje prenosa viroida CBCVd s tlemi, ki ne vsebujejo ostankov okuženih rastlin. V tretjem poskusu smo proučevali možnost prenosa viroida s prepletom korenin okuženih in zdravih rastlin. V posamezne lonce smo skupaj paroma posadili okuženo in zdravo rastlino hmelja in z gnojenjem med obema rastlinama dodatno inducirali preplet korenin. Zgornje dele rastlin smo fizično ločili z mrežo in ločenimi vodili, s čimer smo preprečili stik zelenih delov in morebiten prenos viroida. Ob koncu rastne dobe smo ocenili preplet korenin in testirali rastline na prisotnost CBCVd. Testiranje je potrdilo prenos viroida CBCVd v obsegu 70 % rastlin.

ABSTRACT

Assessing the risk of Citrus bark cracking viroid (CBCVd) transmission via contaminated soil and root contact on hop (Humulus lupulus L.)

Citrus bark cracking viroid (CBCVd) is a circular RNA molecule with 283–286 nucleotides that causes aggressive symptoms on hop (*Humulus lupulus* L.) such as dwarfing, stunting, vine cracking, curling of leaf edges and rotting of roots. CBCVd viroid is mostly transmitted mechanically by exposing plants to contaminated tools and machinery used during the cultivation of hop gardens. Additionally, the viroid spreads extensively through infected planting materials. The purpose of the presented research was to assess the possibility of CBCVd transmission with contaminated soil and intertwined roots of infected

and healthy hop plants. In first experiment we conducted a pot trial, where we used steam-sterilized soil and nonsterile soil for planting CBCVd infected plants. Hop plants were grown for 2 months, removed, and the soil was sieved to eliminate organic infected particles. Healthy hop plants were then planted, after 4 months we analyzed all plants on the presence of CBCVd. This testing was repeated after the dormant period in the subsequent growing season. In the second experiment, we sampled soil nearby roots of CBCVd-infected plants in commercial hop gardens. The soil was sieved to eliminate any plant remains and used for planting healthy plants, which were tested for the presence of CBCVd after 2 months. Sampling and testing were repeated after plants dormancy. In both soil studies we did not confirm presence of CBCVd in hop plant, so we conclude that CBCVd could not be transmitted with contaminated soil with removed plant parts. In third experiment, we studied root transmission between CBCVd-infected hop plants and healthy plants. Each pair of CBCVd-infected and healthy plant was planted in one pot to stimulate the intertwining of roots. The upper parts of the plants were physically separated by a net to prevent any contact and possible infection through greener parts. Additionally, we employed extra fertilization to stimulate root interlacing. After growing season, we evaluated the rate of intertwined roots and tested plants for the presence of CBCVd before and after dormancy, where we found a high rate of infections since 70 % of healthy plants exhibited a positive infection with CBCVd.

Sistemi obdelave tal in herbicidi vplivajo na kritično obdobje za zatiranje plevela

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Velike izgube pridelka koruze (*Zea mays* L.) povzročajo pleveli, ki najbolj vplivajo na rast in razvoj gojenih rastlin v obdobju, imenovanem kritično obdobje za zatiranje plevela (CPWC). Za določitev tega obdobja v razvoju koruze smo v letu 2021, na površinah Kmetijskega inštituta Slovenije v Jabljah, izvedli poljski poskus v zgodnjem obdobju prehoda iz konvencionalnega v manj intenziven sistem konzervirajoče in sistem brez obdelave tal. Poskus je bil zasnovan v naključnih blokih s tremi sistemi obdelave tal: konvencionalna (CN), konzervirajoča (CS) in brez obdelave (NT), pri slednjem je bil pred setvijo uporabljen tudi neselektivni herbicid. Pleveli so bili odstranjeni ali puščeni do različnih razvojnih faz koruze: V3, V6, V9, V15 in R1; poleg tega sta bili vključeni tudi celo leto zapleveljena in celo leto čista površina (kontrola). Začetek in konec kritičnega obdobja za zatiranje plevela, v katerem je bila sprejemljiva izguba pridelka 5 %, sta bila določena z izračunom deleža od pridelka na celo leto čisti površini. Suha biomasa plevela je bila skozi celoten poskus najnižja v sistemu NT. Poleg tega je bil tudi CPWC najkrajši v NT sistemu (V3 do V12) v primerjavi s CN (V2 do R1) in CS sistemom (V2 do V12). Naša študija kaže, da intenzivni postopki obdelave tal, ki se izvajajo v CN sistemu obdelave ter uporaba neselektivnega herbicida pred setvijo v sistemu NT zakasnijo kritični čas odstranjevanja plevelov (CTWR) za več kot 14 dni. S tem se zmanjša potreba po zgodnji uporabi herbicidov po vzniku koruze. Ugotovitve v tej raziskavi lahko pridelovalcem koruze pomagajo zmanjšati stroške in izboljšati učinkovitost njihovih programov za zatiranje plevela.

ABSTRACT

Tillage systems and herbicides affect critical period of weed control

Major yield losses in maize (*Zea mays* L.) cultivation are caused by weeds, which affect growth and development of cultivated plants during the critical period of weed control (CPWC). To determine this period in development of maize, a field experiment was carried out in 2021 at Agricultural institute of Slovenia in Jablje, in the early transition period from conventional to less intensive conservation and no-tillage system. The experiment was designed in randomized blocks with three tillage systems: conventional (CN), conservation (CS) and no-tillage (NT). Weeds were removed or left until the beginning of different maize development stages: V3, V6, V9, V15 and R1; in addition, season-long weedy and season-long weed-free plots (as controls) were included. The beginning and the end of the critical period of weed control with the acceptable yield loss level (AYL) of 5% was determined by calculating the proportion of the maize yield in season-long weed-free plots. Dry weed biomass was the lowest throughout the experiment. Furthermore, the CPWC was also the shortest in the NT system (V3 to V12) compared to CN (V2 to R1) and CS system (V2 to V12). Our study shows that the intensive tillage practices performed in the CN system and the use of pre-sowing herbicide in the NT system delay the critical of weed removal (CTWR) by more than 14 days. This leads to reduction in the need for early application of post-emergence herbicides in maize. These findings could help maize producers reduce costs and improve the effectiveness of weed control programs.

Učinkovitost herbicidov, zmanjšanih odmerkov in mehanskega zatiranja plevelne vegetacije v ozimni pšenici

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Učinkovito upravljanje plevelne vegetacije je eden izmed najpomembnejših tehnoloških ukrepov za zagotavljanje visokih in kakovostnih pridelkov ozimne pšenice. V rastni sezoni 2022/2023 smo na Kmetijskem inštitutu Slovenije izvedli preučevanje različnih kemičnih in mehanskih postopkov uravnavanja plevelne vegetacije, kjer smo v pogojih visoke zapleveljenosti primerjali učinkovitost jesenske in spomladanske uporabe različnih odmerkov herbicidov ter mehanskega zatiranja s česalom. Preučevane aktivne snovi so vključevale mešanico pendimetalina, klorotolurona in diflufenikana (PKD), prosulfokarb (PSK), kombinacijo diflufenikana, penoksulama in florasulama (DPF) ter jodosulfuron (JDS). Rezultati so pokazali bistvene razlike v učinkovitosti med kemičnimi in mehanskimi postopki uravnavanja plevela, pri čemer so bili povprečni pridelki suhega zrnja ozimne pšenice pri uporabi herbicidov (4,5 t/ha) značilno večji od povprečnih pridelkov pri uporabi mehanskega zatiranja plevela (3,7 t/ha). Tudi povprečno število klasov pri uporabi herbicidov (626 m^{-2}) je bilo značilno večje v primerjavi z mehanskimi metodami uravnavanja plevela (550 m^{-2}). Jesenska uporaba herbicidov je bila značilno bolj učinkovita od spomladanskega kemičnega zatiranja tako po manjši količini plevelne biomase (69 g m^{-2} vs. 170 g m^{-2}), kakor po višjem doseženem pridelku suhega zrnja ozimne pšenice (4,6 t/ha vs. 3,8 t/ha). V postopku kombinacije polovičnih odmerkov PSK in DPF (PDPF) smo izmerili povprečni pridelek (5,0 t/ha), ki pa se statistično ni razlikoval

od postopkov z uporabo polnih odmerkov posameznih komponent. Kljub precejšnji zapleveljenosti, ki je v kontroli spomladi presegla 600 plevelov m^{-2} je v splošnem uporaba zmanjšanih odmerkov (50 %) herbicidov v večini primerov zadovoljivo uravnala plevelno vegetacijo. Pri tem smo ugotovili manjše izgube pridelka (od 3 do 8 %), ki pa se statistično niso razlikovali od pridelkov pri enakovrednih postopkih s polnim odmerkom herbicida.

ABSTRACT

Efficacy of herbicides, reduced dosages, and mechanical weed control in winter wheat

Effective weed management is one of the most important technological measures for ensuring high and quality yields of winter wheat. In the growing season 2022/2023, at the Agricultural Institute of Slovenia, we conducted a study of various chemical and mechanical weed control processes in conditions of high weed infestation. We compared the effectiveness of autumn and spring applications of different dosages of herbicides and mechanical control with a spring tine harrow. Active substances studied included a mixture of pendimethalin, chlorotoluron, and diflufenican (PKD), prosulfocarb (PSK), a combination of diflufenican, penoxsulam, and florasulam (DPF), and iodosulfuron (JDS). The results showed significant differences in effectiveness between chemical and mechanical weed control methods. The average dry grain yields of winter wheat were significantly higher with the use of herbicides (4.5 t/ha) compared to mechanical weed control (3.7 t/ha). The average number of wheat heads per square meter was also significantly higher with herbicide use (626 m-2) compared to mechanical weed control methods (550 m-2). Autumn application of herbicides was significantly more effective than spring chemical control in terms of both smaller amount of weed biomass (69 g/m² vs. 170 g/m²) and higher yield of dry grain of winter wheat (4.6 t/ha vs. 3.8 t/ha). In the process of combining half-doses of PSK and DPF (PDPF), we measured an average yield (5.0 t/ha), which did not differ statistically from the full dose treatments of individual components. Despite considerable weed infestation, which in the control exceeded 600 weeds m-2 in the spring, the use of reduced doses (50%) of herbicides in most cases satisfactorily controlled the weed vegetation. Here, we observed minor yield losses (from 3 to 8%), which did not differ statistically from the yields in equivalent processes with a full dose of herbicide.

Ocenjevanje tekmovalne sposobnosti sort ozimne pšenice (*Triticum aestivum* L.) proti plevelom z uporabo klasične in napredne fenotipizacije

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Ocenjevanje razlik v tekmovalnosti sort pšenice s pleveli in izbor bolj tekmovalnih sort zahteva identifikacijo relevantnih fenotipskih in genotipskih lastnosti in razvoj ustreznih metodologij za hitro in učinkovito oceno. Za dosego tega cilja smo na poljih Kmetijskega inštituta Slovenije izvedli tri ločene poskuse: poskus brez plevela (uporaba herbicidov za uničevanje plevela), poskus z ječmenom kot plevel (ostale plevele smo odstranili s

herbicidi) in naravno zapleveljen poskus (poskus (brez zatiranja plevela). Ti poskusi so potekali v treh zaporednih rastnih sezonah od 2020 do 2022 in so vključevali 12 sort pšenice. Spremljane lastnosti so vključevale pokrovnosti pšenice/plevela, biomaso, višino in število rastlin; število listov, listna površina in suha teža listov; pridelek zrnja in pridelek plevela. Opazovanja so bila opravljena v različnih stopnjah rasti pšenice, vključno z razraščanjem, kolenčenjem, cvetenjem in zorenjem. Ob klasičnem ocenjevanju lastnosti smo na poskusih zajemali tudi spektralne odzive z uporabo multispektralne kamere, nameščene na dron. Rezultati so pokazali korelacije med sposobnostmi oviranja razvoja plevela in ocenjenimi lastnostmi sort pšenice. Uporaba metode ječmena kot plevela se je izkazala kot natančnejša in je olajšala identifikacijo sort pšenice z boljšo tekmovalno sposobnost proti plevelu v primerjavi z naravno zapleveljenimi poskusi. Najmočnejše negativne korelacije so bile opažene med številom rastlin plevela ter višino, LAI in biomaso pšenice. Nasprotno, suha biomasa plevela je pokazala pozitivno korelacijo s številom plevelnih rastlin in negativno korelacijo z biomaso in višino pšenice. Šibke do zmerne korelacije smo opazili med pokrovnostjo rastlin in številom listov pšenice ali indeksom listne površine ter številom plevela/biomaso v različnih fazah rasti pšenice. Rezultati nakazujejo, da konkurenčna sposobnost pšenice zajema kombinacijo različnih lastnosti, kar otežuje hiter razvoj tekmovalnejših genotipov. Na podlagi suhe biomase plevelov bi testirane sorte lahko razvrstili v skupine z dobro tekmovalno sposobnostjo s pleveli (Primorka, Marinka, Bernstein in Vulkan); zmerno tekmovalno sposobnostjo s pleveli (Izalco CS, Savinja, Illico, Alixan, Gorolka, Reska); in nizko tekmovalno sposobnostjo s pleveli (CCB Ingenio, Tata Mata). Ta raziskava je bila del raziskovalnega programa »Agrobiodiverziteta« (P4-0072), ki ga je financirala Javna agencija za raziskovalno dejavnost RS, Ljubljana, Slovenija in del raziskovalnega projekta Ecobreed (Grant Agreement 771367), ki ga je financirala Evropska unija.

ABSTRACT

Assessing the competitive ability of winter wheat (*Triticum aestivum* L.) varieties against weeds

Assessing differences in weed competitiveness among wheat varieties and selection of competitive varieties for cultivation in systems without or with reduces use of herbicides, requires the identification of relevant characteristics and the development of appropriate methodologies for rapid and effective assessment. To achieve this objective, three distinct trials were conducted at Agricultural Institute of Slovenia: a weed-free trial (employing herbicides for weed elimination), a trial using barley as weed competitors (with weed removal using herbicides), and a naturally weed-infested trial (without any weed management). These trials spanned three consecutive growing seasons from 2020 to 2022 and involved 12 wheat varieties. The assessed traits included wheat/weed plant cover, biomass, height, and plant count; leaf count, leaf surface area and dry weight; grain yield and weed mimic yield. Observations were made during distinct growth stages, including booting, heading, anthesis, and ripening. The results highlighted correlations between the weed-suppressive abilities of winter wheat varieties and the evaluated traits. Utilizing the weed mimic method facilitated the identification of wheat varieties demonstrating superior weed suppression and traits influencing weed competitiveness. Furthermore, the method employing weed competitors proved more reliable in evaluating wheat's weed competitive ability, displaying less variation compared to naturally weeded trials. The strongest negative correlations were observed between the number of weed competitor plants and wheat height and biomass. On the contrary, the dry biomass of weed competitors showed a strong positive correlation with the number of competitor plants and a negative correlation with wheat biomass and height. However, weak to

moderate correlations were found between plant cover and wheat leaf count or Leaf Area Index and weed count/biomass across different wheat growth stages. Rather than being attributed to a single trait, competitive ability encompasses a combination of different traits. Based on the dry biomass of weed competitors, the tested varieties could be classified into groups displaying good weed competitive ability (Primorka, Marinka, Bernstein, and Vulkan); moderate weed competitive ability (Izalco CS, Savinja, Illico, Alixan, Gorolka, Reska); and low weed competitive ability (CCB Ingenio, Tata Mata). This research was a part of the research program “Agrobiodiversity” (P4-0072) funded by the Slovenian Research Agency, Ljubljana, Slovenia and a part of the research project Ecobreed (Grant agreement 771367) funded by the European Union.

Varstvo sadnega drevja, oljk in jagodičja

Strategija zatiranja krvave uši (*Eriosoma lanigerum* [Hausmann]) v nasadih jablan

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V letih 2021-2023 smo v štirih nasadih jablan na različnih lokacijah po Sloveniji izvajali večletne poskuse, v katerih smo spremljali pojav krvave uši ter preizkušali učinkovitost treh škropilnih programov (standardnega, integriranega in ekološkega) za njeno zatiranje. Sočasno smo spremljali tudi nalet krvavkinega najezdnika (*Aphelinus mali* [Haldeman], Hymenoptera, Aphelinidae), najpomembnejšega naravnega sovražnika krvave uši ter preučevali vpliv različnih obravnavanj na njegovo zastopanost. Velik vpliv na učinkovitost zatiranja krvave uši je imela začetna populacija škodljivca, ki se je razlikovala med lokacijami poskusa. Pri veliki izhodiščni populaciji krvave uši sta le standardni in integriran škropilni program omogočala učinkovito zmanjševanje populacije in preprečevala njeno prerazmnožitev tekom trajanja poskusa. Uporaba ekoloških pripravkov v nasadih z veliko populacijo krvave uši ni bila dovolj učinkovita. Populacija krvavkinega najezdnika se je med leti in lokacijami razlikovala. Uporaba insekticidov ni imela značilnega vpliva na njegovo populacijo in stopnjo parazitiranosti krvave uši. Na podlagi pridobljenih rezultatov smo osnovali učinkovito strategijo varstva jablan pred krvavo ušjo, ki temelji na tehnoloških in varstvenih ukrepih z minimalnim vplivom na populacijo krvavkinega najezdnika.

ABSTRACT

Control strategy of wooly aphid (*Eriosoma lanigerum* [Hausmann]) in apple orchards

In 2021-2023, we conducted multi-year experiments in four apple orchards at different locations in Slovenia, where we monitored the occurrence of the woolly aphid and tested the effectiveness of three spray programs (standard, IPM and organic) to control this pest. We also monitored the flight dynamics of the parasitoid wasp *Aphelinus mali* (Haldeman) (Hymenoptera: Aphelinidae), the most important natural enemy of the woolly aphid, and studied the influence of the investigated treatments on its abundance. The initial pest population, which varied between trial locations, had a major impact on the effectiveness of the different control strategies. In the case of a large initial population of woolly aphid, only standard and IPM program effectively reduced its population and prevented its proliferation over several years of the trial. The use of organic insecticides in orchards with a large woolly aphid population did not provide sufficient efficiency. The *A. mali* population varied between years and locations. The use of insecticides had no significant effect on its population and the level of parasitism. Based on the results obtained, we developed an effective strategy for the protection of apple trees against the woolly aphid with minimal effect on the population of *A. mali*.

Vpliv uporabe insekticidov, registriranih za zatiranje marmorirane smrdljivke v Sloveniji, na koristne vrste in na populacijo rdeče sadne pršice v nasadu jablan

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Marmorirana smrdljivka (*Halyomorpha halys* (Stål, 1855); [Hemiptera, Pentatomidae]) je predstavnik družine ščitastih stenic. Gre za invazivno, tujerodno in polifagno vrsto, ki izvira iz Vzhodne Azije. Sredi 90-ih je bila vnesena v ZDA ter leta 2004 v Evropo. Danes je prisotna v večini evropskih držav. V novih okoljih se hitro prilagaja in uspešno razmnožuje, pri čemer razvije najmanj en popoln rod letno. Z naraščanjem populacij postaja moteč dejavnik v urbanem okolju ter v zadnjem času eden najbolj nevarnih škodljivcev v kmetijski pridelavi. Zatiranje marmorirane smrdljivke s pomočjo fitofarmacevtskih sredstev je oteženo zaradi njene mobilnosti in odpornosti na sama sredstva. Sredstva, ki imajo določen učinek na populacijo marmorirane smrdljivke, pa lahko negativno vplivajo na populacijo plenilskih pršic in s tem povečujejo pojav rdeče sadne pršice. V letu 2021 smo v nasadu jablane izvedli škropilni poskus zatiranja marmorirane smrdljivke po EPPO standardu "PP1/313(1) - *Halyomorpha halys* on fruit tree crops". Primerjali smo delovanje dveh pripravkov, ki imata v Sloveniji dovoljenje za zatiranje marmorirane smrdljivke na jablani; Decis 2,5 EC in Mospilan 20 SG ter ocenili povzročeno škodo od stenic na plodovih in vpliv uporabe omenjenih pripravkov na populacijo plenilske pršice *Typhlodromus pyri* ter na pojav rdeče sadne pršice (*Panonychus ulmi*). Ugotavljali smo prisotnost plenilskih pršic na listih ter v zimskem času opravili štetje odloženih zimskih jajčec rdeče sadne pršice na dolžinski meter vejic.

ABSTRACT

Impact of the use of insecticides registered for the control of the brown marmorated stink bug (*Halyomorpha halys*) in Slovenia on the beneficial species and on the population of the european red spider mite in apple orchards

The brown marmorated stink bug (*Halyomorpha halys* (Stål, 1855); [Hemiptera, Pentatomidae]) is a member of the shielded stink bug family. It is an invasive, non-native and polyphagous species native to East Asia. It was introduced into the USA in the mid-1990s and into Europe in 2004. Today, it is present in most European countries. It adapts rapidly to new environments and reproduces successfully, developing at least one complete generation per year. As populations increase, it is becoming a nuisance in urban environments and, more recently, one of the most dangerous pests in agricultural production. The control of the brown marmorated stink bug by plant protection products is difficult due to its mobility and resistance to the products themselves. However, agents that have some effect on the brown marmorated stink bug population may have a negative impact on the predatory mite population, thereby increasing the incidence of european red spider mite. In 2021, a spraying trial was carried out in an apple orchard to control the brown marmorated stink bug according to the EPPO standard "PP1/313(1) - *Halyomorpha halys* on fruit tree crops". We compared the efficiency of two products licensed in Slovenia for the control of brown marmorated stink bug on apple trees; Decis

2.5 EC and Mospilan 20 SG and assessed the damage caused by stink bugs on the fruit and the impact of the use of these products on the population of the predatory mite *Typhlodromus pyri* and on the occurrence of the european red spider mite (*Panonychus ulmi*). The presence of predatory mites on leaves was determined and a count of the number of european red spider mite eggs laid per metre of twigs during the winter was carried out.

Primerjava kakovosti nanosa fitofarmacevtskih sredstev z ali brez uporabe elektrostatske podpore v nasadu jablan

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Uporaba elektrostatskih metod teoretično poveča depozit brozge fitofarmacevtskih sredstev (FFS) na ciljnih površinah. Danes so iskani podatki o tem, ali lahko nanos FFS prek dveh ali celo več vrst zagotovi enako kakovost zatiranja škodljivih organizmov (ŠO), kot nanos v vsaki vrsti. Nanos preko več vrst je še posebej zanimiv v ekološki pridelavi občutljivih sort jablan in drugih sadnih vrst, kjer je nanos EKO FFS potreben tudi 30 krat letno. V raziskavi izvedeni v letih 2021 in 2022 smo želeli pridobiti praktične podatke o učinkih škropljenja jablan z elektrostatsko podporo. V obeh letih smo testirali tudi sistem škropljenja preko dveh vrst, ki ga v praksi uporabljajo nekateri večji pridelovalci jablan. V poskusu v letu 2021 nismo uspeli potrditi hipoteze, da uporaba elektrostatike značilno izboljša uspešnost zatiranja škodljivih organizmov in da lahko škropljenje preko dveh vrst ob uporabi elektrostatike da enakovreden rezultat, kot škropljenje vsake vrste nasada jablan. V sezoni 2022 smo pri škropljenju preko dveh vrst povečali kapaciteto ventilatorja (iz 32000 m^3/h na 39000 m^3/h). Rezultati raziskave kažejo, da bi škropljenje preko dveh vrst morda lahko bilo enakovredno škropljenju pri vožnji po vsaki vrsti, če lahko ustrezno prilagodimo kapaciteto ventilatorja.

ABSTRACT

Comparison of the quality of the application of plant protection products with or without the use of electrostatic support in apple orchards

The use of electrostatic methods theoretically increases the slurry deposits of plant protection products (PPP) on target surfaces. Today, data is sought on whether the application of PPPs over two or even more rows at the same time can provide the same quality of pest control (PC) as application in each row respectively. Application over several rows at the same time is particularly interesting in the ecological production of sensitive varieties of apple trees and other fruit species, where the application of eco PPPs is required up to 30 times a year. The study was carried out in years 2021 and 2022. The main objective of the study was to obtain practical data on the effects of spraying apple trees with electrostatic support. In both years, we also tested the two-row spraying system, which is used in practice by some larger apple growers. In the experiment in season 2021, we failed to confirm the hypothesis that the use of electrostatic support significantly improves the success of pest control and that spraying

over two species using electrostatics can give an equivalent result to spraying each species of an apple orchard. In the season of 2022, we increased the fan capacity (from 32,000 m^3/h to 39,000 m^3/h) when spraying over two rows. The research shows that spraying over two rows might be equivalent to spraying in each row if we can correctly adjust the fan capacity.

Izkušnje z zatiranjem jablanovega škrlupa v letih 2021 in 2022

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Varstvo jablan pred jablanovim škrlupom se je po letu 2022 močno spremenilo. Fungicidom na osnovi aktivne snovi mankozeb je potekla registracija. Manjša ponudba kontaktnih fungicidov, kot tudi omejitve v številu tretiranj s posameznimi pripravki povečujejo nevarnost pojava odpornosti na posamezne skupine fungicidov. Zato smo v letu 2021 preizkusili tri različne programe varstva jablane proti jablanovemu škrlupu; program 'brez mankozeba', v katerega smo vključili v obdobju primarnih okužb sredstvi Vitisan in Curatio, standardni program in program 'z manj kaptana', kjer v drugem delu rastne dobe niso bili uporabljeni pripravki na osnovi aktivne snovi kaptan. V letu 2022 smo prav tako imeli tri različne programe varstva jablane proti jablanovemu škrlupu in sicer; standardni program (brez mankozeba), ekološki program in program ' brez kaptana'. V letu 2021 je bilo po končanem obdobju primarnih okužb v kontroli (neškropljeno) 86,5 % okuženih listov in 68,8 % plodov, v programu 'brez mankozeba' in ' brez kaptana' 2,0 % listov. V letu 2022 je bilo v kontroli okuženih 67,3 % listov in 3,7 % plodov, v standardnem programu 1,0 %, ' brez kaptana' 1,3 % in v ekološkem programu 1,3 % listov. V obeh letih pri ocenjevanju konec meseca maja, pri nobenem škropilnem postopku, ni bilo okužb na plodovih. V letu 2021 je bilo ob obiranju v škropilnem programu ' brez kaptana' 5,8 % okuženih plodov, v letu 2022 pa 4,3 %, kar pomeni, da so bila uporabljena sredstva dovoljena v ekološkem varstvu v drugem delu rastne dobe manj učinkovita kot pri standardnem programu v obeh letih, kjer je bilo 4,5 % oz. 3,3 % okuženih plodov.

ABSTRACT

Experiences with apple scab control in 2021 and 2022

The protection of apple trees against apple scab has changed considerably since 2022. Fungicides based on the active substance mancozeb have reached the end of their registration period. The reduced availability of contact fungicides, as well as the limitations in the number of treatments with individual products increases the risk of resistance to individual fungicide groups. Therefore, in 2021, three different programs of apple protection against apple scab were tested; a 'without mancozeb' program, which included Vitisan and Curatio during the period of primary infections, a standard program and a 'without captan' program, where no products based on the active substance captan were used during the entire part of the growing season. In 2022, we also had three different apple tree protection programs against apple scab, namely; the standard program 'without mancozeb', the organic program and the 'without captan' program. In 2021, after the end of the primary infection period, 86.5 % of the leaves and 68.8 % of the fruit were infected

in the control (unsprayed) and 2.0 % of the leaves in the 'without mancozeb' and 'without captan' programs. In 2022, 67.3 % of leaves and 3.7 % of fruit were infected in the control, 1.0 % in the standard, 1.3 % in the 'without captan' and 1.3 % in the organic programs. In both years, when evaluated at the end of May, no infections were observed on the fruit in any of the spray treatments. In 2021 and 2022, 5.8 % and 4.3 % of the fruits respectively were infected at harvest in the 'without captan' spray program, which means that the products registered for use in organic protection were less effective in the second part of the growing season than in the standard program in both years, where 4.5 % and 3.3 % of the fruits were infected respectively.

Preizkušanje učinkovitosti fungicidnih pripravkov za zatiranje listne luknjičavosti koščičarjev (*Stigmina carpophila* (Léveillé) Ellis, 1959) na marelicah

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Spremenljive vremenske razmere z izrazitimi temperaturnimi in padavinskimi nihanji ter omejitve glede uporabe sredstev za varstvo rastlin lahko privedejo do večjega pojava fitofagov in rastlinskih bolezni v nasadih koščičarjev. Med pomembne glivične bolezni koščičarjev, še zlasti marelic, uvrščamo listno luknjičavost koščičarjev (*Stigmina carpophila*). Pojav bolezni je izrazit predvsem na sortah San Castrese in Goldrich, ki sta med bolj zastopanimi v naših nasadih. Bolezenska znamenja mikoze se razvijejo na listih, brstih, na poganjkih ter na sadežih, kar je značilno predvsem pri marelicah (*Prunus armeniaca*). Na listih se na mestu okužbe sprva razvijejo vijolične pege, ki kasneje porjavijo. Tkivo v notranjosti peg odmre in izpade. Na listih nastanejo luknje. Pojav okužb z listno luknjičavostjo koščičarjev je izrazit zlasti v zadnjih letih, ko beležimo tople zime ter pogoste padavine v pomladanskem obdobju. Leta 2023 so bili za zatiranje glivične bolezni na marelicah registrirani pripravki na osnovi bakra, s katerimi se je lahko škropilo le v zimskem ter zgodnje-pomladanskem obdobju ter sredstvo na osnovi ditianona. S slednjim se lahko sadovnjake marelic škropi le v času od končanega obiranja do konca mirovanja. Glede na nabor fitofarmacevtskih sredstev je varstvo marelic v času cvetenja oz. razvoja plodov onemogočeno. Zaradi navedenega smo leta 2023 v dveh nasadih marelic v Planini nad Ajdovščino izvedli škropilni poskus, kjer smo v različna obravnavanja vključili škropljenja s sredstvi na osnovi kaptana ter fluopirama in tebukonazola in primerjali z obravnavanjem v katerem smo uporabili sredstvo na osnovi bakra. Poskus je bil zastavljen v dveh nasadih in je vključeval po dve ponovitvi vsakega obravnavanja. Ocena učinkovitosti škropilnega poskusa je bila opravljena na listih marelic. Dobljene rezultate smo ovrednotili s pomočjo analize variance. Iz poskusa je razvidno, da uporaba organskih fungicidov učinkovito zmanjša okužbe listne luknjičavosti koščičarjev na marelicah.

ABSTRACT

Testing of fungicidal products for the control of shot hole disease (*Stigmina carpophila* (Léveillé) Ellis, 1959) on apricots

Changing weather conditions, with extreme temperature and precipitation ranges and restrictions on the use of plant protection products, can lead to an increased incidence of phytophagous pests and plant diseases in stone fruit orchards. Among the important fungal diseases of stone fruit crops, especially apricots are the shot hole of stone fruits (*Stigmina carpophila*). The more susceptible cultivars for the disease are the San Castrese and Goldrich which are very common in our orchards. The symptoms of the mycosis can develop on the leaves, buds, shots and on fruits which is common especially on apricots (*Prunus armeniaca*). On the infected leaves purple spots develop at first, then the colour turns to brown. The leaf spot tissue dries out and fall from the leaf. The leaf now has a shot hole appearance. The occurrence of infections with shot hole of stone fruits disease is particularly severe in recent years, when we have recorded warm winters and frequent rainfall in the spring period. In the year 2023 in order to control the disease on apricots, there were registered products based on cupper. They can be used only for winter treatments and early spring spraying. Beside that a product containing dithianon is also registered on apricots and can be implemented only from end of harvesting until the end of winter dormancy. The registered products on apricots cannot allow the disease control during blooming or fruit ripening. Because of that in the year 2023 we performed a spray efficacy trial in two orchards in the location Planina near the town of Ajdovščina. The trial consists of different treatments that included the use of Captan based product, product containing Fluopyram and Tebuconazole and were compared with the efficacy of the cupric product. The efficacy trial was set in two orchards and was determined by two replicates per treatment. The treatment efficacy rate was performed on apricot leaves. The results were evaluated by the analysis of variance (ANOVA). The efficacy trial results confirmed that the use of organic fungicides reduces the infections of shot hole of stone fruits on apricots.

Preučevanje entomotoksičnih proteinov iz gob za zatiranje škodljivcev na kmetijskih rastlinah

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Entomotoksični rastlinski proteini predstavljajo velik potencial pri razvoju novih biopesticidov kot pomembna alternativa kemičnim insekticidom za zatiranje škodljivcev na gojenih rastlinah. V laboratorijskem poskusu smo preučevali izbrane entomotoksične proteine iz gob na ličinke treh gospodarsko pomembnih kmetijskih škodljivcev. S prehranskimi testi smo ovrednotili toksičnost izbranih lektinov in proteaznih inhibitorjev na ličinkah marmorirane smrdljivke *Halyomorpha halys* Stål (Heteroptera: Pentatomidae), plodove vinske mušice *Drosophila suzukii* [Matsumura] (Diptera: Drosophilidae) in koloradskega hrošča *Leptinotarsa decemlineata* Say (Coleoptera: Chrysomelidae). Proteine smo vključili v umetno hrano ali nanesli na listne diske ter dnevno spremljali vpliv na smrtnost in prehranjevanje žuželk. Dvaindvajset različnih proteinov iz gob (17 lektinov in

5 inhibitorjev proteaz) ni značilno povečalo smrtnosti nimf *H. halys*. Opazili smo tudi visoko občutljivost nimf *H. halys* za fosfatni pufer (PBS), ki se je uporabljal kot kontrola. Podobno smo pri ličinkah *D. suzukii* ugotovili netoksičnost za 17 lektinov iz gob, medtem ko so štirje izkazovali toksične učinke. Za dva najbolj toksična smo določili LC_{50} v območju 100 do 300 µg/ml. Iz nabora šestih entomotoksičnih lektinov iz gob, ki smo jih vključili v prehranjevalne teste z ličinkami koloradskega hrošča, je le en lektin značilno povečal smrtnost in zmanjšanje prehranjevanja. S preiskavo smo znova potrdili, da proteini iz gob predstavljajo zanimivo alternativo za razvoj novih biopesticidov s specifičnim delovanjem.

ABSTRACT

Effects of entomotoxic proteins from mushrooms on agricultural pests

Entomotoxic plant proteins represent a significant potential for the development of new biopesticides as important alternatives to chemical insecticides with high potential for pest control in cultivated plants. In a laboratory experiment, we tested selected entomotoxic proteins from higher fungi on the larvae of three economically important agricultural pests. Using feeding tests, we investigated the toxicity of selected lectins and proteinase inhibitors on the larvae of the brown marmorated stink bug *Halyomorpha halys* Stål (Heteroptera: Pentatomidae), the spotted wing drosophila, *Drosophila suzukii* [Matsumura] (Diptera: Drosophilidae) and the Colorado potato beetle *Leptinotarsa decemlineata* Say (Coleoptera: Chrysomelidae). The proteins were incorporated into artificial diets or applied to leaf discs and the effects on insect mortality and feeding were monitored daily. Twenty-two different mushroom proteins (17 lectins and 5 protease inhibitors) did not significantly increase the mortality of *H. halys* nymphs. We also observed a high sensitivity of *H. halys* nymphs to phosphate buffer (PBS), used as a control. Similarly, in *D. suzukii* larvae, we found no toxicity for 17 mushroom lectins, while four showed toxic effects. For the two most toxic, the LC_{50} was determined in the range of 100 to 300 µg/ml. From a set of six entomotoxic mushroom lectins used in feeding tests with Colorado potato beetle larvae, only one lectin significantly increased mortality and reduced feeding. This study has once again confirmed that proteins from mushrooms represent an interesting alternative for the development of new biopesticides with specific activity.

Glivične bolezni leske v Sloveniji

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Navadna leska (*Corylus avellana*) je pomembna gojena sadna vrsta, ki je razširjena v gozdnih sestojih, kot pionirska vrsta pa tudi zarašča opuščene kmetijske površine. V

Sloveniji je v zadnjih letih razviden trend povečevanja števila kmetijskih gospodarstev, ki se ukvarjajo s pridelavo lešnikov, kot tudi povečevanje kmetijskih površin namenjenih gojenju leske. Leska v kmetijski pridelavi velja, na prvi pogled, za nezahtevno kulturo, kar pa ne odraža realnega stanja. S širjenjem pridelave se povečujejo tudi težave, s katerimi se srečujejo pridelovalci predvsem na področju varstva rastlin. Na leskah se pojavljajo mnogi povzročitelji bolezni, med katerimi so tudi številne gospodarsko pomembne glive. Podnebne spremembe, ki omogočajo ugodnejše razmere za širjenje in razmah glivičnih bolezni, pojav novih tujerodnih gliv ter pomanjkanje fitofarmacevtskih sredstev, so trenutno največji izzivi v zdravstvenem varstvu leske, ki zahtevajo sistematičen pristop pri obvladovanju. V letu 2020 smo prvič potrdili pojav nove vrste pepelovke leske (*Erysiphe corylacearum*) in bolezni rjavenja listnih pecljev, ovojev in plodov leske (*Elsinoe coryli,* sinonim *Sphaceloma coryli*). Obe bolezni spadata med bolj nevarne in gospodarsko pomembne bolezni leske. Invazivna vrsta *E. corylacearum* povzroča obširne okužbe listov, ovojnih listov plodov in celo prezgodnje odpadanje plodov. Vrsta *E. coryli* povzroča nekrotične lezije na listnih pecljih, listnih žilah, mladikah, zelenih ovojnicah plodov ter na plodovih, ki ob zgodnji okužbi zastanejo v rasti in predčasno odpadejo. O škodi zaradi pojava teh bolezni poročajo iz Turčije, Španije in nam bližnje Italije. Poleg teh so v Evropi pomembnejše bolezni leske še gniloba lešnikov (*Monilinia sp.*), antraknoza leske, ki jo povzroča *Piggotia coryli (*syn. *Monostichella coryli)* ter številne listne pegavosti (na primer *Phyllosticta coryli*). Namen raziskave je inventarizacija v Sloveniji prisotnih glivičnih bolezni leske ter opredelitev najbolj razširjenih in gospodarsko pomembnih gliv oz. gliv, ki imajo potencial, da to postanejo.

ABSTRACT

Fungal diseases of hazelnuts in Slovenia

Common hazelnut (*Corylus avellana*) is an important cultivated fruit species, a native component of European forests, and a pioneer species colonizing abandoned agricultural areas. In recent years, the number of fruit growers engaging in hazelnut production and agricultural areas dedicated to hazelnut cultivation increased noticeably in Slovenia. Hazelnut production has been considered undemanding, but this perception does not reflect the real situation. As cultivation expands, so do the challenges faced by growers, particularly in the field of plant protection. Hazelnuts are susceptible to various disease-causing agents, including pathogenic and economically significant fungi. Climate change, creating more favorable conditions for the spread of fungal diseases, emergence of invasive species, and a reduction in use of pesticides are currently the biggest challenges in hazelnut pest and disease management, demanding a systematic approach. In 2020, the first occurrences of hazelnut powdery mildew (*Erysiphe corylacearum*) and a disease causing scab and anthracnose symptoms on hazelnut leaf stalks, sheaths, and fruits (*Elsinoe coryli*, synonym *Sphaceloma coryli*) were confirmed. Both diseases are dangerous and economically significant hazelnut diseases. The invasive species *E. corylacearum* causes extensive infections of leaves, nut bracts, and even premature fruit drop. Damage due to their occurrence has been reported from Turkey, Spain, and nearby Italy. In addition to these, other important hazelnut diseases known in Europe, including hazelnut rot (*Monilinia* sp.), leaf anthracnose caused by *Monostichella coryli* (syn. *Piggotia coryli*), and numerous leaf spot diseases (such as *Phyllosticta coryli*) were diagnosed, partly for the first time from Slovenian hazel stands. The purpose of the research is the inventory of the fungal diseases present in hazelnuts in Slovenia and identification of the most widespread and economically significant fungi or fungi with the potential to become so.

Protimikrobni učinek eteričnih olj in njihovih komponent na bakterijo *Pseudomonas savastanoi* pv. *savastanoi*

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Bakterioze na rastlinah so ene najtežje obvladljivih bolezni v kmetijstvu. Široka uporaba bakra je povzročila razvoj odpornih sevov, zato za učinkovito obvladovanje potrebujemo alternativne in naravi prijazne rešitve. V študiji smo raziskovali protimikrobni učinek petih eteričnih olj (EO), pridobljenih iz rastlin iz družine Lamiaceae in njihovih izbranih komponent EO, proti *Pseudomonas savastanoi* pv. *savastanoi* (Pss), povzročitelju bolezni oljčnega raka. Ugotavljamo, da EO iz vrst *Mentha* in *Salvia* kažejo omejeno protimikrobno učinkovitost proti sevom Pss *in vitro*. Nasprotno sta EO iz *Thymus vulgaris* L. in *Origanum compactum* Benth. učinkovito zavirala rast vseh sevov Pss. Preizkus z mikrodilucijo je dal obetavne rezultate za olja iz *O.riganum majorana* L. in *Salvia officinalis* L., in sicer pri nižji gostoti bakterij, kar kaže na njihov potencial pri uporabi v biopesticidnih formulacijah. Učinek EO je odvisen od uporabljene koncentracije, kar se je izkazalo pri oljih iz *T. vulgaris, O. compactum* in *O. majorana*. Iz tega sklepamo, da imajo EO potencial kot alternativno sredstvo pri preprečevanju oljčnega raka. Poleg EO smo testirali tudi komponente EO, kjer je imel karvakrol najmočnejši protimikrobni učinek, tudi pri nižjih odmerkih. Naši rezultati se skladajo s predhodnimi študijami, katere potrjujejo protimikrobno delovanje fenolnih spojin kot sta timol in karvakrol. Vse testirane spojine so izkazovale protimikrobni učinek pri svojih ustreznih vrednostih MIK, z izjemami EO kot sta *M. piperita* L. in *S. officinalis* L. Sevi bakterij Pss so izkazovali različno občutljivost na EO, zato je pomembno, da razumemo specifične odzive patogenov, kar nam bo v pomoč pri razvoju učinkovitih strategij obvladovanja bolezni rastlin.

ABSTRACT

Exploring antimicrobial effects of essential oils and their components against *Pseudomonas savastanoi* pv. *savastanoi*

Bacterial plant diseases are one of the most difficult diseases to control in agriculture. Use of copper in plant protection resulted in development of resistant strains. For effective management we need alternative and nature friendly solutions. In this study, we investigated the antibacterial effect of five essential oils (EOs) derived from plants within the Lamiaceae family and their selected EO components against *Pseudomonas savastanoi* pv. *savastanoi* (*Pss*), a causative agent of olive knot disease. Our findings revealed that EOs from *Mentha* and *Salvia* species show limited antibacterial efficacy against *Pss* strains *in vitro*. However, EOs from *Thymus vulgaris* L. and *Origanum compactum* Benth. effectively inhibited the growth of all *Pss* strains. A broth microdilution assay indicated promising results for EOs of *Origanum majorana* L. and *Salvia officinalis* L. at lower bacterial density, indicating their potential use in biopesticide formulations. The

concentration-dependent responses of EOs, particularly of *T. vulgaris*, *O. compactum* and *O. majorana* EOs, could be exploited as an alternative in olive knot disease prevention. Furthermore, we determined the concentration-dependent effects of EO components, where carvacrol emerged as the most potent inhibitor, showing effectiveness at low doses. This aligns with previous research highlighting the antimicrobial action of phenolic compounds like thymol and carvacrol. Notably, all tested compounds exhibited antimicrobial effects at their respective MIC values, with noted exceptions for *M. piperita* L. and *S. officinalis* L. EOs. The strains of Pss exhibited varied susceptibility to EOs, emphasizing the importance of understanding strain-specific responses when developing effective treatment strategies.

Ugotavljanje vpliva marmorirane smrdljivke (*Halyomorpha halys* [Stål, 1855], Hemiptera, Pentatomidae) na zgodnje odpadanje plodov oljk (*Olea europaea*) v Slovenski Istri

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Marmorirana smrdljivka je tujerodna invazivna ščitasta stenica, ki se je na območju Primorske prvič pojavila leta 2017 (Šempeter pri Gorici). Hitro se je razširila po celotnem območju Slovenije, na Primorskem pa je postala gospodarsko pomemben škodljivec. Največ škode povzroča v sadjarstvu, predvsem v intenzivnih nasadih koščičarjev in pečkarjev ter v pridelavi vrtnin na prostem. V zadnjih letih velike populacije marmorirane smrdljivke opažamo tudi v oljčnikih v slovenski Istri. Hkrati se v pridelavi oljk srečujemo z velikimi izgubami pridelka zaradi predčasnega odpadanja plodov. Vzroki za ta pojav niso še povsem raziskani in pojasnjeni, zagotovo ima svoj delež pri tem tudi marmorirana smrdljivka. Z namenom pridobitve informaciji o času nastanka, vrsti poškodb in obsegu škode povezane s hranjenjem stenic na plodovih oljk, smo v oljčniku nad Ankaranom zastavili manjši poskus. Poskus je potekal v fazi od konca cvetenja do otrdele koščice (BBCH 69-75), ko je plod oljke najbolj občutljiv na vbode. Po fenofazi konec cvetenja smo na 10 vejic oljk namestili mrežaste vrečke v katere smo dodali po 1 osebek marmorirane smrdljivke v različnih stadijih (ličinke, odrasle stenice). Za primerjavo smo na oljčna drevesa namestili tudi 10 vrečk brez marmorirane smrdljivke. Za kontrolo pa smo na drevesih naključno izbrali in označili 10 vejic brez nameščanja vrečk. Na začetku smo v vseh obravnavanjih in ponovitvah prešteli začetno število plodov. Poskus je bil ocenjen v fazi trdenja koščice (BBCH 75), takrat smo ponovno prešteli vse plodove na vejicah oziroma ostanek plodov. Rezultati enoletnega preizkušanja potrjujejo, da marmorirana smrdljivka s hranjenjem povzroča odpadanje oljk. V obravnavanju z vrečkami, kjer so bile prisotne stenice, je v povprečju odpadlo 88% plodov, v obravnavanju z vrečkami brez marmorirane smrdljivke 38% ter v kontroli 34%. Glede na to, da je do prezgodnjega odpadanja oljk prišlo tudi na drevesih, kjer ni bila prisotna marmorirana smrdljivka, težko ocenimo njen dejanski vpliv na odpadanje. Vzroki za odpadanje oljk so po naših izkušnjah bolj kompleksni, zato to področje potrebuje dodatne raziskave. Iz rezultatov poskusa je razvidno, da je največ plodov odpadlo z vejic, na katerih so bile nameščene vrečke s stenicami. Med številom odpadlih plodov z vejic v vrečki, kjer ni bilo marmorirane smrdljivke in številom odpadlih plodov na nezaščitenih vejicah pa ni bilo razlike.

ABSTRACT

Determining the impact of the brown marmorated stink bug (*Halyomorpha halys* [Stål, 1855], Hemiptera, Pentatomidae) on early fruit drop on olive trees (*Olea europaea*) in Slovenian Istria

Brown marmorated stink bug is a non-native invasive shielded stink bug that first appeared in the Primorska region in 2017 (Šempeter pri Gorici). It quickly spread throughout Slovenia and has become an economically important pest in the Primorska region. It causes the most damage in fruit production, especially in orchards with stone fruit and pome fruit trees and in outdoor vegetable production. In recent years, large populations of the brown marmorated stink bug has also been observed in olive groves in the Slovenian Istria. At the same time, olive production is experiencing high yield losses due to premature fruit drop. The causes of this phenomenon have not yet been fully investigated and explained, and the brown marmorated stink bug certainly plays a role. In order to obtain information on the time of occurrence, the type of damage and the extent of the damage associated with the feeding of stink bugs on olive fruit, a small experiment was set up in an olive orchard above Ankaran. The experiment took place at the stage from the end of flowering to the hardening of the stone (BBCH 69-75), when the olive fruit is most susceptible to punctures. After the late flowering phenophase, 10 olive branches were placed in mesh bags in which 1 specimen of the brown marmorated stink bug at different stages (nymph, adults) was added. For comparison, we also placed 10 marmorated stink bug-free bags on olive trees. As a control, we randomly selected and marked 10 twigs on the trees without the installation of the bags. At the beginning, in all treatments and replications, the initial number of fruits was counted. The experiment was evaluated at the stone setting stage (BBCH 75), at which time all fruits on the twigs or the rest of the fruits were counted again. The results of the one-year trial confirmed that the brown marmorated stink bug causes olive fruit drop by feeding. On average, 88% of the fruit dropped in the treatment with bags where the stink bugs were present, 38% in the treatment with bags without the brown marmorated stink bug and 34% in the control. Given that premature olive dropping also occurred on trees where the brown marmorated stink bug was not present, it is difficult to assess its actual influence on fruit dropping. In our experience, the causes of olive fruit drop are more complex and this area needs further research. The results of the experiment show that most of the fruit dropped from the branches on which the bags were placed. However, there was no difference between the number of fruits dropped from twigs in the bag where there were no insects present and the number of fruits dropped on unprotected twigs.

Prva potrditev vrste *Aculus olearius* Castagnoli (Eriophyidae) na oljkah v Sloveniji

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Med pomembnejše škodljive organizme oljk, ki se pojavljajo pri nas kot v sosednjih pokrajinah sta značilni mikozi pavje oko (*Cycloconium oleaginum*) ter oljkova siva pegavost (*Mycocentrospora cladosporioides*). Med značilne fitofage oljke prištevamo

poleg oljčne muhe (*Bactrocera oleae*), oljčnega molja (*Prays* oleae), ter oljkovega kaparja (*Saissetia oleae*) še marmorirano smrdljivko (*Halyomorpha halys*). Številčnost predstavnika ščitastih stenic se v zadnjih letih povečuje. Gre za polifaga katerega nemalokrat najdemo tudi v oljčnikih kjer povzroča vbode na plodovih, kar lahko privede tudi do predčasnega odpadanja plodov. Poleg omenjenih žuželčjih vrst, mikoz in pojava oljkovega raka (*Pseudomonas savastanoi* pv. *savastanoi*) v posameznih oljčnikih v zadnjih sezonah opažamo prerazmnožitve pršic šiškaric (Eriophyidae). Gre za vrste, ki v našem okolju do nedavnega niso povzročale gospodarske škode in so bile zaradi tega uvrščene med manj pomembne škodljivce. Pršice šiškarice na oljkah so sicer bolj značilne za južno Evropo; iz severnih območij pridelave oljk o gospodarski škodi ne poročajo. Večji pojav pršic šiškaric, zlasti vrste *Aculus olearius* Castagnoli smo zaznali v sezoni 2023 in jo potrdili s pomočjo morfoloških analiz in sekvenciranja DNK. Gre za prvo najdbo prisotnosti vrste v Sloveniji. Za pršico šiškarico so značilne poškodbe cvetnih brstov ter deformacije listov in plodov. Škodo ter številčne kolonije pršic na poganjkih oljk pa opažamo že od leta 2022, in sicer v intenzivnih nasadih oljk ter na vrtovih na območju slovenske Istre, Vipavske doline in goriškega Krasa. V prispevku sledi podrobna predstavitev gospodarsko pomembnega škodljivega organizma.

ABSTRACT

First report of the species *Aculus olearius* Castagnoli (Eriophyidae) on olive crops in Slovenia

Among the most important pathogens of olive occurring in our region and in the adjacent areas are the mycosis of the olive leaf spot (*Cycloconium oleaginum*) and violet spot of olive (*Mycocentrospora cladosporioides*). Among the typical phytophagous pests are the olive fly (*Bactrocera oleae*), the olive moth (*Prays oleae*), black scale (*Saissetia oleae*), but also the brown memorated stink bug (*Halyomorpha halys*). The abundance of the latter species, which belongs to the Pentatomidae family, has been increasing in recent years. This polyphagous insect is often found in olive orchards, where it causes punctures on the fruits, leading to premature fruit drop. Besides the above-mentioned species, in several locations we observed the bacterial canker of olives (*Pseudomonas savastanoi* pv. *savastanoi*) and the outbreak of eriophyid mites' populations in the last growing seasons. These are species that in our environment did not cause important economic damage until recent years, and therefore they were listed as minor pests. Eriophyid mites are more common in southern Europe; in northern cultivation areas, there are no reports of damage to olives. The major outbreak of the species *Aculus olearius* Castagnoli, confirmed by morphological analysis and DNA barcoding, was reported in 2023. This is the first finding of the species in Slovenia. The damage occurs mainly on floral buds, but we observed leaf and fruit deformation as well. In 2022, damage and huge colonies of this mite were found in intensive olive orchards in Slovenenian Istria, Vipava valley, and the Karst region too. In this paper, we describe this new economically important pest.

Preliminarni rezultati dnevnega spremljanja oljčne muhe (*Bactrocera oleae* Rossi) z avtomatsko vabo

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Oljčna muha (*Bactrocera oleae* Rossi) predstavlja glavnega škodljivca oljk v vseh pridelovalnih regijah, kjer lahko ob ugodnih razmerah povzroči občutne poškodbe plodov, ki se odražajo v nižji kakovosti pridelanih oljk in oljčnega olja ter manjših količinah olja. Škoda je še posebej izrazita v vlažnih poletjih, kot je bilo poletje 2023. Z namenom izboljšanja razumevanja bionomije oljčne muhe ter razumevanja dejavnikov, ki vplivajo na njeno pojavnost in številčnost, smo leta 2022 v oljčniku v Slovenski Istri postavili tri avtomatske vabe, ki omogočajo spremljanje ulova oljčne muhe na daljavo več krat dnevno. Poleg tega so pasti opremljene z merilniki relativne zračne vlage in temperature zraka. Preliminarni podatki spremljanja dnevnih podatkov ulova oljčnih muh v prvih dveh letih, povezani z dnevnimi podatki relativne zračne vlage in temperature, so pokazali, da se je oljčna muha številčno pojavila, ko je bila izmerjena temperatura pod 24 °C in relativna zračna vlaga nad 50 %. Hkrati smo ugotovili, da se je največje število oljčnih muh ulovilo podnevi med 6 h in 20 h, najmanjše pa v času noči od 20 h do sončnega vzhoda, kar kaže na neaktivnost oljčne muhe ponoči. Slednja ugotovitev postavlja pod vprašaj učinkovitost škropljenja v jutranjem času pred sončnim vzhodom, predvsem v poletnih mesecih, ko se zaradi visokih temperatur kapljice škropiva hitro sušijo.

ABSTRACT

Preliminary results of daily monitoring of olive fruit fly (*Bactrocera oleae* Rossi) with automatic traps

The olive fruit fly (*Bactrocera oleae* Rossi) is a major pest of olive trees in all olive-growing regions, where, under favourable conditions, it can cause significant damage to the fruit, resulting in lower quality of the olives and olive oil produced, and lower oil volumes. The damage is particularly pronounced in wet summers, such as the summer of 2023. In order to improve our understanding of the olive fly bionomics and the factors influencing its occurrence and abundance, in 2022 we set up three automated traps in an olive orchard in Slovenian Istria, which allow us to monitor the olive fly catch remotely several times a day. In addition, the traps are equipped with relative humidity and air temperature monitors. Preliminary monitoring data of daily olive fly catches in the first two years, linked to daily relative humidity and temperature data, showed that olive fly abundance increased when the temperature was measured below 24 °C and the relative humidity above 50 %. At the same time, we found that the highest number of olive flies was caught during the day between 6 am and 8 pm, and the lowest during the night between 8 pm and sunrise, indicating that olive flies are not active at night. The latter finding calls into question the effectiveness of spraying in the morning before sunrise, especially in the summer months when high temperatures cause spray droplets to dry quickly.

Poskus zatiranja oljčne muhe (*Bactrocera oleae*) z uporabo različnih kombinacij razpoložljivih fitofarmacevtskih sredstev na oljkah (*Olea europaea*)

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Oljčna muha je najpomembnejša škodljivka oljk in brez učinkovitega ukrepanja lahko povzroči veliko škodo na pridelku, tako glede kakovosti kakor tudi količine oljk. Zaradi

omejevanja rabe oz. manjšega nabora FFS-jev smo izvedli škropilni poskus, pri katerem smo želeli preučiti učinkovitost treh kombinacij razpoložljivih pripravkov za varstvo rastlin. Poskus smo izvajali v oljčniku na Beneši (nad Ankaranom), na sorti 'Istrska belica', ki je zelo dovzetna za napad oljčne muhe. Podoben poskus smo že izvedli leta 2022 v oljčniku na lokaciji Strunjan. V poskusu smo preučevali štiri različna obravnavanja, in sicer: ekološko varstvo, obravnavanje, v katerem smo uporabili samo kaolin oz. talk, integrirano varstvo in kontrola, ki je bila netretirana. Pred spravilom pridelka smo nabrali reprezentativen vzorec 100 plodov na obravnavanje na ponovitev, plodove smo pregledali v laboratoriju in ocenili delež aktivne ter celotne poškodovanosti plodov. Sledila je statistična analiza podatkov, ki je pokazala, da je statistično značilno najbolje deloval integriran način varstva proti oljčni muhi.

ABSTRACT

Control of olive fruit fly (*Bactrocera oleae*) using different combinations of available phytopharmaceutical products on olive trees *(Olea europaea*)

The olive fruit fly is the most important pest of olives and, without effective pest control, can cause significant damage to the crop, both in terms of quality and quantity of olives. Due to the limitation of the use or the reduced range of PPPs, a spraying experiment was carried out to study the effectiveness of three combinations of registered plant protection products. The experiment was carried out in an olive orchard in Beneša (near Ankaran) on the variety 'Istrska belica', which is highly susceptible to olive fly attack. A similar trial has already been carried out in 2022 in an olive orchard in Strunjan. In the experiment, four different treatments were studied: ecological protection, treatment with kaolin or talc only, integrated protection, and untreated control. A representative sample of 100 fruits per treatment per replicate was collected before harvest, the fruits were examined in the laboratory and the percentage of active and total fruit damage was estimated. Statistical analysis of the data was then carried out, which showed that the integrated olive fly control method worked statistically significantly best.

Results of the experimental activity for the containment of the peacock spot disease on the Bianchera variety in Friuli Venezia Giulia using low copper inputs

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Starting from 2021, a multi-year experimental trial has been carried out in an olive grove located in Ragogna (UD), that has a high presence of the Bianchera cv. The aim of the study was to compare various copper-based formulations with low inputs per hectare associated with some adhesive products. From the first results, it is highlighted that the use of more persistent copper products combined with adhesives increases the protection times of the products. This strategy has proven particularly useful to contain the olive peacock spot disease, especially during periods with greater rainfall.

Poskus zatiranja pavjega očesa (*Spilocaea oleagina*) z registriranimi fungicidnimi pripravki na oljkah (*Olea europaea*)

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Pavje oko ali oljkova kozavost (*Spilocaea oleagina*) je najpomembnejša glivična bolezen oljk na celotnem območju njihove pridelave. V Sloveniji je na bolezen zelo občutljiva naša najpomembnejša in številčno najbolj zastopana sorta 'Istrska belica'. Za pojav bolezni so ugodna deževna pomladanska in jesenska obdobja. Najbolj so izpostavljeni oljčniki na nižjih in manj prevetrenih legah. Močne okužbe privedejo do odpadanja listov, oslabelih dreves in manjšo pridelavo v naslednjih sezonah. Namen poskusa je bilo preizkušanje učinkovitosti razpoložljivih fungicidov. Posebno nas je zanimala učinkovitost novo registriranih sredstev na osnovi antagonistične bakterije *Bacillus amyloliquefaciens*. Poskus je potekal dve leti in zajemal štiri različna obravnavanja (neškropljeno obravnavanje, ekološko varstvo, integrirano varstvo in uporaba sredstev na osnovi mikroorganizmov). Skupno smo izvedli 4 ocenjevanja in ugotovili, da obstajajo med posameznimi škropilnimi programi statistično značilne razlike. Najbolj učinkovito je bilo obravnavanje kjer je potekal integriran način varstva oljk.
Ključne besede: oljka, pavje oko, varstvo oljk, škropilni poskus

ABSTRACT

Trials on the control of peacock leaf spot (*Spilocaea oleagina*) with registered fungicide products on olive tree (*Olea europaea*)

Peacock leaf spot (*Spilocaea oleagina*) is the most important fungal disease of olive trees in the entire olive-growing area. In Slovenia, our most important and most spread variety, 'Istrska belica', is highly susceptible to the disease. The rainy spring and autumn periods are favourable for the disease development. Olive groves at lower altitudes and less ventilated locations are most exposed. Heavy infections lead to leaf drop, weakened trees, and reduced production in the following seasons. The aim of the experiment was to test the effectiveness of available fungicides. We were particularly interested in the efficacy of newly registered products based on the antagonistic bacterium *Bacillus amyloliquefaciens*. The trial was carried out over a period of two years and included four different treatments (non-sprayed treatment, organic protection, integrated protection, and the use of products based on micro-organisms). In total, we carried out 4 evaluations and found that there were statistically significant differences between the individual spray programmes. The most effective treatment was the one where IPM was applied.

Vrednotenje občutljivosti avtohtonih sort oljke (*Olea europea*) na pojavnost pavjega očesa (*Venturia oleaginea* (Castagne) Rossman & Crous)

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Bolezen pavjega očesa, ki ga povzroča biotrofna gliva *Venturia oleaginea* (Castagne), je najpomembnejša glivična bolezen, s katero se soočajo oljkarji celega sveta. Hude in ponavljajoče se okužbe povzročajo intenzivno odpadanje listov in s tem oslabljeno sposobnost fotosinteze, sledi odmiranje vej in vsesplošno slabšanje kondicije drevesa, kar navsezadnje privede do zmanjšanja rodnega potenciala. Zaradi prirojenih fizioloških prilagoditev so nekatere sorte oljke (*Olea europea*) manj občutljive na pojavnost pavjega očesa. Zanimalo nas je kakšna je pojavnost okužbe pri nekaterih domačih in tujerodnih sortah oljke. Od leta 2018 do 2022 smo na letni ravni v mesecu maju in oktobru na več lokacijah določali stopnjo okuženosti posameznih sort. Podrobneje smo se osredotočili na lokacije (Purisima, Sečovlje, Šempeter) ter sorte, ki imajo več ponovitev skozi spremljano obdobje in tako primerjali stopnjo okuženosti štirih avtohtonih sort ('Istrska belica', 'Drobnica', 'Buga' in 'Črnica') in dveh tujerodnih sort ('Leccino', 'Maurino'), ki sta pogosto gojeni v slovenskih oljčnikih in sta po literaturi znani po tem, da na okužbo nista občutljivi. Najbolj občutljivi sta sorti 'Drobnica' in 'Istrska belica', medtem ko sta sorti 'Buga' in 'Črnica' manj občutljivi.

ABSTRACT

Evaluation of the susceptibility of native olive varieties (*Olea europaea*) to the incidence of peacock's eye disease (*Venturia oleaginea* (Castagne) Rossman & Crous)

The threat posed by the biotrophic fungus *Venturia oleaginea* (Castagne), known as olive peacock's eye disease, is a significant challenge for olive cultivators worldwide. Severe infections lead to extensive leaf shedding, compromised photosynthesis, and branch dieback, resulting in an overall decline in olive tree vigour and reduced yields. Certain olive cultivars (*Olea europaea*) are less susceptible to peacock's eye due to intrinsic physiological adaptations. This study explores infection prevalence in specific native and introduced olive varieties. From 2018 to 2022 in the month of May and October, we systematically assessed infection levels at selected locations: Purisima, Sečovlje, and Šempeter. The focus extended to varieties with most recurring instances. The comparative analysis included infection levels of four native varieties ('Istrska belica,' 'Drobnica,' 'Buga,' and 'Črnica') and two introduced varieties ('Leccino' and 'Maurino') known for their reduced susceptibility. Results highlight 'Drobnica' and 'Istrska belica' as the most susceptible varieties, while 'Buga' and 'Črnica' show comparatively diminished susceptibility.

Prva najdba glive *Verticillium dahliae*, povezane z ovenelostjo poganjkov oljk v Slovenski Istri

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V sklopu strokovne naloge javne službe zdravstvenega varstva rastlin, ki je potekala v letu 2023 na območju slovenske Istre je bilo vzorčenih več oljčnikov, kjer so drevesa kazala bolezenska znamenja venenja in sušenja poganjkov. Omenjene simptome smo zaznali na različnih sortah dreves v polni rodnosti. Vzorci so bili poslani na Kmetijski Inštitut Slovenije na analizo prisotnosti gliv povezanih s pojavom simptomov. Glive so bile izolirane iz subkortikalnih temnih razbarvanj v lesu, kar kaže na prisotnost gliv, ki povzročajo gnilobo lesa. Glede na tipične morfološke značilnosti in zaporedja molekulskih črtnih kod smo kot povzročitelja simptomov iz štirih nasadov oljk identificirali aksomicetno glivo *Verticillium dahliae.* Za vse okužene rastline je bilo značilno sušenje poganjkov, izrazitega odmiranja vej pa v letu, ko je raziskava potekala nismo zaznali. Glede na rezultate strokovne naloge gre za prvo potrditev omenjene glive, ki je povezano z lesno nekrozo in ovenelostjo mladih vej oljčnih dreves v Sloveniji. Vrsta je sicer polifagna, vendar se v literaturi večkrat omenja kot patogen oljk ter se uvršča med pomembne glivične bolezni oljk. V prispevku so predstavljeni natančnejši opisi bolezenskih znamenj ter morfološke značilnosti glive.

ABSTRACT

First report of *Verticillium dahliae* associating shoot wilting of olive in Slovene Istria

As a research task of the public plant protection service, olive trees showing shoot wilting and drying were sampled from several orchards in Slovene Istria during 2023. Mature trees of different cultivars were sampled, shipped to the Agricultural Institute of Slovenia and analysed for fungi associating observed disease symptoms. Ascomycetous fungus *Verticillium dahliae* was isolated from four orchards and from subcortical, dark wood streaking indicating occurrence of wood decaying fungi. Typical morphological characters and molecular barcode sequences identified the pathogen. The sampled trees showed shoot drying, however, severe branch drying was not noticed in other trees of the studied orchards in the year of the survey. Accordingly, this is the first report of *V. dahliae* associating wood necrosis and twig wilting of olive trees in Slovenia. The species is known to be polyphagous and was reported already as an olive pathogen in the literature.

Investigations on spray drift mitigation by means of artificial barriers in high tunnel strawberries

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Strawberry cultivation under high plastic tunnel is mainly due to the possibility to protect plants and their production from atmospheric agents which can favour the development of fungal pathogens such as rot or other diseases. Even if the use of plant protection products is also necessary under tunnel, it can be considered more efficient and environmentally safe because of the washout avoidance ensured by the plastic cover. Another issue to consider when spraying high tunnel strawberries is how it is also possible to manage in the proper way spray drift if the machinery used to apply PPPs is a cannon sprayer because of the high drift potential shown by this equipment. In the reported work experiments were carried out to evaluate the effect of an anti-insect net on drift mitigation and to compare

leaf deposits. The complete closure of the tunnel exit was also tested in the comparative trials. The anti-insect net hallowed a ground sediment reduction of about 50% compared to the open tunnel configuration. By the full closure of the front openings, an almost complete reduction of spray drift towards the pesticide sensitive area seems possible. No clear conclusions can be drawn about the effect of the shielding system on the deposit formation on vegetation.

Daljinsko zaznavanje učinkov biotičnega varstva proti ogorčicam koreninskih šišk vrste *Meloidogyne hapla* pri občutljivi vrsti jagodnjaka

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Ogorčice koreninskih šišk (RKN) veljajo za najpomembnejšo skupino rastlinsko-parazitskih ogorčic zaradi širokega spektra rastlinskih gostiteljev in pomembnega vpliva k zmanjšanju ali izpadu pridelka. Z lončnima poskusoma v steklenjaku in zunanjem plastičnem tunelu smo ovrednotili nematocidno delovanje bakterij *Bacillus* cf. *firmus* na ogorčice *Meloidogyne hapla,* kot tudi možne učinke spodbujanja rasti rastlin beloplodnega jagodnjaka (*Fragaria chiloensis* (L.) Mill.). Učinke ogorčic in bakterij na rastline jagodnjaka smo z različnimi obravnavanji preizkušali ločeno ali v kombinaciji. V poskusu v rastlinjaku je dodatek bakterij bistveno zmanjšal populacijo ogorčic *M. hapla*, primerljivo s kemičnim nematocidom Velum (Bayer). V tunelskem poskusu dodatek bakterij ni pokazal nematicidnega delovanja v primerjavi z netretirano kontrolo. Inokulacija spor *Bacillus* cf. *firmus* na korenine jagodnjaka je značilno povečala mikrobno aktivnost substrata in pozitivno učinkovala na rasti rastlin s povečanjem listne površine in sveže mase nadzemnih delov rastlin. Pri rastlinah tretiranih z bakterijami ter rastlinah okuženih z ogorčicami, smo prav tako izmerili višje vrednosti fizioloških parametrov neto fotosinteze, fotokemičnega kvantnega izkoristka fotosistema II in višjo relativno vsebnost klorofila v listih. V obeh poskusih smo s hiperspektralnim slikanjem v spektralnem območju 400–2500 nm in nadaljno analizo posnetkov, testirali zmožnost razvrščanja rastlin v različna obravnavanja. Za klasifikacije smo uporabili metodi analize glavnih komponent (kPCA) ali delnih najmanjših kvadratov (PLS) v povezavi z metodo podpornih vektorjev (SVM). Z analizo hiperspektralnih podatkov smo uspešno razlikovali med rastlinami v različnih obravnavanjih, saj smo v obeh poskusih dosegli natančnost klasifikacij nad 91 %. Študija je pokazala na potencialno uporabnost daljinskega zaznavanja za fenotipizacijo rastlin večjega obsega, spremljanje rasti rastlin, ali prisotnosti oz. razširjanja patogenov. Zahvala: finančna podpora s strani Horizon 2020, Grant agreement No. 817946 – EXCALIBUR ter programski skupini Agrobiodiverziteta (P4-0072) in Kmetijstvo naslednje generacije (P4-0431).

ABSTRACT

Remote sensing of biological control measures against *Meloidogyne hapla* in a susceptible strawberry species

Root-knot nematodes (RKN) are considered the most important group of plant-parasitic nematodes due to their wide range of plant hosts and significant contribution to yield losses in agricultural production systems. A glasshouse and plastic tunnel pot experiments were conducted to test the nematicidal as well as possible plant growth-promoting effects of *Bacillus* cf. *firmus* on white-fruited strawberry plants (*Fragaria chiloensis* (L.) Mill.) infected with RKN *Meloidogyne hapla*. Effects of the nematode and the bacteria on strawberry plants were tested either in isolation or in combination. In the glasshouse pot experiment, the bacteria significantly reduced *M. hapla* population, which was comparable to the application of the chemical nematicide Velum (Bayer). In the tunnel pot experiment, *Bacillus* failed to exhibit nematicidal activity compared to the untreated control. Inoculation of *Bacillus* cf. *firmus* spores on plant roots significantly increased the substrate microbial activity and elicited plant growth-promoting effects. In the tunnel experiment, significantly higher leaf area and crown fresh weight were measured. *Bacillus*-treated and nematode-infected plants also exhibited significantly higher photosynthetic rate, effective quantum yield of PSII, and higher relative chlorophyll content in leaves. In both experiments, we further tested the ability of hyperspectral imaging in the spectral range of 400–2500 nm and image analysis to classify plants in different treatments. Kernel PCA (kPCA) or partial least squares (PLS) methods in conjunction with support vector machines (SVM) were used for classifications. Analysis of hyperspectral data differentiated plants between different treatments with overall classification success above 91 % in both the glasshouse and tunnel pot experiments. This demonstrates the usefulness of the remote sensing approach for potential high-throughput phenotyping applications in the field, evaluating plant growth or pathogen presence and spread.

Obvladovanje in spremljanje orehove muhe (*Rhagoletis completa*) v severovzhodni Sloveniji

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Orehova muha (*Rhagoletis completa* Cresson) je glavni škodljivec orehov v Sloveniji, ki povzroča veliko škodo na plodovih, kar lahko vodi do 80 % izgube pridelka. Strategija obvladovanja orehove muhe temelji na spremljanju populacije z vabami, ki so sestavljeni iz rumene lepljive plošče in atraktanta amonijevega karbonata. S spremljanjem populacije lahko kmetje določijo čas uporabe fitofarmacevtskih sredstev, da zmanjšujejo populacijo orehove muhe in tako preprečijo večjo gospodarsko škodo. Sezonsko dinamiko in število orehove muhe smo spremljali na štirih lokacijah in sicer, Pesniški dvor, Petrovče, Buče in poskusnem polju lupinarjev v Mariboru. Vabe so bile postavljene na dveh različnih višinah (2 m in 6 m) med leti 2020 – 2023. Rezultati kažejo, da so bile populacije muh največje

leta 2021 na vseh spremljanih lokacijah. Na vabah, obešenih na višini 6 m, je bilo ujetih do 12-krat več muh kot v vabah, obešenih na višini 2 m. Na treh lokacijah smo zabeležili populacijski vrh: v tretji dekadi julija (Buče), v prvi dekadi avgusta (Pesniški dvor) ali v drugi dekadi avgusta (Petrovče). Na lokaciji Maribor smo zabeležili dva populacijska vrhova: v drugi dekadi avgusta in v prvi dekadi septembra. Število orehove muhe je bilo manjše ob vznožju hriba kot na vrhu hriba (Pesniški dvor). Poskus obvladovanja orehove muhe v letu 2023 je pokazal, da je zatiranje orehove muhe, ko sta na voljo samo dva pripravka z isto aktivno snovjo, zelo oteženo. Poskus smo izvajali z različno velikostjo kapljic. Še posebej v vremenskih razmerah, kot so bile v poletju 2023, se je pokazalo, da zatiranje ni dovolj učinkovito. Možni vzroki za visok delež napadenih plodov v kontroli kot tudi v obeh postopkih je dolga karenca obeh pripravkov (30 dni) in kratko trajanje delovanja pripravkov.

ABSTRACT

Pest control and monitoring of walnut husk fly (*Rhagoletis completa*) in northeastern Slovenia

The walnut husk fly (*Rhagoletis completa* Cresson) (WHF) is a major pest of walnuts in Slovenia, causing significant damage to the fruit, leading to crop losses and reducing the market value by up to 80%. The control strategy of WHF is based on monitoring the population with special traps consisting of a yellow sticky plate and an attractant of ammonium carbonate. By monitoring population density, farmers can determine the need for control measures that reduce pest population and damage. Seasonal dynamics and density of the WHF population was observed on four sites. In Pesniški dvor, Petrovče, Buče and Maribor orchards, two plates were placed at two different heights (2 m and 6 m) in the period 2020-2023. The results show that populations of WHF were greatest in 2021 at all sites surveyed. Plates hung at 6 m height had up to 12 times the number of flies trapped compared to plates hung at 2 m height. At three sites we recorded a population peak: in the third decade of July (Buče) or in the first decade of August (Pesniški dvor) or in the second decade of August (Petrovče). At the Maribor site, there were two population peaks: in the second decade of August and in the first decade of September. The number of WHF was lower at the foot of the hill than at the top of the hill (Pesniški dvor). A pest contol trial in 2023 showed that WHF control is very difficult when only two products with the same active substance are available. The experiment was conducted with different droplet sizes. Especially in weather conditions such as in the summer of 2023, it has been shown that protection is not effective enough. Possible reasons for the high proportion of fruit attacked in the control as well as in both treatments are the long withdrawal period of both products (30 days) and the short duration of action of the products.

Kakovost nanosa fitofarmacevtskih sredstev v nasadih z mrežami proti toči

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Tržna pridelava sadja in grozdja zahteva redne in kakovostne pridelke vsako leto. Mreže proti toči so že nekaj časa obvezni zaščitni del trajnih nasadov, ki ohranijo pridelek

nepoškodovan. V zadnjih letih pa se vse pogosteje zanje odločajo tudi vinogradniki, saj so neurja s točo vse pogostejša. V prispevku bomo predstavili nastavitve pršilnikov za učinkovit nanos fitofarmacevtskih sredstev v nasadu jablan in hrušk, ter v vinogradu z mrežo proti toči s poudarkom na zmanjševanju zanašanja škropilnega oblaka stran od mesta nanašanja fitofarmacevtskih sredstev.

ABSTRACT

Deposit quality of plant protection products in orchards and vineyards with anti-hail nets

Production of fruit for the market and grapes requires regular and high-quality yield every year. Anti hail nets have been a mandatory protective part of orchards for some time, keeping the fruits undamaged. In recent years, however, winegrowers have also been choosing them more and more often, as hail storms are becoming more frequent.
In this presentation, we would like to present to you the settings of sprayers for effective application of ffs in an apple and pear orchard, and in a vineyard with a net anti hail net, with an emphasis on reducing the drift of the spray cloud away from the place of application of ffs.

Varstvo vinske trte

Avtomatiziran proces nanašanja škropilne brozge pri ekološki pridelavi grozdja v vinogradu

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V zadnjih desetletjih se nenehno razvijajo različne alternativne tehnike, ki omogočajo avtomatiziran proces nanašanja škropilne brozge v vinogradih. V članku avtorji predstavljamo del raziskovalnega dela, opravljenega na terenu in katero se nanaša na področje senzorske merilne tehnike za digitalno vrednotenje karakterističnih lastnosti krošenj vinskih trt in kontrolirano odmerjanje škropilne brozge, da bi izboljšali proces nanašanja škropilne brozge in ga naredili bolj trajnostnega. Predlagane so nekatere nove metode ter opisan razvoj avtomatiziranega prototipa pršilnika. Razvita tehnologija je zanimiva z vidika prilagajanja odmerkov škropilne brozge značilnostim zelene stene vinograda. V ekološkem vinogradu smo skozi sezono škropljenja v letu 2023 testirali avtomatiziran prototip pršilnika na katerega smo namestili avtomatiziran modularni sistem z omogočenim krmiljenjem odmerkov škropilne brozge, glede na velikost in gostoto zelene stene - listne površine. Testirali smo avtomatiziran prototip pršilnika, z omogočenim pulzno širinskim načinom krmiljenja škropilne brozge preko elektromagnetnih ventilov. Primerjali smo porabljeno količino škropilne brozge, izraženo v odstotkih med avtomatiziranim in konvencionalnim načinom delovanja pršilnika skozi individualne šobe na pršilniku. Ugotovili smo, da je znašal največji prihranek škropilne brozge 70,95 %, merjeno preko količine brozge sproščene skozi individualne šobo, v razvojnem stadiju trte BBCH 57. Prihranki zaradi zmanjšane porabe FFS so za levo stran pršilne garniture znašali 131,40 EUR/ha ter za desno stran 156,80 EUR/ha.

ABSTRACT

Automated process of spray application in the vineyard with an organic production system

In recent decades, various alternative techniques have been continuously developed, which enable an automated process of applying plant protection products (PPP) spray in vineyards. In the article, the authors present a part of the research work carried out in the field and, which refers to the field of sensor measurement techniques for the digital evaluation of the properties of the vine canopies and the controlled dosing of the PPP spray in order to improve the process of applying the spray and make grape protection more sustainable. Some new methods are presented, and the development of an automated new sprayer prototype is described. The developed technology is interesting from the point of view of adjusting the doses of the spray to the characteristics of the grape green wall. In the organic vineyard, during the 2023 spraying season, we tested an automated sprayer prototype, on which we installed an automated modular system that enabled control of spray dosages depending on the size and density of the green wall - the leaf surface area. We tested a computerized sprayer prototype with enabled pulse-width control of the spray slurry via electromagnetic valves. We compared the amount of spray applied, expressed in percentages, between the automated and conventional

modes of operation of the sprayer through analysis of outputs of individual nozzles on the sprayer. We found that the maximum saving of spray amounted to 70.95%, measured by the amount of spray released through individual nozzles, in the BBCH 57 development stage of the grapevine. The savings due to the reduced use of PPP for the left side of the sprayer nozzle set amounted to 131.40 EUR/ha, and for the right side 156.80 EUR/ha.

Vpliv filtratov koreninskih izločkov izbranih vrst posevkov na zmanjšanje populacije ogorčic vrste *Xiphinema index* Thorne & Allen, 1950 v *in vitro* razmerah

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Ogorčice vrste *Xiphinema index* Thorne & Allen, 1950 so rastlinski paraziti, katerih glavna gostiteljica je vinska trta (*Vitis vinifera* L.). Ogorčice te vrste se prosto gibljejo v tleh in se prehranjujejo na koreninah gostiteljske rastline. Z značilnim močnim bodalom lahko prodrejo v korenine vinske trte in iz rastlin črpajo celični sok. Ne le, da rastline na ta način izčrpavajo in s poškodbami na koreninah omogočajo lažji vstop drugim patogenom v rastlino, temveč so pomembne predvsem z vidika prenosa virusa. Ogorčice vrste *X. index* so prenašalke virusa pahljačavosti listov vinske trte (GFLV). Z omenjenim virusom okužen vinograd se odraža v zmanjšanem pridelku, pridelek je slabše kakovosti, trte imajo krajšo življenjsko dobo, prav tako so dovzetnejše na vplive sprememb v okolju. V vinogradih lahko bolezen prepoznamo po rumenenju in deformaciji listov ter nepravilnem izraščanju poganjkov. Ker je viruse v kasnejši fazi rasti nemogoče izločiti iz rastlin, je smiselno pozornost posvetiti preprečevanju širjenja oz. eliminaciji prenašalcev virusa, torej ogorčic *X. index*. V poskusu smo se osredotočili na različne izbrane posevke, ki bi lahko s svojimi koreninskimi izločki vplivali na preživetje ogorčic vrste *X. index*. V lončke s peščenim substratom smo posejali 8 različnih posevkov (bela lupina – *Lupinus albus* L., grašica – *Vicia vilosa* Roth, inkarnatka – *Trifolium incarnatum* L., ječmen – *Hordeum vulgare* L., lucerna – *Medicago sativa* L., oves – *Avena sativa* L., sončnica – *Helianthus* sp. L., žametnica – *Tagetes* sp. L.), kot negativno kontrolo smo uporabili peščeni substrat brez posevka, pozitivno kontrolo pa je predstavljal registriran nematocid Velum® Prime. Neposredno delovanje različnih filtratov koreninskih izločkov na ogorčice smo preverjali v *in vitro* pogojih z mikrotitrskimi ploščami. Izkazalo se je, da je imel negativen vpliv na preživetje ogorčic vrste *X. index* poleg nematocida še ječmen. Z nadaljnjimi raziskavami bomo poskušali ugotoviti, kaj točno je vplivalo na smrtnost ogorčic – koreninski izločki ali morebiti kateri od drugih prisotnih biotičnih agensov.

ABSTRACT

Impact of filtrated root exudates from selected crop varieties on the reduction of population nematode species *Xiphinema index* Thorne & Allen, 1950 under *in vitro* conditions

The nematode species *Xiphinema index* Thorne & Allen, 1950, known as plant-parasitic organisms, predominantly infect the grapevine (*Vitis vinifera* L.) as their primary host.

These nematodes exhibit free-living mobility within the soil matrix, where they target the roots of plants. Their typical robust stylet enables the penetration of grapevine roots, facilitating the pumping of cytoplasm from plant cells. In addition to depleting plant vitality, they play a crucial role as vectors for the Grapevine fanleaf virus (GFLV), resulting in reduced yields, compromised quality, shortened vine longevity, and increased susceptibility to environmental stresses in infected vineyards. We observe disease symptoms, including leaf chlorosis, deformation, and anomalous shoot growth. Due to ineffective challenges in eliminating the virus from plants post-infection, the focus shifts to controlling the spread of the primary vector *X. index,* or its complete eradication. With experiments, we tried to explore the impact of root exudates from selected crop varieties on nematode survival. We sowed eight cultivars (white lupin – *Lupinus albus* L., hairy vetch – *Vicia vilosa* Roth, crimson clover – *Trifolium incarnatum* L., barley – *Hordeum vulgare* L., lucerne – *Medicago sativa* L., oat – *Avena sativa* L., sunflower – *Helianthus annuus* L., marigold – *Tagetes* sp. L.) in pots with sandy substrate. The experimental design incorporated a negative control, a bare-sandy substrate, and a positive control wherein we used the registered nematicide Velum® Prime. We evaluated the direct impact of selected root exudate filtrates on *X. index* nematodes under *in vitro* conditions utilizing microtiter plates. The research revealed an effect on the reduction of the *X. index* nematode population with the positive control (nematocide) and also with the barley cultivar. Subsequent research aims to discover the specific determinants affecting nematode mortality, researching the contributions of root exudates and other potentially involved biotic agents that were possibly presented in the experimental milieu.

Problematika virusa pahljačavosti listov vinske trte (GFLV) in njegovega prenašalca, ogorčice *Xiphinema index*

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V rod *Nepovirus* je uvrščenih več virusov, ki okužujejo vinsko trto (*Vitis vinifera* L.), vse pa prenašajo ogorčice. Med njimi je najpomembnejši virus pahljačavosti listov vinske trte (GFLV – grapevine fanleaf virus), ki je prisoten v večini vinogradniških območij po svetu in ga prenašajo ogorčice vrste *Xiphinema index* Thorne & Allen, 1950. V Sloveniji je GFLV razširjen večinoma na Primorskem, v letošnjem letu pa je bil prvič potrjen tudi na Štajerskem. Bolezenska znamenja se kažejo na listih, poganjkih in pridelku. Količina pridelka z leti upada in je slabše kakovosti, okužena trta pa je tudi vir nadaljnjih okužb v vinogradu, kjer so v tleh prisotne ogorčice prenašalke. Škoda, ki jo virus povzroči, je odvisna od starosti trte ob okužbi in od občutljivosti posameznih sort. Poleg tega, da prenašajo GFLV pa ogorčice s prehranjevanjem na njihovih koreninah povzročajo tudi neposredno škodo na trtah. Trte na mestih vbodov ogorčic razvijejo zadebelitve imenovane šiške, takšne korenine pa so manj učinkovite pri prevzemu hranil in vode iz tal. Pospešeno širjenje okužb z GFLV je opazno v slovenskih vinogradih, kot je znano, pa se s podobnimi težavami srečujejo tudi v nekaterih drugih evropskih državah. Največjo škodo na območju Slovenije GFLV povzroča prav na Primorskem, kjer ima zaradi razširjenosti prenašalca idealne pogoje za širjenje. Število posameznih osebkov *X. index* je namreč v nekaterih

vinogradih izjemno visoko. Problematika je tako pereča, da je potrebno čim hitreje poiskati možnosti za obvladovanje te bolezni v vinogradih. Tako smo v okviru Euphresco projekta Xiphivir preizkušali nove metode določanja GFLV v ogorčicah *X. index*, in njihovo učinkovitost primerjali z drugimi uporabljanimi metodami. V okviru aplikativnega projekta Resens-Vitis in nalog Integriranega varstva rastlin pa načrtujemo spremljanje populacije *X. index* in njene okuženosti z GFLV ter preučiti različne možnosti njunega obvladovanja na okuženih vinogradniških legah.

ABSTRACT

The problem of grapevine fanleaf virus (GFLV) and its vector, the nematode *Xiphinema index*

Several viruses infecting grapevines (*Vitis vinifera* L.) are members of nematode transmitted genus *Nepovirus*. Among them, the most important is the grapevine fanleaf virus (GFLV), present in the majority of vinegrowing regions worldwide, and transmitted by *Xiphinema index* Thorne & Allen, 1950. In Slovenia, GFLV is mainly distributed in the Primorska region, while few infected wines were found this year also in Štajerska region. Disease symptoms can be observed on leaves and shoots; over the years, the yield diminishes in both quality and quantity. Infected vines serve as a source of further infections in the vineyard, where vector nematodes are present in the soil. The damage caused by the virus depends on the age of the vine at the time of infection and the susceptibility of individual varieties. In addition to transmitting GFLV, nematodes cause direct damage to vines by feeding on their roots. Vines develop swellings called galls at the feeding sites, decreasing the ability of roots to absorb nutrients and water from the soil effectively. While the rapid spread of GFLV infections is observed in Slovenian vineyards, similar problems are present in some other European countries. In Slovenia, GFLV is most harmful in the Primorska region, where, due to the prevalence of the vector, it has ideal conditions for spreading. The number of individual *X. index* nematodes is exceptionally high in some vineyards. Due to the significant economic losses effective measures are urgently needed for disease management. As part of the Euphresco project Xiphivir, we tested new methods for detecting GFLV in *X. index* and compared their effectiveness with other commonly used methods. As part of the applied project Resens-Vitis and the Integrated pest management assignments, we plan to monitor the *X. index* population, its infection with GFLV, and explore various options for their control in affected locations.

Spremljanje sezonske dinamike ameriškega škržatka (*Scaphoideus titanus*) v severovzhodni Sloveniji med leti 2018 in 2023

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V vinogradih severovzhodne Slovenije je vsako leto več okužb s fitoplazmo zlate trsne rumenice (Grapevine flavescence dorée – GFD), katere najpomembnejši naravni prenašalec je ameriški škržatek (*Scaphoideus titanus*). V letu 2018 je bilo na zlato trsno rumenico v tem delu Slovenije pozitivnih 10,9 % vzorcev, že v naslednjem letu se je ta odstotek povečal na 52,3 %. V letu 2023 je odstotek pozitivnih vzorcev znašal 71,7 %.

Eden od osnovnih ukrepov za preprečevanje širjenja bolezni zlate trsne rumenice je vzdrževanje nizke populacije ameriškega škržatka v vinogradih. Vsako leto spremljamo sezonsko dinamiko ameriškega škržatka s pomočjo rumenih lepljivih plošč, ki so postavljene v vinogradih v različnih regijah severovzhodne Slovenije (okolica Maribora, Slovenske gorice, Goričko, …). Rumene lepljive plošče v vinograde postavimo konec junija ali v začetku julija, odvisno od samega razvoja ličink ameriškega škržatka (pojava L5 stadija), torej tik preden se začnejo pojavljati odrasli škržatki. V letih med 2018 in 2023 smo spremljanje izvajali v štirih različnih vinogradih – Maribor, Nebova, Bodkovci in Vučja Gomila. Sezonska dinamika ameriškega škržatka se spreminja med leti, tako zaradi vremenskih razmer kot tudi zaradi spreminjanja načina zatiranja le-tega. V teh letih se je zatiranje ameriškega škržatka iz enega obveznega škropljenja na leto na določenih območjih povečalo na tri obvezna škropljenja, nekatera učinkovita sredstva pa so izgubila dovoljenje za uporabo. V razmejenih območjih zlate trsne rumenice je zatiranje ameriškega škržatka obvezno v skladu s Pravilnikom o ukrepih za preprečevanje širjenja in zatiranje zlate trsne rumenice (UL RS, št. 48/2014, 19/16 in 8/17) in je opredeljeno v Načrtu ukrepov. Javna služba zdravstvenega varstva rastlin vsako leto napove natančnejše roke zatiranja ameriškega škržatka za vsa vinogradniška območja v Sloveniji.

ABSTRACT

Seasonal dynamics of American grapevine leafhopper (*Scaphoideus titanus* Ball) in northeastern Slovenia between years 2018 and 2023

Every year, vineyards in north-eastern Slovenia are more and more infected with the phytoplasma Grapevine flavescence dorée (GFD), the most important natural vector of which is the American leafhopper (*Scaphoideus titanus*). In 2018, 10.9 % of samples in this part of Slovenia were positive for GFD, which increased to 52.3 % the following year. In 2023, the percentage of positive samples was 71.7 %. One of the basic measures to prevent the spread of GFD is to maintain a low population of the American leafhopper in vineyards. Every year, we monitor the seasonal dynamics of the American leafhopper using yellow sticky plates placed in vineyards in different regions of north-eastern Slovenia (around Maribor, Slovenske gorica, Goričko, ect.). The yellow sticky panels are placed in the vineyards at the end of June or the beginning of July, depending on the actual development of the larvae (L5 stage), i.e. just before adults start to emerge. Between 2018 and 2023, monitoring was carried out in four different vineyards - Maribor, Nebova, Bodkovci and Vučja Gomila. The seasonal dynamics of the American grapevine leafhopper varies between years, both due to weather conditions and to changes in control methods. Over the years, the control of the American grapevine leafhopper has increased from one compulsory spraying per year in certain areas to three compulsory sprays, and some effective products have lost their authorisation for use. In demarcated areas of Grapevine flavescence dorée, the control of American grapevine leafhopper is compulsory in accordance with the Regulation on measures to prevent the spread and control of grapevine flavescence dorée (OJ RS, No 48/2014, 19/16 and 8/17) and is defined in the Action Plan. Each year, the Public Service for Plant Health announces more precise deadlines for the control of American grapevine leafhopper for all wine-growing areas in Slovenia.

Ugotavljanje razširjenosti škržatkov (Hemiptera: Cicadellidae) – potencialnih prenašalcev fitoplazme Grapevine Flavescence Dorée (FD) v nasadih leske in vinogradih ter njihovi okolici

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Poleg ameriškega škržatka (*Scaphoideus titanus*), ki je poznan prenašalec fitoplazme povzročiteljice zlate trsne rumenice - Flavescence dorée (FD), lahko različne izolate fitoplazem iz skupine 16SrV z alternativnih gostiteljev na vinsko trto prenesejo tudi drugi žuželčji prenašalci. Do sedaj je bilo identificiranih več vrst škržatkov (Auchenorrhyncha), ki bi lahko bili potencialni prenašalci fitoplazem. Med njimi tudi vzhodnjaški škržatek (*Orientus ishidae*), ki se omenja kot možen prenašalec FD fitoplazme z leske na trto, povezuje pa se ga tudi s širjenjem fitoplazmatskih obolenj leske. Z namenom ugotavljanja razširjenosti in zastopanosti potencialnih prenašalcev FD fitoplazme, je bilo v letu 2023 izvedeno sistematično spremljanje škržatkov na štirih reprezentativnih lokacijah po Sloveniji, kjer so bili vinogradi v neposredni bližini nasadov ali večjih sestojev leske: Šempas, Lekmarje, Ilovci, Litmerk. V izbrane nasade leske in vinograde ter v mejice na robu le teh smo namestili po tri rumene lepljive plošče (RLP), ki smo jih menjavali vsakih 14 dni, v obdobju od konca maja do začetka septembra. V laboratoriju je bila izvedena identifikacija vseh škržatkov, ki so se ulovili na RLP. Skupno smo pregledali 330 RLP. Pri vrstah, ki so bile v raziskavi opredeljene kot potencialni prenašalci fitoplazem, je bilo izvedeno tudi štetje osebkov. Skupno smo identificirali 52 vrst škržatkov, med njimi 12 vrst s statusom potencialnih prenašalcev fitoplazem (*Allygidius atomarius*, *Allygidius, commutatus, Allygus modestus, Anoplotettix fuscovenosus, Anoplotettix horvathi, Fieberiella flori, Lamprotettix nitidulus, Oncopsis avellanae, Orientus ishidae, Phlogotettix cyclops, Thamnotettix confinis* in *Thamnotettix dilutior)*. V nasadih leske na vseh štirih lokacijah je izrazito izstopal ulov vzhodnjaškega škržatka. Številčni sta bili tudi vrsti *A. fuscovenosus* in *P. cyclops*, na lokaciji Šempas tudi vrsta *F. florii*. Podobno vrstno zastopanost škržatkov, vendar manjšo številčnost smo zabeležili tudi v mejicah v neposredni bližini leskovih nasadov. V vinogradih so bile populacije škržatkov na splošno majhne. Prevladoval je ameriški škržatek, po številčnosti mu je sledila vrsta *A. fuscovenosus*. V vinogradu na lokaciji Lekmarje je bil drugi najpogostejši *A. horvathi*. Zelo skromen ulov vzhodnjaškega škržatka v vinogradih kaže na to, da vinska trta ni dober gostitelj te vrste. Preostale vrste potencialnih prenašalcev fitoplazem, so se pojavljale v zelo majhnem številu. Med potencialnimi prenašalci FD fitoplazme, ki jih navaja literatura, na izbranih lokacijah spremljanja nismo potrdili le vrste *Allygus mixtus*, kljub temu, da je v Sloveniji splošno razširjena.

ABSTRACT

Distribution and diversity assessment of leafhoppers (Hemiptera: Cicadellidae) – potential vectors of Grapevine Flavescence Doreé Phytoplasma (FDp) in hazelnut orchards and vineyards and their vicinity

Beside *Scaphoideus titanus,* which is a well-known vector of Grapevine flavescence dorée phytoplasma (FDp), various 16SrV phytoplasma isolates can be transmitted from alternative hosts to grapevine also by other insect vectors species. Several leafhoppers (Auchenorrhyncha) have been so far identified as potential vectors of phytoplasmas. Among them, the Oriental leafhopper (*Orientus ishidae*) can potentially transmit FDp from hazel plants to grapevines and is thought to be responsible for the transmission of phytoplasmas between hazelnuts. A systematic monitoring of leafhoppers was carried out in 2023 at four representative locations in Slovenia, with vineyards in close vicinity to a hazelnut orchard: Šempas, Lekmarje, Ilovci, Litmerk. At each location 3 yellow sticky traps were placed in the selected hazelnut orchard and vineyard and also into the adjacent edge vegetation. The yellow sticky traps were replaced every 14 days from end of May to the beginning of September. A total of 330 the sticky traps were exanimated in the laboratory and all the leafhopper specimens caught on the traps were identified. For all the species in the research determined as potential phytoplasma vectors, individual specimens counting was done. We identified 52 different species of leafhoppers, among them there were 12 potential phytoplasma vectors (*Allygidius atomarius*, *Allygidius, commutatus, Allygus modestus, Anoplotettix fuscovenosus, Anoplotettix horvathi, Fieberiella flori, Lamprotettix nitidulus, Oncopsis avellanae, Orientus ishidae, Phlogotettix cyclops, Thamnotettix confinis* and *Thamnotettix dilutior*). *Orientus ishidae* was the most abundant species in the hazelnut orchards at all four locations, followed by *A. fuscovenosus* and *P. cyclops*. In the hazelnut orchard at Šempas we identified also large number of *F. florii*. The same species communitie, but less numerous was found in the adjacent edge vegetation. In general, the population of leafhoppers was lower in vineyards, with *Scaphoideus titanus* as predominated species and followed by *A. fuscovenosus.* In the vineyard at Lekmarje, *A. horvathi* was second most abundant. Low captures of *O. ischidae* in the vineyards indicate that grapevine may not be suitable host for this species. The remaining species identified as potential phytoplasma vectors occurred in very small numbers. Among the potential phytoplasma vectors species known from the literature, only *Allygus mixtus* was not found during our survey, although the species is widespread in Slovenia.

Nova spoznanja o epidemiologiji zlate trsne rumenice na osnovi proučevanja genetske raznolikosti povzročitelja bolezni

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Zlata trsna rumenica je neozdravljiva bolezen trte, ki jo povzroča karantenska fitoplazma Grapevine flavescence dorée. Pomemben vir prenosa fitoplazme povzročiteljice zlate trsne rumenice na večje razdalje so okuženi cepiči, podlage in trsne cepljenke, med trtami pa fitoplazmo učinkovito raznaša ameriški škržatek (*Scaphoideus titanus*). Navzočnost te fitoplazme je bila potrjena tudi v divji trti (*Vitis sylvestris*), navadnem srobotu (*Clematis vitalba*), črni jelši (*Alnus glutinosa*), velikem pajesenu (*Ailanthus altissima*), leski (*Corylus avellana*) in vrbi (*Salix sp.*). Iz teh alternativnih gostiteljev lahko fitoplazmo na trto naključno prenesejo nekatere druge žuželke, ki sesajo rastlinski sok, kot so vzhodnjaški škržatek (*Orientus ishidae*), jelšev škržatek (*Oncopsis alni*) in navadni dolgoglavec (*Dictyophara europaea*). Za učinkovito preprečevanje širjenja bolezni zlate trsne rumenice je nujno dobro poznavanje njene epidemiologije. V ta namen smo proučili genetsko raznolikost izolatov fitoplazme povzročiteljice zlate trsne rumenice, ki smo jih zaznali v vinogradih v Sloveniji v obdobju od 2017 do 2023. Genotipe izolatov fitoplazme iz trt smo primerjali z genotipi izolatov, ki smo jih odkrili v alternativnih gostiteljih in prenašalcih ter z genotipi izolatov odkritih v drugih državah. Na podlagi teh primerjav smo orisali možne poti širjenja te fitoplazme v Sloveniji ter ovrednotili pomen alternativnih gostiteljev in prenašalcev, kar bomo v prispevku tudi predstavili.

ABSTRACT

New insights into the epidemiology of Grapevine flavescence dorée based on a study of the genetic diversity of the causal agent

The quarantine phytoplasma Grapevine flavescence dorée causes an incurable disease of grapevines. Infected grafts, rootstocks and cuttings are an important source of long-distance transmission of the phytoplasma, while *Scaphoideus titanus* effectively spreads the phytoplasma between vines. The presence of this phytoplasma has also been confirmed on wild grapevine (*Vitis sylvestris*), clematis (*Clematis vitalba*), black alder (*Alnus glutinosa*), tree of heaven (*Ailanthus altissima*), hazelnut (*Corylus avellana*), and willow (*Salix*). Other insects, such as *Orientus ishidae*, *Oncopsis alni*, and *Dictyophara europaea*, can inadvertently transfer the phytoplasma from these alternative hosts to the grapevines. To effectively prevent the spread of Grapevine flavescence dorée, a thorough understanding of its epidemiology is essential. To achieve this, we investigated the genetic diversity of phytoplasma isolates causing grapevine yellows disease detected in Slovenian vineyards between 2017 and 2023. We compared the genotypes of grapevine isolates with those found in alternative hosts and insect vectors, as well as with genotypes detected in other countries. Based on these comparisons, we outlined possible transmission pathways of this phytoplasma in Slovenia and evaluated the importance of alternative hosts and vectors, which we will present.

Results of the three-year study with adhesive products to increase defence against the Grapevine Black Rot on the Soreli variety resistant to downy mildew and powdery mildew grown in a organic system

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In the three-year period 2019-2021, a study was conducted in a vineyard located in Risano (Pavia di Udine) in which the variety grown was Soreli, resistant to both downy mildew

and powdery mildew. Different products with adhesive capacity were tested, in combination with copper-based treatments, for their ability to increase plant defences to the black rot disease. The persistence and durability conferred by the tackifiers has proved to be particularly useful in periods with greater precipitations. The study revealed also that the adhesive products can improve the defense against Black rot, especially in cases where copper inputs are reduced.

Učinkovitost jesenskega škropljenja vinogradov z žveplom za zmanjševanje pojava trsne listne pršice šiškarice (*Colomerus vitis* Pagst.)

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Trsna listna pršica šiškarica (*Colomerus vitis* Pagst.) povzroča »erinozo« vinske trte. Te pršice prav tako prenašajo viruse, ki povzročajo zakrnelost vinske trte, ki se v Sloveniji pojavlja že od leta 2001, v večjem obsegu pa se jo opaža od leta 2012. Eden izmed možnih vzrokov zakrnelosti vinske trte je okužba z virusom vinske trte sivi pinot - »*Grapevine Pinot gris virus* – GPGV«, ki je v Sloveniji zelo razširjen. Za zatiranje trsne listne pršice šiškarice se priporoča spomladansko škropljenje z žveplovimi pripravki v najvišjih dovoljenih odmerkih. Poskus je bil izveden v tem smislu, da bi naj jesensko škropljenje z žveplovimi pripravki zmanjšalo prezimitveno populacijo samic. V poskusu v letu 2022 in 2023 smo preizkusili učinkovitost jesenskega in spomladanskega škropljenja z žveplovim pripravkom (v dveh različnih odmerkih – 6 in 8 kg/ha) za zmanjševanje pojava »erinoze« vinske trte. V obeh letih izvajanja poskusa je bil višji odmerek žvepla (8 kg/ha) bolj učinkovit kot nižji odmerek (6 kg/ha), ne glede na čas škropljenja (jeseni ali spomladi). Na podlagi rezultatov smo prav tako ugotovili, da je bilo spomladansko škropljenje enako učinkovito kot jesensko.

ABSTRACT

The efficiency of autumn spraying of vineyards with sulphur to reduce the occurrence of the grape leaf blister mite (*Colomerus vitis* Pagst.)

Grape leaf blister mite (*Colomerus vitis* Pagst.) causes grapevine "erinosis". These mites also transmit viruses that cause stunting of grapevines, which have appeared in Slovenia since 2001, and have been observed on a larger scale since 2012. One of the possible causes of grapevine stunting is infection with the Pinot gris vine virus - "*Grapevine Pinot gris virus* - GPGV", which is widespread in Slovenia. Spring spraying with sulphur in the highest permitted doses is recommended to control the grape leaf blister mite. The experiment was carried out in the sense that autumn spraying with sulphur should reduce the overwintering population of females. In the years 2022 and 2023, we checked in trials the efficiency of autumn and spring spraying with a sulphur (in two different doses – 6 and 8 kg/ha) to reduce the occurrence of grapevine erinosis. In both years, higher dose of sulphur (8 kg/ha) was more effective than the lower one (6 kg/ha), regardless of the time of spraying (autumn or spring). Based on the results we can also conclude, that spring spraying was as effective as autumn spraying.

Napredno odkrivanje *Xylophilus ampelinus* v vinski trti: večstranski pristop pri razvoju in validaciji PCR v realnem času

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Povzročitelj bakterijskega ožiga vinske trte *Xylophilus ampelinus,* predstavlja veliko nevarnost za vinogradništvo. Čeprav v EU bakterija *X. ampelinus* ni več uvrščena med karantenske škodljive mikroorganizme, sum na njeno prisotnost pogosto omejuje mednarodno trgovino s tretjimi državami. Zaradi počasne rasti bakterije se za detekcijo uporabljajo predvsem molekularni testi, a prihaja ob testiranju dormantnega sadilnega materiala do neskladnih rezultatov med različnimi testi. Zato na Nacionalnem inštitutu za biologijo vodimo projekt Euphresco 2021-A-383 v okviru katerega želimo razjasniti neskladne rezultate in razviti nove teste PCR v realnem času (qPCR) za zanesljivejšo detekcijo *X. ampelinus* v razširjenem naboru matriksov. Z bioinformatsko analizo javno dostopnih podatkov genomov *X. ampelinus* in sorodnih bakterij smo razvili 18 različnih kompletov začetnih oligonukleotidov in sond za specifično detekcijo *X. ampelinus*. V procesu validacije smo preverili ali novi qPCR testi pomnožujejo tarčne seve *X. ampelinus* in ali prihaja do navzkrižnih reakcij s številčnim naborom netarčnih sevov: (i) sorodne bakterije iz rodu *Xylophilus*, (ii) bakterije, ki povzročajo podobna bolezenska znamenja na vinski trti in (iii) različni sevi izolirani iz vinske trte. Rezultati omogočajo izbor testov, ki se v zaznavanju tarčnih in netarčnih bakterij dopolnjujejo. S kombinacijo več testov smo znatno zmanjšali navzkrižno reaktivnost z netarčinimi sevi. Tako smo določili 8 novih qPCR testov s katerimi je mogoče zaznati vse tarčne seve. Uporabnost najbolj obetavnih testov smo razširili na testiranje različnih delov rastline vinske trte tako, da smo preverili vpliv ozadja ekstraktov listov, ksilema in korenin na mejo detekcije pri čemer vpliv ni bil ugotovljen. Za dodatno preverjanje najobetavnejših testov smo organizirali medlaboratorijsko primerjavo metod (TPS) v katerem sodelujejo drugi laboratoriji, ki sodelujejo v projektu. Z uvedbo kombinacije testov qPCR bi lahko povečali zanesljivost zaznavanja *X. ampelinus* tudi kadar je bakterija prisotna v latentni obliki in tako preprečili ekonomsko škodo v mednarodni trgovini. To predstavlja pomemben napredek pri odkrivanju *X. ampelinus* in ponuja zanesljiv pristop, ki lahko postane ključno orodje v globalni skrbi za zdravje rastlin vinske trte.

ABSTRACT

Advanced detection of *Xylophilus ampelinus* in grapevine: a multi-pronged approach in the development and validation of real-time PCR

Xylophilus ampelinus, the causative agent of the bacterial blight of grapevines, poses a major threat to viticulture. It is no longer a quarantine microorganism in the EU, so the testing focuses on international trade of planting material. Due to the slow growth of the bacterium, molecular tests are mainly used for detection. However, when testing dormant planting material, the various molecular tests can give contradictory results. Therefore, the

National Institute of Biology is organizing the Euphresco project 2021-A-383 in which we aim to clarify the status of these results and develop new real-time PCR tests (qPCR) for a more reliable detection of *X. ampelinus*. Using publicly available genome data of *X. ampelinus* and related species, we have developed 18 different primer and probe sets for the specific detection of *X. ampelinus*. During validation, we tested the selectivity of the new qPCR on target strains, bacteria of the genus *Xylophilus*, bacteria causing similar disease symptoms on grapevines, and various strains isolated from grapevines. We have identified 8 new qPCR tests that can detect all target strains. By combining several tests, we were able to significantly reduce cross-reactivity. The applicability of the most promising tests was extended to the examination of different parts of the grapevine by checking the influence of leaf, xylem and root extracts on the limit of detection, where no influence was found. For additional verification of the most promising tests, we are organising test performance study in which participate other laboratories that are part of the project. By introducing new qPCR tests for the reliable detection of *X. ampelinus*, we could prevent economic damage in international trade due to false results in the testing of plant material and the spread of the disease to new countries. Our research represents a significant advance in the detection of *X. ampelinus* and offers a reliable multi-assay approach that promises to become an invaluable tool for global viticulture health management.

Splošna sekcija in sekcija Fitofarmacevtska sredstva in okolje

Integrirano varstvo rastlin – odnos do vključevanja pripravkov z nizkim tveganjem in biostimulatorjev

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Integrirano varstvo rastlin (IVR) je sistem za obvladovanje za rastline škodljivih organizmov (ŠO), ki se nenehno razvija skozi čas in je pred številnimi novimi izzivi. Namen je razvijati pristope, ki omogočajo ekonomsko učinkovito zatiranje ŠO z najmanj negativnimi učinki za ljudi in okolje. Ker je razpoložljivih, visoko učinkovit kemičnih sredstev vse manj, je koncept IVR potrebno nekoliko prenoviti, saj je obstoječi sistem preveč togo kurativno naravnan. Nove generacije FFS (biotična FFS in pripravki z nizkim tveganjem) so po konceptu uporabe preventivno naravnani, uporabiti jih moramo, ko so rastline še v dobrem zdravstvenem stanju na podlagi zgodnje napovedi pojava začetnih populacij ŠO. Posebej nedorečena je vloga biostimulatorjev, kjer imamo težave s pravilnim strokovnim umeščanjem njihove uporabe. Zaradi nerazumevanja uporabe ne dosegamo učinkov za omejevanje ŠO, ki bi jih lahko. Glede na njihov registracijski status pri njihovi uporabi ne smemo izpostavljati možnosti zatiranja ŠO. To povzroča, da biostimulatorje premalo vklapljamo v IVR sheme. To velja tako za biostimulatorje na mikrobni, kot na mineralni osnovi. Premalo pozornosti posvečamo abiotičnemu stresu, ker obstaja tesna povezava med obsegom le-tega in obsegom pojava ŠO. V članku podajamo nekatere predloge glede bolj učinkovitega vklapljanja pripravkov z nizkim tveganjem in biostimulatorjev v IVR koncept.

ABSTRACT

Integrated plant protection - attitude towards the inclusion of low-risk preparations and biostimulators

Integrated Plant Protection (IPP) is a plant pest and diseases (PD) control system constantly evolving over time and facing many new challenges. The aim is to develop approaches that allow for economically effective suppression of PD with the most minor adverse effects for people and the environment. Since the highly effective chemical agents are fewer and fewer available, the concept of IPP needs to be slightly revised, as the existing system is too rigidly curative-oriented. The new generations of plant protection products (biotic PPPs and preparations with low risk) are preventively oriented according to the concept of use; they must be applied when the plants are still in a good state of health based on an early prediction of the occurrence of PD. The role of biostimulators is particularly unclear, and we have problems with the correct professional placement of their use. Due to a lack of understanding of their use, we are not achieving the plant protection effects we could. Depending on their registration status, we are not allowed to expose the possibility of suppression of the PD when using them. This causes biostimulators to be insufficiently included in IPP schemes. We pay too little attention to the abiotic stress of plants because there is a close connection between the extent of abiotic stress and the extent of the occurrence of PD. The article suggests the more effective incorporation of low-risk preparations and biostimulators into the IVR concept.

Novosti podjetja Corteva AgriScience SLO d.o.o. – zakaj razvijamo nova sredstva?

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Sodobna podjetja za varstvo kmetijskih rastlin sledijo sodobnim trendom rastlinske pridelave. Delno se prilagajo povpraševanju na tržišču, delno pa z lastnimi raziskavami in spremljanjem najnovejših ugotovitev spodbujajo uvajanje novih, okolju in kmetu primernejših tehnologij pridelave kmetijskih rastlin. Na podjetju Corteva Agriscience SLO d.o.o. smo v zadnjih letih uvedli kar nekaj novih sredstev za varstvo in boljšo vitalnost rastlin. Herbicid Hector® Flex smo uvedli z namenom izboljšane učinkovitosti zatiranja plevela v koruzi, fungicid Verben™ odlikuje najsodobnejša formulacija, ki omogača izboljšano učinkovitost, eden od razlogov za spreminjanje programov škropljenja pa je tudi opustitev določenih sredstev pripravkov zaradi prepovedi uporabe določene aktivne snovi. Zato smo npr. namesto fungicida ZORVEC™ Endavia™ uvedli fungicid ZORVEC™ Entecta™. Ympact®, N-Lock™ Super in Utrisho®N pa smo uvedli zaradi boljšega izkoriščanja dušika in ostalih hranil ter varovanja okolja pred onesnaženjem z dušikom. Poleg kemičnih sredstev za varstvo rastlin in semena uvajamo še pripravke, dovoljene v ekološki pridelavi, ter pripravke, s katerimi povečujemo vitalnost in pridelek kmetijskih rastlin. V skladu usmeritev trajnostnega kmetijstva pa varujemo okolje našim zanamcem.

ABSTRACT

New products by Corteva AgriScience SLO d.o.o. – why are new crop protection products being developed?

Modern crop protection product manufacturers follow cutting-edge cropping trends. In part, they adapt to demand on the market, and, in part, they use their in-house research and monitoring of the latest findings to promote new environment- and farmer-friendly crop production. During the recent years, Corteva Agriscience SLO d.o.o. has introduced several new crop protection products intended to protect and improve the vitality of crops. Herbicid Hector® Flex has been introduced to improve the effectiveness of controlling weeds in maize, whereas the Verben™ fungicide is distinguished by its state-of-the-art formula facilitating an improved effectiveness. Spraying programmes have also been changed on account of abandoning of certain substances contained in the preparations resulting from the ban on the use of specific active substances. As a result, the ZORVEC™ Entecta™ has replaced the ZORVEC™ Endavia™ fungicide. On the other hand, Ympact®, N-Lock™ Super and Utrisho®N have been introduced to boost the utilisation of nitrogen and other nutrients and to protect the environment against nitrogen pollution. In addition to agrochemicals used to protect crops and seeds, the company has been introducing preparations allowed in organic plant production and preparations that boost the vitality and yield of crops. In compliance with sustainable agriculture guidelines, it has been protecting the environment for our descendants.

Uporaba metode DNA črtnih kod za hitro identifikacijo žuželk, ki povzročajo škodo na rastlinah

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Standardizirana DNA črtna koda gena za podenoto 1 citokrom c-oksidaze (*COI*), ki so jo prvotno predstavili Herbert in sod. leta 2003, se pogosto uporablja za identifikacijo žuželk kot rastlinskih škodljivcev. V projektu Q-Entry (CRP V4-2003) smo preizkusili protokol za metodo DNA črtnih kod z uporabo gena *COI* na različnih referenčnih vzorcih žuželk v različnih življenjskih fazah (ličinke in odrasli), zbranih z rutinskimi raziskavami ali pridobljenih iz mednarodnih sodelovanj. Razvili in uporabili smo standardiziran protokol za ekstrakcijo DNA, PCR pomnoževanje gena *COI*, ločljivost PCR produktov v agaroznem gelu, njihovo čiščenje in sekvenciranje po Sangerju, ki ga izvaja akreditirani ponudnik. Po strogih parametrih kontrole kakovosti, so bile COI konsenzusne sekvence za posamezne vzorce ustvarjene s programsko opremo Geneious Prime (Geneious Prime 2023.2.1). Konsenzusne sekvence visoke kakovosti (z rezultatom Phred > 30) pričakovane dolžine (> 604 bp) so bile pridobljene za vse vzorce, testirane iz produktov PCR, ki so bili prečiščeni z uporabo kompleta za ekstrakcijo iz agaroznega gela in pridobljeni tudi iz razredčenih neprečiščenih produktov PCR. Končna identifikacija vrst žuželk je bila izvedena s primerjavo konsenzusnih sekvenc s tistimi, ki so prisotne v referenčnih podatkovnih bazah, kot so EPPO-Q-Bank, BOLD Systems in NCBI GenBank. S to metodo smo uspešno identificirali vse testirane vrste žuželk, vključno s *Spodoptera frugiperda S. exigua, S. littoralis, Pieris brassicae, Thrips tabaci, Chrysodeixis chalcites, Liriomyza bryoniae, Frankliniella occidentalis* kot tudi žuželke izbranih neidentificiranih vzorcev. Projekt Q-Entry je učinkovito implementiral metodo DNA črtnih kod za identifikacijo žuželk, ki podpira morfometrično identifikacijo in razširja identifikacijske zmogljivosti na življenjska obdobja žuželk, ki presegajo tradicionalne pristope.

ABSTRACT

DNA Barcoding as a Rapid Method for the Identification of Insect Pests of Plants

The standardised barcode of the cytochrome c oxidase subunit 1 (COI) gene, initially introduced by Herbert et al. in 2003, is widely used for the identification of insect pests. In the Q-Entry project (CRP V4-2003), we tested the COI DNA barcoding protocol on different reference specimens of insects at different life stages (larvae and adults), collected through routine surveys or obtained from international collaborations. We have developed and applied a standardised protocol for DNA extraction, PCR amplification of COI, agarose gel resolution of PCR products, their purification and Sanger sequencing, carried out by an accredited provider. Following rigorous quality control parameters, consensus COI sequences for individual samples were generated using Geneious Prime software (Geneious Prime 2023.2.1). High quality consensus sequences (with a Phred score > 30) of expected length (> 604 bp), were obtained for all samples tested from PCR products that were purified using an agarose gel extraction kit and were also obtained from diluted unpurified PCR products. The final identification of the insect species was

carried out by comparing the consensus sequences with those present in reference databases, such as EPPO-Q-Bank, BOLD Systems and NCBI GenBank. Using this method, we were able to successfully identify insect species for all species tested, including *Spodoptera frugiperda S. exigua, S. littoralis, Pieris brassicae, Thrips tabaci, Chrysodeixis chalcites, Liriomyza bryoniae, Frankliniella occidentalis* as well as selected unidentified specimens. The Q-Entry project has effectively implemented the DNA barcoding of insects, which supports their morphometric identification and extends identification capabilities to life stages of the insects beyond traditional approaches.

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IPM Adviser: Spletno orodje za pregled in primerjavo sistemov za podporo pri odločanju za integrirano varstvo rastlin

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Sistemi za podporo odločanja (SZPO, Ang. DSS) za integrirano varstvo rastlin (IVR) so računalniška orodja, ki z uporabo integriranih modelov, dostopnih podatkovnih zbirk (npr. vremenskih podatkov) ter podatkov, ki jih vnese uporabnik, napovedujejo stopnjo in čas pojava tveganja za nastanek škode zaradi škodljivih organizmov. Uporabniku zato pomagajo pri načrtovanju časa izvedbe varstvenega ukrepa, zato se izboljša učinkovitost in zmanjša količina uporabljenih fitofarmacevtskih sredstev (FFS). Med kmeti in kmetijskimi svetovalci je uporaba tovrstnih orodij relativno slabo razširjena, med glavnimi razlogi za to pa je nedostopnost informacij o SZPO za IVR. Informacije so običajno razpršene po spletnih straneh posameznih razvijalcev ali SZPO in zato za končnega uporabnika težko dostopne. Poleg tega pa uporabnik zelo težko primerja značilnosti posameznih SZPO. Z namenom boljše dostopnosti do informacij o SZPO za uporabo v IVR in lažje izbire najustreznejšega SZPO za uporabnika, smo razvili spletno orodje "*IPM Adviser*" (https://ipmadviser.ijs.si/). Orodje na prijazen način, brezplačno in brez ustvarjanja uporabniškega računa omogoča pregled, primerjavo in izbiro najustreznejšega SZPO. V spletno orodje *IPM Adviser* je implementirana tipologija, ki smo jo razvili za SZPO za IVR za uporabo v Evropi. Na osnovi tipologije smo določili 50 kriterijev s katerimi smo opisali 79 SZPO, ki so na voljo za IVR v Evropi. Kriteriji tipologije opisujejo strukturne in funkcionalne lastnosti obravnavanih SZPO. Orodje *IPM Adviser* omogoča tudi primerjave do štirih izbranih SZPO po vseh opisnih kriterijih hkrati. Orodje tako pomaga pri premagovanju ene izmed ključnih ovir pri uvajanju SZPO v IVR v Evropi to je pomanjkanje dostopa do uporabniških informacij. Pridelovalcem močno olajša izbiro primernih SZPO s katerimi bodo lažje izpolnili zahteve Evropske komisije za zmanjševanje uporabe FFS ter prešli na bolj trajnostno rabo FFS.

ABSTRACT

IPM Adviser: A web tool for reviewing and comparing integrated pest management decision support systems

Decision support systems (DSS) for integrated pest management (IPM) are computer tools that use integrated models, available databases (e.g. weather data) and user data inputs to predict the level and timing of pest damage risk. Therefore, they help the user to plan the timing of crop protection measures, resulting in improved efficiency and a reduction in the amount of plant protection products (PPPs) applied. The utilisation rate of such tools is relatively low among farmers and farm advisors, and one of the main reasons for this is the lack of accessible information on IPM DSS. This information is usually scattered across the websites of individual developers or DSSs and therefore difficult to find. In addition, this makes it very difficult to compare the characteristics of each DSS. To improve the accessibility of information on IPM DSS and to make it easier for the user to select the most suitable DSS, we have developed the web tool *'IPM Adviser'* (https://ipmadviser.ijs.si/). This tool allows you to review, compare and select the most suitable DSS in a user-friendly way. It is free and accessible without creating a user account. The *IPM Adviser* web tool implements the typology that we have developed specifically for IPM DSS in Europe. The criteria of the typology describe the structural and functional characteristics of the considered DSS. The *IPM Adviser* tool also enables the simultaneous comparison of up to four selected DSSs across all descriptive criteria. The tool thus helps to overcome one of the main barriers to the adoption of DSS in IPM in Europe which is the lack of access to information on IPM DSS. It makes it easier for users to select suitable DSS that help them meet the European Commission's requirements to reduce PPP use and move towards a more sustainable use of PPPs.

Izboljšanje standardov zdravstvenega varstva rastlin: 5 let odličnosti slovenskega nacionalnega referenčnega laboratorija za bakterijske patogene na rastlinah

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V zadnjih petih letih je Nacionalni inštitut za biologijo deloval kot slovenski nacionalni referenčni laboratorij za škodljive organizme rastlin na področju določanja bakterij. Inštitut ima ključno vlogo pri ugotavljanju in obvladovanju bakterijskih rastlinskih patogenov, ima karantensko postajo, opremljeno z najsodobnejšimi laboratoriji, rastnimi komorami in karantenskim rastlinjakom. Naš laboratorij vestno izpolnjuje obveznosti členov 100 in 101 uredbe EU (2017/625). Osredotočamo se na usklajevanje in izpopolnjevanje laboratorijskih analitičnih metod za doseganje natančne identifikacije bakterij v rastlinah, semenu, žuželkah in okoljskih vzorcih. To delo je ključnega pomena za ohranjanje zdravja rastlin ter s tem za ohranjanje kmetijske pridelave in varnosti trgovine. K našemu napredku je pripomogla predanost laboratorija nepristranskosti, mednarodnim standardom in napredku na področju raziskav. Pomemben vidik našega dela je učinkovito usklajevanje z EU konzorcijskim referenčnim laboratorijem katerega član smo in drugimi nacionalnimi laboratoriji in stalno usposabljanje in razvoj kompetenc in veščin osebja. Naš laboratorij je uspešno sodeloval pri številnih testih usposobljenosti ter tudi pri medlaboratorijskih primerjavah metod. Poleg tega imamo več metod in testov, akreditiranih v skladu s standardom ISO/IEC 17025, kar dodatno zagotavlja zanesljivost in natančnost naših analiz. Za učinkovito delovanje laboratorija je ključno tudi validiranje reagentov in vzdrževanje delovne zbirke bakterij. S temi celovitimi prizadevanji naš laboratorij še naprej krepi svojo

vlogo pri celostnem upravljanju zdravja rastlin in učinkovito združuje znanstvene pristope s sodelovalnimi inovacijami za zaščito kmetijstva in javnega zdravja.

ABSTRACT

Advancing Plant Health Standards: 5 Years of Excellence at the Slovenian National Reference Laboratory for Bacterial Pathogens in Plants

Over the last five years, the National Institute of Biology has acted as the Slovenian National Reference Laboratory for plant health in relation to bacteria. The institute plays a crucial role in identifying and managing bacterial diseases and houses a quarantine station equipped with cutting-edge laboratories and a quarantine greenhouse. Our laboratory has dutifully fulfilled the responsibilities elucidated in Articles 100 and 101 of EU regulation (2017/625). We concentrate on aligning and refining laboratory analytical methods to attain accurate bacterial identification in plants, seeds, insects, and environmental samples. This work is crucial in preserving plant health and, therefore, sustaining agricultural productivity and trade safety. The laboratory's dedication to impartiality, international standards, and advancements in research has been instrumental in our progress. A remarkable facet of our work involves efficient coordination with other EU and national laboratories, essential for conducting inter-laboratory comparative and proficiency tests and continuous development of the competency and skills of our staff. Our laboratory has successfully participated in numerous tests, demonstrating our high standards of practice. In addition, we have several tests accredited according to ISO/IEC 17025, further ensuring the reliability and accuracy of our analyses. Furthermore, our facility plays a crucial role in validating reagents and maintaining a working bacterial collection; these are essential for outbreak diagnosis and confirmatory tests. Through these comprehensive efforts, our laboratory continues to reinforce its role as a cornerstone in plant health management, effectively blending scientific rigor with collaborative innovation to safeguard agricultural integrity and public health.

Trenutne nematološke znanstvene raziskave in strokovno delo na Kmetijskem inštitutu Slovenije

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Ogorčice oziroma rastlinsko parazitski nematodi zajedajo številne rastline, med njimi tudi pomembne kmetijske rastline. Če se prekomerno razmnožijo, zmanjšajo kakovost in količino pridelkov. Ocenjujejo, da so ogorčice odgovorne za 110 milijard evrov izgub letno. V prispevku bomo predstavili trenutne znanstvene raziskave in strokovno delo za obvladovanje teh škodljivcev v Sloveniji. Na Kmetijskem inštitutu Slovenije raziskujemo ogorčice v okviru več mednarodnih in nacionalnih projektih. Naše trenutno znanstveno raziskovalno delo je fokusirano na vrste ogorčic, ki za Slovenijo predstavljajo največje grožnje: ogorčice koreninskih šišk (*Meloidogyne luci, M. chitwoodi, M. fallax* in druge tropske vrste), krompirjeve ogorčice (*Globodera rostochiensis* in *G. pallida*), borova ogorčica (*Bursaphelenchus xylophilus*) in vrsta *Xiphinema index*. V naših raziskavah se osredotočamo na razvoj novih okolju prijaznih načinov obvladovanja ogorčic, zgodnje

zaznavanje napada ogorčic s pomočjo daljinskega zaznavanja, genomske raziskave ter razvoj novih protokolov detekcije in identifikacije vrst ogorčic. Prav tako je velikega pomena strokovna podpora na področju ogorčic, ki jo nudimo Upravi za varno hrano, veterinarstvo in varstvo rastlin (UVHVVR, Ministrstvo za kmetijstvo, gozdarstvo in prehrano) v okviru strokovne naloge s področja zdravstvenega varstva rastlin. Glavni stebri našega strokovnega dela so nacionalni programi preiskav za ugotavljanje prisotnosti karantenskih in drugih gospodarsko pomembnih ogorčic, laboratorijska diagnostika, predlogi za obvladovanje ogorčic prisotnih na območju Slovenije, določanje odpornosti novih sort krompirja proti krompirjevim ogorčicam, razvoj novih praktičnih pristopov za zgodnje zaznavanje ogorčic s pomočjo analiz hiperspektralnih posnetkov itd. Vse naše znanstveno raziskovalno in strokovno delo na področju ogorčic je namenjeno zagotavljanju zadostne in zdrave hrane, kar je eden od strateških ciljev Slovenije.

ABSTRACT

Current nematological scientific research and expert work at the Institute of Agriculture of Slovenia

Plant parasitic nematodes parasitise many plants, including important agricultural crops. When they multiply excessively, they affect the quality and quantity of crops. Plant parasitic nematodes have a major impact on global food production with an estimated annual loss of around 110 billion euros worldwide. We will present the current state of scientific research and expert work on the management of these pests in Slovenia. At the Agricultural Institute of Slovenian, we participate in several international and national projects on plant parasitic nematodes. Our current scientific research focuses on the nematode species that pose the greatest threat to Slovenia: root-knot nematodes (*Meloidogyne luci*, *M. chitwoodi, M. fallax* and other tropical species), potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*), pine wood nematode (*Bursaphelenchus xylophilus*) and *Xiphinema index*. Our research focuses on the development of new environmentally friendly nematode management approaches, early detection of nematode infestations by remote sensing, genomics and the development of new protocols for detection and identification. In addition, we support the Administration for Food Safety, Veterinary Sector and Plant Protection (Ministry of Agriculture, Forestry and Food) in the field of nematology. The main pillars of our expertise are national survey programmes for the detection of quarantine and other economically important nematodes, laboratory diagnostics, management of nematodes occurring in Slovenia, determination of resistance of new potato varieties to potato cyst nematodes, development of new practical approaches for early detection of nematodes by analysis of hyperspectral images, etc. All our scientific research and the work of our experts in the field of nematology are aimed at ensuring sufficient and healthy food, which is one of Slovenia's strategic goals.

Razvoj mobilnih aplikacij Službe za varstvo rastlin na KGZS – Zavod Novo mesto

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Primarna dejavnost javne službe zdravstvenega varstva rastlin je izvajanje nalog s področja spremljanja, opazovanja in napovedovanja pojava bolezni ter škodljivcev rastlin (prognoza škodljivih organizmov). Za spremljanje škodljivih organizmov se uporabljajo različni pripomočki, od feromonskih vab in lepljivih plošč do novejših tehnik daljinskega spremljanja. Poleg prej naštetih pripomočkov je v tem času zelo pomembna še dobra strojna in programska oprema, ki nam omogoča prihranek pri času za vnos vseh potrebnih podatkov, obdelavo in možnost stalnega dostopanja. S tem namenom je Služba za varstvo rastlin na KGZS Novo mesto od leta 2000 dalje iskala rešitve za poenostavitev dela. Začelo se je z vpisovanjem podatkov v zvezek, nadaljevalo z vnosi v preglednico MS Excel in nato še v obrazec v MS Access. Leta 2020 smo s pomočjo spletnega orodja AppSheet, ki zagotavlja brezkodno razvojno platformo za aplikacijsko programsko opremo, izdelali spletno aplikacijo ZumZum 3.0. Poleg omenjenega spletnega orodja uporabljamo tudi oblačno storitev Dropbox, ki nam omogoča shranjevanje vseh pridobljenih podatkov. Z izdelavo aplikacije ZumZum 3.0 se je odprla možnost razvoja dodatnih aplikacij (Fitozapis, Konopko, …), ki so močno olajšale delo prognostikom, zunanjim opazovalcem in preglednikom na KGZS - Zavodu Novo mesto.

ABSTRACT

Development of mobile applications by the Plant Protection Service at the CAFS, Agricultural and Forestry Institute Novo mesto

The primary activity of the plant protection service is to carry out tasks in the field of monitoring, surveillance and prediction of diseases and plant pests (harmful organism prognosis). To monitor harmful organisms, a variety of accessories is used, such as sex pheromone traps, sticky plates and modern techniques like automated pest monitoring system. In addition to these accessories, a good hardware and software is also important, which allows us to save time in entering the data, processing and accessing it on a daily basis. This is why the plant protection service at the Agricultural and forestry institute Novo mesto has been looking for solutions since 2000 to simplify the work. We started with entering the data in a notebook, shifted to an MS Excel spreadsheet and then in a form in MS Access. In 2020, with the help of the AppSheet online tool that features the no-code development platform for the application software, we developed an online application ZumZum 3.0. In addition to this online tool, we also use the Dropbox cloud service that enables us to save all the acquired data. By creating the ZumZum 3.0 application, an opportunity to develop additional applications have arisen (Fitozapis, Konopko, etc.) and these considerably facilitate the work of prognostics, external observers and inspectors at the Agricultural and forestry institute Novo mesto.

Posebne ugotovitve iz mikološkega diagnostičnega laboratorija Kmetijskega inštituta Slovenije

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Kmetijstvo in vrtnarstvo se sooča s posledicami, povezanimi s podnebnimi spremembami, ki omogočajo uveljavljanje potencialno invazivnih ali novih rastlinskih patogenov in spreminjajo vedenje neinvazivnih, že prisotnih gliv, vključno z rastlinskimi patogeni. Spremenjene strategije varstva pred škodljivci spreminjajo pogoje in lahko sprožijo izbruhe nenavadnih patogenov ali nenavaden razvoj simptomov. Uporaba novih diagnostičnih orodij omogoča tudi identifikacijo različnih, vendar tesno sorodnih in morfološko težko razločljivih vrst. Tovrstna problematika je obravnavana na podlagi vzorcev, ki se rutinsko obdelujejo v mikološkem laboratoriju Kmetijskega inštituta Slovenije v okviru diagnostične ali strokovne dejavnosti. Primeri vključujejo *Colletotrichum* spp. iz navadnega fižola in oreha, *Pilidium lythri* na plodovih borovnic, različne povzročitelje jabolčne pegavosti, vključno z *Diplocarpon coronariae* in *Neocosmospora* sp., *Globisporangium* (*Pythium*) *mastophorum* iz peteršilja in druge. Obravnavani primeri poudarjajo potrebo po rutinskih programih spremljanja, ki omogočajo evidentiranje kmetijsko pomembnih patogenih gliv.

ABSTRACT

Peculiar findings from the mycological diagnostic lab of the Agricultural Institute Slovenia

Agri- and horticultural systems are challenged by climate change related consequences allowing potentially invasive or new plant pathogens to become established and altering the behaviour of non-invasive, already present fungi including plant pathogens. Altered pest management strategies change the conditions and may trigger outbreaks of unusual pathogens or unusual symptom developments. Utilization of novel diagnostic tools also allow identification, e.g., of different, however, closely related and morphologically hardly distinguishable species. The issue is discussed on the basis of materials that are routinely processed in the mycological labs of the Agricultural Institute of Slovenia in the context of diagnostic or professional activities. Examples include *Colletotrichum* spp. from common bean and walnut, *Pilidium lythri* on blueberry fruits, various apple blotch agents including *Diplocarpon coronariae* and *Neocosmospora* sp., *Globisporangium* (*Pythium*) *mastophorum* from parsley, and others. Discussed examples emphasize the need for routine monitoring programs allowing inventorying agriculturally relevant, pathogenic fungi.

Bakteriofagi: kaj so in kako nam lahko pomagajo?

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Bakterije so povzročiteljice mnogih pomembnih rastlinskih bolezni, ki lahko v pridelavi hrane povzročijo precejšnjo gospodarsko škodo. Povsod, kjer so prisotne, prej ali slej povzročajo težave v pridelavi, tudi v Sloveniji. Omejena možnost uporabe in manjša učinkovitost zaščitnih sredstev sta izziv pri obvladovanju bakterijskih bolezni rastlin. Iskanje alternativnih sredstev, ki so okolju prijazna, je torej ključno, če želimo kljub vsem tem izzivom ohraniti pridelavo na zaščitenih površinah. Za zmanjšanje možnosti pojava in preprečitev širjenja okužbe se pridelovalci že poslužujejo tudi drugih ukrepov, med katerimi so uporaba zdravega sadilnega in semenskega materiala, izbira odpornih sort ter

širok kolobar v primeru enoletnih rastlin. Ena izmed alternativ za zaščito rastlin predstavljajo tudi bakteriofagi (fagi). Bakteriofagi so virusi, ki okužujejo bakterije in so najštevilčnejša skupina mikroorganizmov na planetu. Posedujejo nekatere edinstvene lastnosti, ki bi jih s pridom lahko uporabili v varstvu rastlin. Delujejo izjemno selektivno in se razmnožujejo le v primeru prisotnosti gostiteljske celice. Ne predstavljajo tveganja za rastline, živali in ljudi ter se za razliko od kemičnih zaščitnih sredstev na osnovi bakra ne nalagajo v tleh. Zanimanje za uporabo bakteriofagov v varstvu rastlin in raziskave na tem področju so v porastu, vendar je za njihovo splošno uporabo potrebnega še veliko raziskovalnega dela. Na Kmetijskem inštitutu Slovenije smo zato pričeli z raziskovanjem možnosti uporabe bakteriofagov za obvladovanje črne žilavke, pomembne bakterijske bolezni kapusnic.

ABSTRACT

Bacteriophages: What they are and how they can help us?

Bacteria are causative agents of many important plant diseases and can cause considerable economic damage in food production. Wherever they are present, they pose challenges, also in Slovenia. Limited options for use and lower effectiveness of protective agents present a challenge in managing bacterial plant diseases. Therefore, seeking environmentally friendly alternatives is crucial to reduce the use of pesticides and preserve production in protected areas. To reduce the occurrence and spread of bacterial diseases, growers already employ alternative measures, including the use of healthy planting and seed material, selection of resistant varieties, and use a broad crop rotation. One of important alternatives is the use of bacteriophages (phages). Bacteriophages are viruses of bacteria and are the most abundant group of microorganisms on the planet. They possess some unique characteristics that could be beneficially exploited in plant protection. They act extremely selectively and reproduce only in the presence of a host cell. They pose no risk to plants, animals, and humans, and unlike copper-based chemical protective agents, they do not accumulate in the soil. The interest in using bacteriophages in plant protection and research in this field is on the rise. However, there is still a need for extensive research before their widespread application can be realized. At the Agricultural Institute of Slovenia, we have therefore commenced research into the possibilities of using bacteriophages to control black rot, an important bacterial disease of brassicas.

Preizkušanja učinkovitosti ultravijolične (UV-C) svetlobe za preprečevanje glivičnih bolezni rastlin

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Ultravijolična (UV) svetloba je kratkovalovno (100-400nm) elektromagnetno sevanje, ki ga v naravi oddaja Sonce, proizvedemo pa ga lahko tudi z umetnimi viri oz. sijalkami. UV spekter lahko glede na valovne dolžine razdelimo na UV-A, UV-B in UV-C. Pri tem ima UV-C (100-280nm) izrazito negativno delovanje na organizme, saj lahko izpostavljenost

žarkom povzroča hude opekline, ožige in poškodbe DNA. Ta lastnost se že več kot stoletje uporablja kot učinkovita fizična metoda za preprečevanje škodljivih mikroorganizmov v medicini in živilski industriji, predvsem za razkuževanje vode, zraka in prostorov. Uporabnost metode se je v zadnjem desetletju razširila tudi na področje varstva rastlin, kjer se kot alternativna metoda fitofarmacevtskim sredstvom (FFS) vpeljuje predvsem za preprečevanje pepelovk in sive plesni z aplikacijo avtonomnih robotskih naprav. Z namenom vpeljevanja in razvoja te metode v Sloveniji smo v okviru projekta UV4PLANTS izvedli več laboratorijskih poskusov s katerimi smo preskušali učinkovitost UV-C obsevanja na različnih patoloških modelih. V ta namen je bila izdelana in validirana obsevalna komora, ki omogoča računalniško krmiljenje UV-C odmerkov (J/m^2). Preskušanja smo izvedli na hmelju, kjer smo proučevali preventivno in kurativno delovanje na glivo *Podosphaera macularis*, na paradižniku za preprečevanje glive *Alternaria alternata* ter na plodovih malin za preprečevanje glive *Botrytis cinerea*. V prispevku predstavljamo prve rezultate učinkovitosti UV-C obsevanj in nadaljnje usmeritve za uporabo UV-C tehnologije v varstvu rastlin.

ABSTRACT

Efficacy testing of ultraviolet (UV-C) light for preventing fungal diseases in plants

Ultraviolet (UV) light is short-wavelength (100-400nm) electromagnetic radiation emitted by the sun in nature, and it can also be produced using artificial sources or lamps. The UV spectrum can be divided into UV-A, UV-B, and UV-C based on wavelength. UV-C (100-280nm) has a distinctly harmful effect on organisms, as exposure to its rays can cause severe burns, scalds, and damage to DNA. This property has been utilized for over a century as an effective physical method for preventing harmful microorganisms in medicine and the food industry, particularly for disinfecting water, air, and spaces. In the past decade, the application of this method has expanded to plant protection, where it is introduced as an alternative method to plant protection products, especially for preventing powdery mildews and gray mold with the use of autonomous robotic devices. In order to introduce and develop this method in Slovenia, we carried out several laboratory experiments within the UV4PLANTS project to test the effectiveness of UV-C on various pathological models. For this purpose, an irradiation chamber was designed and validated, enabling computer-controlled UV-C dosages (J/m2). The experiments were conducted on hops, where we studied the preventive and curative effects on the fungus *Podosphaera macularis*, on tomatoes to prevent the fungus *Alternaria alternata*, and on raspberry fruits to prevent the fungus *Botrytis cinerea*. In this presentation, we present first results on the effectiveness of UV-C irradiation and further directions for the use of UV-C technology in plant protection.

Pomen podatkov pri odločanju o varstvu rastlin - principi in primeri dobrih praks

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Praktično vse naše odločitve temeljijo na podatkih. To velja tako za vsakodnevne odločitve, kot za odločitve povezane z varstvom rastlin. Skozi področje spremljanja in napovedovanja populacije škodljivcev, bomo prikazali kako pomembni so osnovni principi

obvladovanja podatkov (zajem, čiščenje in izboljševanje podatkov). V prispevku bomo na primeru dobrih praks predstavili tudi uporabno vrednost tovrstnih podatkov.

ABSTRACT

Data driven crop protection - principles and best practices

Almost all our decisions are data driven and crop protection related decisions are no exception. Basic data management principles (collect, purify, enhance) will be explained in the realm of monitoring and forecasting pest insects. Furthermore, some of the best practices of using such data will be presented.

Varstvo gozdnega drevja

Vzroki hiranja navadne bukve v Sloveniji

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V zadnjem času po vsej Sloveniji opažamo hiranje navadne bukve (*Fagus sylvatica* L.). Povprečna osutost bukove krošnje se je od leta 1993 do 2020 na sistematični mreži 16 × 16 km povečala iz 13,9 % na 32,2 %. Dolgoročen linearen trend je pokazal, da se je povprečna osutost bukove krošnje povečala za 0,63 % na leto. Povprečna osutost bukve se hitreje veča na jugu in zahodu države, kjer je na robu svojega areala. Z raziskavo smo potrdili, da je v proces hiranja navadne bukve v Sloveniji vpletenih večje število škodljivih dejavnikov, ki skupaj povzročajo kompleksno bolezen. Bolezni povzročijo v povprečju večjo poškodovanost navadne bukve v Sloveniji kot žuželke in drugi škodljivi dejavniki. V proces hiranja navadne bukve so vpleteni predvsem endofiti, ki se v stresnih razmerah aktivirajo in povzročajo poškodbe in jih zato obravnavamo kot fakultativne patogene. Med najpogostejšimi fakultativnimi patogeni smo identificirali glive *Neohendersonia kickxii*, *Neonectria coccinea* in *Apiognomonia errabunda*. Najbolj pogoste žuželke so bile *Orchestes fagi*, *Phyllaphis fagi*, *Psilocorsis reflexella* in *Phyllonorycter maestingella*; vendar je bil njihov prispevek k obsegu poškodovanosti majhen. Združbe gliv in združbe žuželk so se značilno razlikovale med deli drevesa, ne pa tudi med razredi dreves poškodovano/zdravo. Slednja ugotovitev je zelo pomembna, ker nakazuje, da so v zdravih bukvah prisotni že vsi škodljivi organizmi, ki so tudi v poškodovanih. Zato so izjemnega pomena zunanji sprožilni dejavniki, ki spodbudijo patogeno delovanje teh vrst. Determiniranim boleznim in škodljivcem smo poskušali določiti njihovo vlogo pri hiranju bukve, tako da smo jih razdelili v tri skupine: dejavniki predispozicije, sprožilni dejavniki in dodatni dejavniki. Dejavniki predispozicije so: podnebne spremembe, onesnažen zrak, neustrezno rastišče, neustrezen izvor semena, fitoftore, stalno prisotni škodljivci. Sprožilni dejavniki so: suša, pozeba, defoliatorji. Dodatni dejavniki so: bolezni vejic in vej oz. fakultativni patogeni, bolezni debla in koreničnika, bolezni listja, trohnobne glive, podlubniki in druge žuželke.

ABSTRACT

Causes of common beech decline in Slovenia

In recent years, we have observed the decline of common beech (*Fagus sylvatica* L.) throughout Slovenia. The average defoliation of beech crown increased from 13.9% in 1993 to 32.2% in 2020 on the systematic grid of 16 × 16 km. A long-term linear trend showed that the average defoliation of beech crown increased by 0.63% per year. The average defoliation of beech is increasing faster in the south and west of the country, where it is at the edge of its range. The study confirmed that several harmful factors are involved in the process of common beech decline in Slovenia, which together cause a complex disease. Diseases cause on average more damage to common beech in Slovenia than insects and other harmful factors. The process of common beech decline involves mainly endophytes, which are activated in stressful conditions and cause damage and are therefore considered as facultative pathogens. Among the most common facultative pathogens we identified fungi *Neohendersonia kickxii*, *Neonectria coccinea* and

Apiognomonia errabunda. The most common insects were *Orchestes fagi*, *Phyllaphis fagi*, *Psilocorsis reflexella* and *Phyllonorycter maestingella*; however, their contribution to the extent of damage was small. Fungal communities and insect communities differed significantly between parts of the tree, but not between classes of trees damaged/healthy. The latter finding is very important because it indicates that all harmful organisms in damaged trees are already present in healthy ones. Therefore, external triggering factors that stimulate the pathogenic activity of these species are of paramount importance. We tried to determine the role of determined diseases and pests in the decline of beech by dividing them into three groups: predisposing factors, triggering factors and additional factors. Predisposing factors are climate change, air pollution, inadequate habitat, inappropriate seed origin, *Phytophthora* species, permanently present pests. Triggering factors are drought, frost, defoliators. Additional factors are branch diseases or facultative pathogens, trunk and root diseases, leaf diseases, decay fungi, bark beetles and other insects.

Vpliv ravnanja z ostanki poseka na podlubnike

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Podlubniki so v zadnjih desetletjih povzročili številne težave zaradi vse pogostejših obsežnih podnebnih motenj. Raziskanih je bilo veliko različnih metod za nadzor izbruhov podlubnikov, vendar učinki sečnih ostankov ostajajo premalo raziskani. Sečnja dreves je v gozdovih pogosta praksa. Vejevje je po poseku tradicionalno zloženo na kupe z namenom zmanjšanja morebitne površine zalege, ki jo lahko napadejo podlubniki, in s tem nevarnosti poseličnih napadov na okoliška drevesa. Nikoli pa ni bilo raziskano, kako uspešna je ta metoda v primerjavi z drugimi pristopi ravnanja z ostanki. Naš cilj je bil raziskati najuspešnejšo metodo ravnanja z ostanki v okviru upravljanja s podlubniki. Pripravili smo ploskve s tremi tretmaji, 1) ostanki v kupih, 2) ostanki razporejeni in 3) ostanki odstranjeni, in to smo primerjali s 4) kontrolno ploskvijo, kjer ni bilo sečnje. Na vsaki lokaciji je bilo določenih pet ploskev na tretma. Skupno so bile izbrane 3 lokacije, ena na visoki nadmorski višini in dve na nižji nadmorski višini v različnih delih Slovenije. V tretmajih smo izmerili temperaturo in vlago na 20 cm nad tlemi, ujeli in prešteli podlubnike, ki so jih privabila tretiranja, ter prešteli luknjice v majhnih in velikih vejah. Poleg tega smo en mesec po začetku poskusa prešteli tudi število napadenih dreves v okolici tretmajev. Ugotovili smo, da je v kupih prisotna večja vlažnost in nižja temperatura v primerjavi z drugimi tretiranji. Več podlubnikov sta privabljala tako tretma ostanki v kupih kot tudi razporejeni ostanki, vendar pa so bile debele veje pogosteje napadene pri razpršenih ostankih. Po tretiranju ni bilo razlik v napadenih drevesih. Razpravljali bomo o posledicah rezultatov za obvladovanje podlubnikov.

ABSTRACT

Effect of felling residue management on bark beetles

Bark beetles have caused many problems in the last decades, due to increasing numbers of large-scale climatic disturbances. Many different methods for the control of bark beetle outbreaks have been investigated, but the effects of felling residues remain understudied. Felling trees is a common practice in forests. Following felling, traditionally branches are put in piles with the thought to reduce the potential brood material area that can be attacked by bark beetles, and therefore reduce danger of consequent attacks to surrounding trees. However, it was never investigated how successful this method is compared to other approaches of residue management. Our aim was to investigate the most successful method of residue management in the context of bark beetle management. We prepared plots with three treatments, 1) residues in piles, 2) residues scattered and 3) residues removed and compared this with 4) a control plot where no felling activity took place. Five plots per treatment were established per site. In total 3 sites were selected, one on high elevation and two on lower elevation in different parts of Slovenia. We measured the temperature and humidity in the treatments at 20 cm above the ground level, trapped and counted the bark beetles attracted to the treatments and counted the holes in both small and large branches. In addition to this, we also counted the number of attacked trees in the vicinity of the treatments one month after the start of the experiment. We found that piles have higher humidity and lower temperatures compared to other treatments. More bark beetles are attracted to residues in both piles and scattered treatments, but the thick branches were attacked more often in scattered residues. There was no difference in attacked trees after the treatment. We will discuss the consequences of the results for bark beetle management.

Tri milijarde dreves – perspektiva zdravja gozdov

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Ena izmed zavez strategije EU za biotsko raznovrstnost do leta 2030 je zasaditev treh milijard dodatnih dreves na prostoru EU. Akcija ima široko podporo javnosti in tudi stroke. A akcija odpira pomembna, a prezrta vprašanja iz vidika zdravja in varstva gozdov pa tudi širše. Pomembni dejavniki tveganja pri krepitvi odpornosti okolja, prilagajanju na klimatske razmere in ohranjanju biotske raznovrstnosti so namreč tudi organizmi, ki povzročajo bolezni in poškodbe rastlin, invazivni tujerodni organizmi ter organizmi, ki lahko vplivajo na kakovost rastlin (na sadiko in kasneje tudi na odraslo rastlino) pa tudi na kakovost in zdravje tal in okolja, kjer izvajamo sadnjo. V Sloveniji nimamo podatka o prenosih bolezni in škodljivcev iz drevesnic v gozdne sestoje s sadilnim materialom, a je glede na raziskave v Evropi in svetu pridelava »vroča točka« za začetek okužb oziroma kontaminacij, sadnja pa ena najpomembnejših poti vnosa škodljivih organizmov na nova območja, kjer imajo ti organizmi lahko dolgoročne in nepovratne vplive na vse funkcije gozdov. V prispevku poudarjamo biovarnostna tveganja, ki jih predstavlja pridelava in sadnja ter pomen ozaveščanja o tveganjih, ki jih sadnja predstavlja.

ABSTRACT

Three billion trees – perspective of forest health

One of the commitments of the EU Biodiversity Strategy is to plant three billion additional trees in the EU until 2030. The action has broad support from the public and also from professionals. But the action raises important but ignored questions from the perspective of health and forest protection, and wider. Organisms that cause diseases and damages to plants, invasive non-native organisms and organisms that can affect the quality of plants (seedlings and later) are important risk factors in strengthening the resilience of the environment, adapting to climatic conditions, and preserving biodiversity, but in addition, they can also affect the quality and health of the soil and environment where planted. In Slovenia, we do not have data on the transmission of diseases and pests from nurseries to forest stands via planting material, but according to global and European studies, nurseries are "hot spots" for the onset of contaminations, and planting is one of the most important routes for the introduction of harmful organisms to new areas where these organisms can have long-term and irreversible effects on all forest functions. Here, we emphasize the biosecurity risks posed by production and planting of forest reproductive material and the importance of raising awareness about the risks posed by planting.

Potencialna razširjenost navadne bukve v Sloveniji glede na različne scenarije podnebnih sprememb do konca 21. stoletja

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Razvili smo model naravne razširjenosti navadne bukve (*Fagus sylvatica* L.) v Evropi in na njegovi podlagi narediti projekcijo potencialne razširjenosti navadne bukve v Sloveniji do konca 21. stoletja glede na štiri scenarije podnebnih sprememb (RCP) in devet podnebnih modelov (GCM). Neodvisne spremenljivke, s katerimi smo pojasnjevali naravno razširjenost bukve, so opisovale podnebje in tla. Najpomembnejše pojasnjevalne spremenljivke so bile kontinentalnost (razlika med temperaturo zraka najtoplejšega meseca in najhladnejšega meseca), vsebnost organskega ogljika v tleh, povprečna letna količina padavin in povprečna letna temperatura zraka. Model naravne razširjenosti bukve smo razvili s šestimi modelskimi pristopi v programski opremi R s knjižnico BIOMOD2. Napoved potencialne razširjenosti v prihodnosti smo izvedli s pomočjo ansambla šestih modelov, ki je imel relativno visoko zanesljivost (True Skill Statistics = 0,88). V obdobjih 2021–2040 in 2041–2060 bo potencialna razširjenost navadne bukve glede na napovedi ansambla modelov ostala na takšni ravni kot v referenčnem obdobju 1970–2000, tj. pojavljala se bo po vsej Sloveniji. Ansambel modelov je napovedal, da se bo potencialna razširjenost navadne bukve verjetno pričela zmanjševati po letu 2060. Vendar so GCM napovedi zelo variabilne, kar zmanjšuje zanesljivost napovedi. Bukev je na JZ Slovenije na robu svojega areala, zato se bo predvidoma potencialno krčenje njene razširjenosti pričelo iz te smeri. Večje spremembe v potencialni razširjenosti navadne bukve so predvidene v scenarijih, ki predvidevajo višje temperature in nižje količine padavin. Po scenariju RCP4.5 se bo v obdobju 2081–2100 potencialna razširjenost bukve skrčila na 90 % gozdov

(trenutno se pojavlja v vseh gozdovih v Sloveniji), po scenariju RCP7.0 na 78,2 % gozdov, po scenariju RCP8.5 pa je predviden velik upad na 41,5 % gozdov.

ABSTRACT

Potential distribution of common beech in Slovenia according to different scenarios of climate change by the end of the 21st century

We developed a model of natural distribution of common beech (*Fagus sylvatica* L.) in Europe and used it to project the potential distribution of common beech in Slovenia by the end of the 21st century according to four scenarios of climate change (RCP) and nine global climate models (GCM). The independent variables that explained the natural distribution of beech were climate and soil. The most important explanatory variables were continentality (the difference between the air temperature of the warmest month and the coldest month), the content of organic carbon in the soil, the average annual amount of precipitation and the average annual air temperature. We developed the model of natural distribution of beech with six modelling approaches in R software with the BIOMOD2 library. We performed the prediction of potential distribution in the future using an ensemble model that had relatively high reliability (True Skill Statistics = 0.88). In the periods 2021–2040 and 2041–2060, the potential distribution of common beech according to the predictions of the ensemble model will remain at the same level as in the reference period 1970–2000, i.e. it will occur throughout Slovenia. The ensemble model predicted that the potential distribution of common beech will likely begin to decrease after 2060. However, the GCM predictions are very variable, which reduces their reliability. Beech is on the edge of its range in SW Slovenia, so it is expected that the potential shrinkage of its distribution will begin from this direction. Larger changes in the potential distribution of common beech are predicted in scenarios that assume higher temperatures and lower precipitations. According to the RCP4.5 scenario, the potential distribution of beech will shrink to 90% of forests in the period 2081–2100 (currently it occurs in all forests in Slovenia), according to the RCP7.0 scenario to 78.2% of forests, according to the RCP8.5 scenario a large decline to 41.5% of forests is expected.

Preučevanje učinkovitosti različnih tipov pasti za gosenice in metulje gobarja (*Lymantria dispar* L.) v severovzhodni Sloveniji

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V dveletnem poskusu (2022-2023) smo v gozdovih severovzhodne Slovenije preučevali učinkovitost različnih tipov pasti za lovljenje gosenic in metuljev gobarja (*Lymantria dispar*). Za spremljanje gosenic smo uporabili dva tipa mehanskih pasti, ki smo jih pritrdili na debla dreves. Pasti, ki smo jih uporabili, so tržno dostopne. Spremljanje ulova je potekalo v tedenskih intervalih, od aprila do julija. Za spremljanje številčnosti metuljev smo uporabili tri različne tipe feromonskih pasti, katere smo pregledovali v tedenskih intervalih, od junija do septembra. Menjava feromonskih nosilcev je potekala v mesečnih intervalih. Prav tako smo v raziskavi preučevali učinkovitost metode konfuzije za zatiranje gobarja. Učinkovitost delovanja nanesenega gela smo prav tako spremljali v tedenskih intervalih. V letu 2023 smo pridobili tudi podatke o učinkovitosti elektronskih pasti za lovljenje metuljev gobarja. Ugotovili smo, da se učinkovitost ulova gosenic/metuljev razlikuje glede na tip pasti. V prispevku bodo predstavljeni povprečni ulovi gosenic/metuljev gobarja na vabo na dan.

ABSTRACT

Evaluating the effectiveness of different types of traps for larvae and adults of gypsy moth (*Lymantria dispar*) in north-eastern Slovenia

In a two-year experiment (2022-2023), we have studied the effectiveness of different types of traps for catching larvae and adults of gypsy moth (*Lymantria dispar*) in the forests of northeastern Slovenia. We have used two different types of mechanical traps, which were attached to the tree trunks. Monitoring of trunk traps was performed in weekly intervals, from April till July. Three different pheromone traps were used to monitor the abundance of adults, which were checked in weekly intervals from June till September. Replacement of pheromone dispensers was performed in monthly interval. Furthermore, efficacy of mating disruption against gipsy moth adults was also tested. Electronic trap devices were also used to monitor gypsy moth adults. Based on our study, we can confirm that efficacy of caught larvae/adults differs according to trap type. Paper will present data as average number of caught larvae/adults per trap per day.

The LIFE eGymer project is co-funded by the LIFE Programme of the European Union under contract number LIFE20 ENV/GR/000801 and with the contribution of the Green Fund.

Nova tujerodna ambrozijska podlubnika v Sloveniji: *Xylosandrus compactus* (Eichoff, 1875) in *Anisandrus maiche* (Kurentzov, 1941)

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Invazivni tujerodnih organizmi predstavljajo veliko nevarnost za naravne ekosisteme po vsem svetu, pomembno gonilo vnosa teh organizmov pa je mednarodna trgovina. Z različnimi lesnimi proizvodi, rastlinskim reprodukcijskim materialom in lesenim pakirnim materialom so na nova območja vse bolj pogosto vneseni tudi ambrozijski podlubniki (Coleoptera: Curculionidae, Scolytinae), ki se na takih območjih pogosto uspešno naselijo, nekatere vrste pa postanejo invazivne in lahko povzročijo gospodarsko in ekološko škodo. V sklopu programov preiskav smo v letu 2023 v Sloveniji odkrili dva nova tujerodna ambrozijska podlubnika, in sicer *Xylosandrus compactus* (Eichoff, 1875) in *Anisandrus maiche* (Kurentzov, 1941). Vrsta *X. compactus* je bila odkrita v bližini Luke Koper, vrsta *A. maiche* pa na treh lokacijah v vzhodnem delu Slovenije. V prispevku poročamo o prvih najdbah teh dveh vrst v Sloveniji ter razpravljamo o možnih poteh vnosa in širjenja. Na podlagi biologije in ekologije ter poročil iz drugih območij, kamor sta bili vrsti vneseni, razpravljamo o možnih vplivih, ki bi jih ti dve vrsti lahko imeli na naše gozdne ekosisteme.

ABSTRACT

Two new non-native ambrosia beetles in Slovenia: *Xylosandrus compactus* (Eichoff, 1875) in *Anisandrus maiche* (Kurentzov, 1941)

Invasive alien organisms pose a major threat to natural ecosystems worldwide, and international trade is a major driver of the introduction of these organisms. Ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) are being increasingly introduced to new areas with various wood products, plant reproductive material and wood packaging material. In these areas, they often successfully settle, while some species become invasive and can cause economic and ecological damage. During the national survey of quarantine species in 2023, two new alien ambrosia beetles, *Anisandrus maiche* (Kurentzov, 1941) and *Xylosandrus compactus* (Eichhoff, 1875), were recorded for the first time in Slovenia. *X. compactus* was found near the port of Koper, and *A. maiche* at three locations in the eastern part of Slovenia. We report the first findings of these two species in Slovenia and discuss the possible pathways of introduction and dispersal. Based on biology and ecology, and reports from other areas where the two species were introduced, we discuss the potential impacts these two species could have on our forest ecosystems.

Razširjenost sredozemskega borovega strženarja (*Tomicus destruens*) na Kraškem gozdnogospodarskem območju

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Borovi strženarji (*Tomicus* spp.) so podlubniki (Coleoptera: Curculionidae: Scolytinae), ki veljajo za primarne in sekundarne škodljivce borov (*Pinus* spp). Zalegajo predvsem v sveže podrta in oslabljena drevesa, v katerih se prehranjujejo in razvijajo v predelu ličja in kambija, mladi hrošči pa se zrelostno prehranjujejo v strženu poganjkov dreves, ki so lahko povsem zdrava. V Skandinaviji in vse do severnih predelov Sredozemlja sta splošno razširjeni vrsti *Tomicus piniperda* in *Tomicus minor*. V Sredozemlju pa je splošno razširjena vrsta *Tomicus destruens*, ki je bolj prilagojena na toplejše podnebne razmere. Takšne razmere so tudi na slovenskih priobalnih območjih, kjer je bila prisotnost vrste nedavno potrjena. Glavni gostitelji so sredozemske vrste borov, pojavlja pa se tudi na črnem boru (*P. nigra*), ki je splošno razširjen v jugozahodni Sloveniji. *T. destruens* in *T. piniperda* sta morfološko kriptični vrsti, ki sta bili v preteklosti pogosto napačno identificirani., zato so podatki o njuni razširjenosti pogosto netočni. Cilj raziskave je bil ugotoviti razširjenost in preveriti morebitno prekrivanje areala vrste *T. destruens* z arealoma drugih dveh omenjenih vrst iz rodu *Tomicus* v Sloveniji, ter ugotoviti njihovo dinamiko pojavljanja. V ta namen smo na širšem Kraškem gozdnogospodarskem območju postavili 16 križnih pasti v sestoje črnega bora, v tri temperaturne pasove in izvajali spremljanje ulova skozi enoletno obdobje. *T. destruens* smo dokumentirali na lokacijah, kjer je bila zabeležena povprečna temperatura najhladnejše četrtine leta ≥ 4 °C. Višek ulova vrste *T. destruens* smo dokumentirali pretežno v pozni jeseni (oktober), medtem ko je bil višek ulova pri *T. piniperda* in *T. minor* v spomladanskem času (april). Na vseh lokacijah, kjer smo zabeležili vrsto *T. destruens* smo dokumentirali tudi prisotnost *T. minor*, prekrivanja arealov *T. destruens* in *T. piniperda* pa nismo ugotovili. Od omenjenih treh vrst je v ulovu močno prevladovala vrsta *T. minor*.

ABSTRACT

Distribution of the Mediterranean pine shoot beetle (Tomicus destruens) in Karst Forest management region

Pine shoot beetles (*Tomicus spp.*) are bark beetles (Coleoptera: Curculionidae: Scolytinae), which are primary and secondary pine tree pests (*Pinus* spp.). They mostly infest weakened or freshly fallen trees, on which they feed and develop in the phloem and cambium. The young beetles feed on the shoots of trees, which can be completely healthy. *Tomicus piniperda* and *Tomicus minor*, are widely spread from Scandinavia to the north of the Mediterranean region. In the Mediterranean region, the species *Tomicus destruens* is commonly found, where it is adapted to warmer climatic conditions. Such conditions are also present in the coastal region of Slovenia, where the presence of this species has recently been confirmed. Main hosts of *T. destruens* are Mediterranean pine species, as well as Black pine (*P. nigra*). The latter species is widespread in southwestern Slovenia. *T. destruens* and *T. piniperda* are morphologically cryptic species and have often been misidentified in the past. Therefore, their distribution data is often inaccurate. The aim of this research was to determine the distribution and investigate the potential spatial overlap of *T. destruens* with the distribution of the other two *Tomicus* species in Slovenia, as well as to determine their temporal dynamics. For this purpose, we set up 16 cross-traps within the broader Karst Forest management area, placed in stands of Black pine, across three temperature zones, and conducted monitoring over a one-year period. We documented *T. destruens* at locations where the mean temperature of the coldest quarter of the year was ≥ 4°C. The peak capture of *T. destruens* was predominantly recorded in late autumn (October), while the peak captures of *T. piniperda* and *T. minor* were in the springtime (April). At all locations where we recorded *T. destruens*, we also

documented the presence of *T. minor,* while *T. destruens* and *T. piniperda* were spatially segregated. Of the three species mentioned, *T. minor* dominated the catch.

Razširjenost glive *Dothistroma pini* v Sloveniji in vpogled v prisotnost njenih paritvenih tipov

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Rdeča pegavost borovih iglic je bolezen borov (*Pinus* spp.), ki jo povzročata glivi *Dothistroma septosporum* in *D. pini*. Glivi sta si morfološko zelo podobni in ju lahko zanesljivo ločimo le s pomočjo molekularnih podatkov. Omenjena bolezen borov je bila v Sloveniji prvič zabeležena leta 1971. V zadnjih dveh desetletjih se je pojavnost bolezni v Sloveniji znatno povečala, tako da jo je danes moč zaznati po vsej državi, še posebej na Krasu v sestojih črnega bora (*P. nigra*). Gliva *D. pini* naj bi bila tako v svetovnem merilu kot tudi pri nas bolj redka. Gre za heterotalično vrsto, kar pomeni, da se pojavlja v dveh paritvenih tipih, MAT1-1 in MAT1-2. V Sloveniji smo do nedavnega poročali večinoma le o prisotnosti paritvenega tipa MAT1-2, paritveni tip MAT1-1 pa je bil potrjen le na eni lokaciji. V 2023 smo opravili pregled dosedanjih najdb glive *D. pini,* ki so bile izvedene v Laboratoriju za varstvo gozdov na Gozdarskem inštitutu Slovenije, vključno z določanjem paritvenih tipov shranjenih vzorcev v zbirkah laboratorija. Dodatno smo na treh lokacijah, kjer je bila gliva *D. pini* že potrjena v preteklosti, izvedli popis poškodovanosti borov ter dodatno vzorčenje simptomatičnih iglic. Tudi ti vzorci so bili vključeni v molekularne analize, s katerimi smo preverjali prisotnost glive *D. pini* oziroma njenih paritvenih tipov. Rezultati kažejo, da je gliva *D. pini* bolj razširjena kot so kazale dosedanje raziskave, bolj pogost pa je tudi paritveni tip MAT1-1. Prisotnost obeh paritvenih tipov glive vodi v večjo genetsko variabilnost in večjo možnost nastanka bolj patogenih oblik te glive.

ABSTRACT

Distribution of the fungus *Dothistroma pini* and its mating types in Slovenia

Dothistroma needle blight is a disease affecting pines (*Pinus* spp.), caused by fungi *Dothistroma septosporum* and *D. pini*. These fungi are morphologically very similar and can only be reliably distinguished using molecular data. Dothistroma needle blight was first recorded in Slovenia in 1971. Over the past two decades, its prevalence in Slovenia has significantly increased, and can now be observed throughout the country, particularly in the black pine (*P. nigra*) stands in the Karst region. Globally, the fungus *D. pini* is considered to be rarer, which also applies for Slovenia. It is a heterothallic species, meaning it appears in two mating types, MAT1-1 and MAT1-2. Until recently, reports in Slovenia mostly indicated the presence of the MAT1-2 mating type, with the MAT1-1 mating type confirmed at only one location. In 2023, we conducted a review of previous findings of the fungus *D. pini* performed in the Laboratory for Forest Protection at the Slovenian Forestry Institute, including the determination of the mating types of samples deposited in the laboratory collections. Additionally, at three locations where the fungus *D. pini* had been previously confirmed, we assessed the damage on pines and conducted additional sampling of symptomatic needles. These samples were also included in

molecular analyses to verify the presence of the fungus *D. pini* and its mating types. The results indicate that the fungus *D. pini* is more widespread than previous research suggested, and the MAT1-1 mating type is more common as it was initially assumed. The simultaneous presence of both mating types of the fungus can lead to greater genetic variability and consequently increases the potential for development of more pathogenic forms of this fungus.

Vpliv podnebnih sprememb na globalno potencialno razširjenost rjavenja borovih iglic, *Lecanosticta acicola*

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Rjavenje borovih iglic, ki jo povzroča gliva *Lecanosticta acicola* (Thüm.) Syd., izvira iz Severne Amerike in je bila vnesena v Evropo in Azijo. Intenziteta poškodb in razširjenost bolezni se je v zadnjih dveh desetletjih v Severni Ameriki in Evropi povečala kot odziv na podnebne spremembe. Uporabili smo podatkovno zbirko 2.970 neodvisnih opazovanj *L. acicola* skupaj s podatki o globalni razširjenosti borov in 44 neodvisnimi spremenljivkami, ki so opisovale značilnosti podnebja in okolja. Preizkusili smo štiri modelne pristope. Skupaj smo razvili osem modelov. Za napovedovanje potencialne razširjenosti *L. acicola* smo uporabili ansambel treh najboljših modelov. Zanesljivost ansambla modelov je bila zelo dobra, tj. z visoko natančnostjo (0,87) in zelo visokim AUC (0,94). Potencialno razširjenost *L. acicola* smo izračunali za pet podnebnih modelov (GCM) in tri scenarije podnebnih sprememb (RCP) za obdobje 1971–2100. Izračunali smo povprečje rezultatov petih GCM na RCP (mediana) in 30-letno obdobje. Dejanska razširjenost *L. acicola* v referenčnem obdobju 1971–2000 je pokrivala 5,9 % globalne površine borov. Vendar pa je ansambel modelov napovedal potencialno razširjenost *L. acicola*, ki bi v referenčnem obdobju pokrivala povprečno kar 58,2 % globalne razširjenosti borov. Različni scenariji podnebnih sprememb (pet GCM, trije RCP) so pokazali pozitiven trend v možni širitvi območja *L. acicola* do konca 21. stoletja. Glede na povprečne napovedi modelov se bo potencialna razširjenost *L. acicola* dvignila na 62,2 % (za RCP 2.6), 61,9 % (RCP 4.5), 60,3 % (RCP 8.5) globalne površine borov. Vendar pa je bil 95 %interval zaupanja širok in je zajemal 35,7–82,3 % globalne površine borov v obdobju 1971–2000 in 33,6–85,8 % v obdobju 2071–2100, kar kaže na visoko variabilnost različnih GCM napovedi.

ABSTRACT

The impact of climate change on the global potential distribution of brown spot needle blight, *Lecanosticta acicola*

Brown spot needle blight (BSNB), caused by *Lecanosticta acicola* (Thüm.) Syd., is an emerging forest disease of *Pinus* species originating from North America and introduced to Europe and Asia. Severity and spread of the disease has increased in the last two decades in North America and Europe as a response to climate change. This study utilises a global dataset of 2,970 independent observations of *L. acicola* presence and absence from the geodatabase, together with *Pinus* spp. distribution data and 44 independent climatic and environmental variables. Four modelling approaches were tested. Altogether, eight models were developed. An ensemble of the three best models

was used to make predictions for the potential distribution of *L. acicola*. Performance of the model ensemble was very good, with high precision (0.87) and very high AUC (0.94). The potential distribution of *L. acicola* was computed for five global climate models (GCM) and three climate change scenarios (RCP) for the period 1971–2100. The results of the five GCMs were averaged on RCP (median) per 30-year period. The actual distribution of *L. acicola* in the reference period 1971–2000 covered 5.9% of *Pinus* spp. area globally. However, the model ensemble predicted potential distribution of *L. acicola* to cover an average of 58.2% of *Pinus* species global cover in the reference period. Different climate change scenarios (five GCMs, three RCPs) showed a positive trend in possible range expansion of *L. acicola* for the period 1971–2100. The average model predictions towards the end of the century showed the potential distribution of *L. acicola* rising to 62.2%, 61.9%, 60.3% of *Pinus* spp. area for RCP 2.6, RCP 4.5, RCP 8.5, respectively. However, the 95% confidence interval was wide and encompassed 35.7–82.3% of global *Pinus* spp. area in the period 1971–2000 and 33.6–85.8% in the period 2071–2100, which shows high variability of different GCM predictions.

Obnova gozda po požaru na goriškem Krasu in zagotavljanje gozdnega reprodukcijskega materiala

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Obnova gozdov po obsežnih gozdnih požarih predstavlja zaradi spremenjenih rastiščnih razmer in degradacije tal velik izziv za gozdarsko stroko. Požar Goriški Kras predstavlja do sedaj največji požar v Sloveniji, saj je zajel skupaj 3.707 ha površin, od tega 2.902 ha gozdov. Večina gozda (2.500 ha) je bila poškodovana do te mere, da ga bo treba obnoviti bodisi po naravni poti ali s sadnjo sadik gozdnega drevja in setvijo semen. Drevesno sestavo bodočih gozdov je potrebno prilagoditi rastiščnim razmeram, ohranjenosti rastišč, pričakovanim posledicam sprememb podnebja in tveganjem, ki jih prinaša požarna ogroženost gozdnih sestojev na Krasu. Obnova poškodovanih gozdov s sadnjo in setvijo mora potekati izključno z zdravim in kakovostnim gozdnim reprodukcijskim materialom (GRM) ustrezne provenience (submediteranska ekološka regija). Ohranjanje genetske pestrosti in zagotavljanje prilagoditvene sposobnosti bodočih gozdnih sestojev na Krasu na pričakovane spremembe v okolju zahteva uporabo genetsko pestrega GRM, ki ga zagotavljamo s pridobivanjem semena iz velikega števila dreves v času močnega cvetenja in obroda, s povečevanjem števila virov semena oziroma gozdnih semenskih objektov (GSO), s strokovno ustreznim mešanjem partij GRM in s prenosom GRM med provenienčnimi območji v skladu s pričakovanimi spremembami podnebnih parametrov v okolju. V submediteranski ekološki regiji je bilo v času nastanka požara na voljo 26 GSO za 15 drevesnih vrst, dodatno pa je bilo takoj po požaru odobrenih še 31 GSO, ki poleg obstoječih predstavljajo ustrezen semenski vir za dodatnih 14 drevesnih vrst. Podnebne spremembe močno vplivajo tudi na drevesno sestavo bodočih gozdov, zato je potrebno v okviru sanacije gozdnogojitveno preizkusiti tudi drevesne vrste iz robnih področij kraških rastišč.

ABSTRACT

Forest restoration after the fire on Goriški Karst and provision of forest reproductive material

The restoration of forests after large-scale forest fires represents a major challenge for the forestry professionals due to changed site conditions and soil degradation. The Goriški Karst fire is the largest fire in Slovenia to date, as it covered a total of 3.707 ha of land, of which 2.902 ha were forests. The majority of the forest (2,500 ha) has been damaged to such extent that it will have to be restored either by natural regeneration or by planting forest tree seedlings and sowing seeds. The tree composition of the future forests must be adapted to the site conditions, the preservation of the sites, the expected consequences of climate change and the risks of future forest fires on Karst. Restoration of damaged forests by planting and sowing must be carried out exclusively with healthy and high-quality forest reproductive material (FRM) of appropriate provenance (sub-Mediterranean ecological region). Preserving genetic diversity and ensuring the ability of future forest stands in the Karst to adapt to expected changes in the environment, requires the use of genetically diverse FRM. This material is ensured by collecting seeds from a large number of trees during periods of strong flowering and fruiting, by increasing the number of seed sources or forest seed objects (FSO), with professionally appropriate mixing of FRM lots and with the transfer of FRM between provenance areas in accordance with expected changes of climatic parameters in the environment. In the sub-Mediterranean ecological region, 26 GMOs for 15 tree species were available at the time of the fire, and in addition, 31 FSOs were approved immediately after the fire, which, in addition to the existing ones, represent a suitable seed source for an additional 14 tree species. Climate change also has a strong impact on the tree composition of future forests, so it is necessary to test tree species from the marginal areas of Karst sites.

Zatiranje velikega pajesena

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Veliki pajesen (*Ailantus altissima* (Mill.) Swingle) je drevesna vrsta, domorodna v Vzhodni Aziji. V Evropo so jo vnesli že v 17. stoletju in ker je skromna rastlina, močno semeneča, se širi s poganjki iz korenin, ker oddaja alelopatske snovi in ker ji je primeren habitat opustošeno, ruderalno zemljišče, ima velik invaziven potencial. V Sloveniji predstavlja težavo tako na gozdnih kot kmetijskih zemljiščih, prav tako pa tudi povsod drugod, npr. v urbanem okolju. Kot invazivna rastlina v gozdovih vpliva na zgradbo in sestavo naravnih gozdnih združb ter preprečuje pomlajevanje avtohtonih drevesnih vrst.
Za preprečevanje širjenja velikega pajesena na vseh zemljiščih veljajo ukrepi za preprečitev vnosa in širjenja, določeni z Uredbo Evropske unije 1143/2014. Kot ena najboljših metod zatiranja in preprečevanja širjenja te vrste se je sicer izkazala uporaba fitofarmcevtskih sredstev, ki pa je v slovenskih gozdovih prepovedana. Tako se lahko poslužujemo le mehanskega zatiranja. Glede na literaturo in glede na izkušnje je najbolj učinkovito puljenje drevesc, ko so še mlada in ko je razširjenost še obvladljiva. Ko veliki pajesen začne rasti v sestojih, preprečujemo širjenje s slabljenjem semenečih dreves, najbolje z obročkanjem. To pomeni, da odstranjujemo drevesno skorjo v min. 15 cm pasu.

Drevo na ta način propade počasi in ne začne divje razraščati iz korenin. Na pogorišču požara Goriški Kras iz leta 2022 in širše smo izbrali 16 ploskev, ki skupaj zajemajo 4 ha gozdnega zemljišča, kjer smo semeneča drevesa velikega pajesena obročkali z namenom preprečevanja širjenja na druga zemljišča. Spomladi 2023 smo obročkali 1448 dreves, konec rastne sezone pa smo na terenu naredili pregled obročkanih rastlin. Odstranili smo kalus oziroma poganjke, ki so se razrasli kot odziv na obročkanje. Prav tako bi bilo smiselno izvajati ukrepe proti širjenju velikega pajesena tudi na zaraščajočih kmetijskih zemljiščih Krasa, za kar smo kot država po uredbi Evropske unije 1143/2014 tudi zavezani.

ABSTRACT

Controling of tree of heaven

The tree of heaven (*Ailanthus altissima* (Mill.) Swingle) is a tree species native to Eastern Asia. It was introduced to Europe in the 17th century, and because it is a modest plant with strong seed dispersal, and since it spreads through shoots from its roots, and releases of allelopathic substances and its suitable habitat being devastated, ruderal land, it has significant invasive potential. In Slovenia, it poses a problem in both forest and agricultural areas, as well as in other places, for example, in urban environments. As an invasive plant in forests, it affects the structure and composition of natural forest communities and prevents the regeneration of native tree species. To prevent the spread of the tree of heaven on all lands, measures to prevent its introduction and spread, as specified by the European Union Regulation 1143/2014, are applicable. Although one of the most effective methods for controlling and preventing the spread of this species is the use of herbicides, it is prohibited in Slovenian forests. Therefore, only mechanical control methods can be employed. According to literature and experience, the most effective method is the uprooting of trees when they are still young and the infestation is manageable. When the tree of heaven begins to grow in stands, spreading can be prevented by weakening seed-producing trees, preferably through girdling. This involves removing the tree bark in a minimum 15 cm-wide strip. This way, the tree deteriorates slowly and does not start rampant growth from the roots. We selected 16 plots, covering a total of 4 hectares of forestland in the Karst area. There, we girdled the seed-producing trees of heaven with the aim of preventing their spread to other lands. In spring 2023, we girdled 1448 trees, and at the end of the growing season, we conducted a field inspection of the girdled trees. We removed callus or shoots that had proliferated in response to girdling. It would also make sense to implement measures against the spread of the tree of heaven on overgrown agricultural land in Karst. As a country, we are obligated to do so according to the European Union Regulation 1143/2014.

Varstvo vrtnin

Ostanki fitofarmacevtskih sredstev v zelenjavi s slovenskih tržnih polic in v medu slovenskih čebelarjev

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Iz slovenskih trgovin smo v letu 2023 odvzeli 50 vzorcev: brstični ohrovt, korenje, cvetačo, ohrovt, motovilec, solato, papriko, špinačo, paradižnik in bučke. 28 % vzorcev je bilo slovenskega porekla, 70 % vzorcev je izviralo iz drugih držav, 2 % vzorcev pa je bilo neznanega porekla. 30 % vzorcev je izviralo iz ekološke pridelave in 70 % vzorcev iz konvencionalne pridelave. Vse vzorce smo analizirali na prisotnost 75 aktivnih spojin s plinskim in tekočinskim kromatografom, ki sta bila sklopljena s tandemskim masnim spektrometrom. V 20 % vzorcev smo našli 10 aktivnih spojin. Ostanke fitofarmacevtskih sredstev smo določili v 6,7 % vzorcev iz ekološke in v 25,7 % vzorcev iz konvencionalne pridelave. 21,4 % vzorcev slovenskega porekla in 20,0 % vzorcev tujega porekla je bilo pozitivnih. V letu 2023 smo zbrali tudi 31 vzorcev medu iz 11 statističnih regij Slovenije. Vse vzorce smo analizirali na prisotnost 33 aktivnih snovi s plinskim kromatografom sklopljenim s tandemskim masnim spektrometrom. V 3 vzorcih smo našli 1 aktivno snov, kar pomeni, da je bilo 9,7 % vzorcev pozitivnih.

ABSTRACT

Pesticide residues in vegetables from Slovenian stores and in honey from Slovenian beekeepers

In 2023 we gathered 50 samples of vegetables from Slovenian stores: brussels sprouts, carrot, cauliflower, kale, lamb`s lettuce, lettuce, pepper, spinach, tomato and zucchini. 28 % of samples were of Slovenian origin, 70% of samples originated from other countries and for 2% of samples, origin was unknown. 30 % of samples originated from organic production and 70 % from conventional production. All samples were analysed on presence of 75 active substances with gas chromatograph and liquid cromatograph, both coupled with tandem mass spectrometer. 10 active substances were found in 20% of samples, Pesticide residues were determined in 6.7 % of samples from organic and in 25.7 % of samples from conventional production. 21.4 % of samples of Slovenian origin and 20.0 % of samples of foreign origin were positive. In 2023 we also gathered 31 samples of honey from 11 statistical regions of Slovenia. All samples were analysed on presence of 33 active substances with gas chromatograph coupled with tandem mass spectrometer. 1 active substance was found in 3 samples, meaning that 9.7 % of samples were positive.

Katero pivo imajo polži najraje?

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Polži predstavljajo gospodarsko pomembne škodljivce v kmetijstvu, saj s svojim hranjenjem poškodujejo dele rastlin in tako posledično vplivajo na zmanjšan pridelek, okrasno in tržno vrednost rastlin, ter povečajo tveganje za okužbo z mikroorganizmi. Za zatiranje polžev se uporabljajo razne ne-kemijske prakse, limacidi na podlagi železovega (III) fosfata in metaldehida ter biotično varstvo s parazitsko ogorčico *Phasmarhabditis hermaphrodita*. Med okoljsko sprejemljive načine zatiranja polžev uvrščamo uporabo pasti s pivom. Pasti za polže se najpogosteje postavi med mestom za spanje in mestom za hranjenje. V dvoletni raziskavi (2022-2023), ki je potekala na prostem, smo preučevali vpliv 5 vrst piva (Union, Guinness, Paulaner, Chimay blue in BrewDog Punk IPA) za lovljenje polžev. Izbor piva je temeljil na njihovi različni sestavi sladu, vsebnosti alkohola, in količini hmelja. Rezultati raziskave so pokazali, da smo v dveh letih v pasti s pivom ulovili preko 7000 polžev. V lovilne posode so se lovili le polži dveh vrst; španski lazar (*Arion vulgaris*) ter veliki slinar (*Limax maximus*). V letu 2022 se je najbolje izkazalo pivo vrste Chimay blue. V obeh letih se je najmanj polžev ujelo v pasti, ki so vsebovale pivo BrewDog Punk IPA. Kemična analiza piv je pokazala razlike v njihovi sestavi. V prihodnje želimo optimizirati postopke uporabe pasti s pivom za lovljenje gospodarsko pomembnih vrst polžev.

ABSTRACT

Which beer do slugs prefer?

Slugs represent economically significant pests in agriculture as their feeding damages plant parts, subsequently impacting reduced yield, ornamental and market value of plants, and increasing the risk of microbial infection. Various non-chemical practices, molluscicides based on iron (III) phosphate and metaldehyde, and biotic control with the parasitic nematode *Phasmarhabditis hermaphrodita* are used for mollusc control. Among environmentally friendly methods of slug control, the use of beer traps is considered. Slug traps are commonly placed between the sleeping and feeding areas. In a two-year study (2022-2023) conducted outdoors, we examined the impact of 5 types of beer (Union, Guinness, Paulaner, Chimay blue, and BrewDog Punk IPA) for slug trapping. The selection of beers was based on their different malt compositions, alcohol content, and quantity of hops. The research results showed that over 7000 slugs were captured in the beer traps over two years. Only two species of slugs, the Spanish slug (*Arion vulgaris*) and the great grey slug (*Limax maximus*), were caught in the traps. In 2022, Chimay blue beer showed the best performance. In both years, the traps containing BrewDog Punk IPA caught the fewest slugs. Chemical analysis of the beers revealed differences in their compositions. In the future, we aim to optimize the use of beer traps for capturing economically important slug species.

Izkušnje pri zatiranju plevelov v čebuli (*Allium cepa* L.) s herbicidi

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Uravnavanje plevelne vegetacije je eden od najpomembnejših agrotehničnih ukrepov v pridelavi čebule. Zaradi pogostih neugodnih vremenskih razmer, kot so sušna, hladna ali pretirano vlažna obdobja v pomladanskem času, je vznik plevelov lahko neenakomeren. Posledica je lahko nezadostna učinkovitost delovanja herbicidov v tem, za rast čebule pomembnem obdobju. V tujini za zatiranje plevelov uporabljajo herbicide oziroma kombinacije herbicidov v nižjih in deljenih odmerkih, da tako zatrejo vznik plevelov skozi daljše obdobje. Odmerki večkratne uporabe herbicidov ne presegajo skupnega enkratnega odmerka. Uporaba nižjih odmerkov zmanjša možnost izpiranja aktivnih snovi uporabljenih herbicidov v nižje plasti tal in onesnaževanje podtalnice. Poleg tega je hitrejša tudi mikrobiološka razgradnja aktivnih snovi herbicidov v tleh. Z namenom preverbe uporabe deljenih in zmanjšanih odmerkov herbicidov v naših pogojih smo v letu 2023 na Inštitutu za hmeljarstvo in pivovarstvo Slovenije, Kmetijsko gozdarskem zavodu Maribor in Kmetijskem inštitutu Slovenije izvedli poljske poskuse za zatiranje plevelov v čebuli (*Allium cepa* L.). Preverjali smo učinkovitost herbicidov: Flexidor (a.s. *izoksaben*), Challenge (a.s. *aklonifen*), Sharpen plus (a.s. *pendimetalin*) in Lentagran WP (a.s. *piridat*). Kombinacije deljenih aplikacij so se v prvih dveh letih poskusov (2021, 2022) pokazale kot najučinkovitejše za zatiranje plevelov in hkrati smo pri njih izmerili najvišje pridelke. V smislu zmanjševanja rabe FFS smo v letu 2023 preizkušali tudi kombinacije deljenih aplikacij s 25 % zmanjšanjem odmerka na hektar. V letu 2023 smo deljenim aplikacijam s 25 % zmanjšanjem odmerka na hektar dodali tudi herbicid Challenge. Prvič smo preizkusili tudi učinkovitost kombinacije herbicidov Flexidor (Pre-em) in Challenge (Post-em 2). Bločno zasnovani poskusi so bili opravljeni na treh lokacijah, s sedmimi obravnavanji, v štirih ponovitvah. V rastni dobi čebule smo ocenjevali učinkovitost in fitotoksičnost herbicidov po njihovi aplikaciji ter ob koncu ovrednotili pridelek posameznih obravnavanj. Cilj poskusa je bil zatiranje plevelov v zgodnjih razvojnih fazah z deljenimi odmerki, s katerimi smo uspeli podaljševati učinkovitost herbicidov na zatiranje plevelnih vrst. Zaradi manjše konkurence plevelov so bili pri obravnavanjih z deljenimi odmerki herbicidov pridelki čebule večji.

ABSTRACT

Experiences in controlling weeds in onion (*Allium cepa* L.) with herbicides

Weed control is one of the most important agrotechnical measures in onion cultivation. Due to frequent unfavourable weather conditions such as dry, cold, or excessively humid periods in the spring, weed emergence can be uneven. This can result in insufficient efficacy of herbicides during this crucial period for onion growth. Herbicides or combinations of herbicides are often used in lower and split doses to suppress weed emergence over an extended period. The multiple applications of herbicides do not exceed the total single dose. The use of lower doses prevents the leaching of active substances into lower soil layers and groundwater pollution. Additionally, a faster microbiological degradation of herbicide active substances in the soil can be achieved. To assess these conditions, in 2023, field experiments for weed control in onions (Allium cepa L.) were conducted at Inštitut za hmeljarstvo in pivovarstvo Slovenije, Kmetijsko gozdarski zavod Maribor and Kmetijski inštitut Slovenije. The efficacy of 4 herbicides on

weeds (Flexidor - *isoxaben*, Challenge - *aclonifen*, Sharpen plus - *pendimethalin*, and Lentagran WP - *pyridate*), was examined. Combinations of split applications proved to be the most effective for weed control in the first two years of experiments (2021, 2022), and simultaneously, the highest yields were recorded with them. In terms of reducing herbicide usage, combinations of split applications with a 25% reduction in the dose per hectare were tested in 2023. In 2023, herbicide Challenge was also added to split applications with a 25% reduction in the dose per hectare. For the first time, efficacy of the combination of Flexidor (pre-emergence) and Challenge (post-emergence) was tested. Block-designed experiments were conducted at three locations, with seven treatments and four replications. Throughout the experiments, the efficacy and phytotoxicity of individual herbicides were evaluated after their application, and at the end, the yield of individual treatments was assessed. The focus was on weed control in early developmental stages in combination with split doses, which successfully extended the effect of herbicides on weed species emergence. Consequently, onion yields were higher in treatments with split doses of herbicides.

Izkušnje z zatiranjem ozkolistnih plevelov s poudarkom na zatiranju užitne ostrice (*Cyperus esculentus* L.) v letih 2022 in 2023

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Užitno ostrico (*Cyperus esculentus* L.) uvrščamo družino Cyperaceae, v rod *Cyperus*, ki zajema do sedaj znanih 900 vrst. Razmnožuje se vegetativno in s semenom. Gomoljčki za vegetativno razmnoževanje se nahajajo na globini do 15 cm in so veliki med 5 in 15 mm. Zraste do 60 cm visoko, listi so svetlo zeleni na trirobem steblu. V zimskem času nadzemni del pomrzne.Iz ohranjenih gomoljčkov v tleh spomladi odženejo nove rastline. Vsaka rastlina lahko tvori do 100 gomoljčkov. Do prenosa gomoljčkov in s tem razmnoževanja pride najpogosteje z neočiščeno mehanizacijo. Na Dravskem in Ptujskem polju se užitna ostrica pojavlja kot plevel v vseh posevkih, povzroča pa tudi težave v pridelavi zelenjave, saj prodre tudi skozi črno folijo. Izgube so ob močni razrasti korenin vidne ob prevrtanju korenov, gomoljev in drugih podzemnih delov gojenih rastlin. Do vidnih izgub pridelka pride, ko imamo na njivah 3-5 rastlin/m^2, ob večjih populacijah so lahko izgube tudi do 80 %. V kontrolnih obravnavanjih našega poskusa, v posevku koruze, je bilo povprečno prisotnih 100 rastlin/m^2. Herbicidi za zatiranje ozkolistnih plevelov v koruzi kažejo slabe učinkovitosti. S tem namenom smo v letu 2023 pridobili dovoljenje za raziskave in razvoj. V poskusu smo preverili učinkovitost herbicida Sempra (a.s. halosulfuron metil), ki sam daje nezadovoljive rezultate učinkovitosti, med tem ko kombinacije herbicida z drugimi pripravki zadovoljive. To v praksi še vedno pomeni prenizke učinkovitosti za uspešno obvladovanje užitne ostrice.

ABSTRACT

Experiences on the control of narrow-leaved weeds with focus on the control of yellow nutsedge (*Cyperus esculentus* L.) in years 2022 and 2023

The Yellow Nutsedge (*Cyperus esculentus* L.) is classified in the family Cyperaceae, in the genus *Cyperus*, which comprises 900 species known to date. It reproduces vegetatively and by seed. The tubers for vegetative propagation are at a depth of up to 15 cm and are between 5 and 15 mm in size. It grows up to 60 cm high, with light green leaves on a three-edged stem. In winter, the above-ground part freezes from the preserved tubers in the soil, and new growth is driven off in spring. Each plant can form up to 100 tubers. The transfer of tubers and thus reproduction occurs most often by uncleaned machinery. In the Drava and Ptuj fields, the edible sedge is a persistent weed in all crops and also causes problems in vegetable production, as it can penetrate black film. Losses are visible when roots, tubers and other underground parts of cultivated plants are uprooted by strong root growth of Yellow Nutsedge. Visible yield losses occur when there are 3-5 plants/m^2 on the field, with losses up to 80% in larger populations. In the control treatments of our experiment in the maize crop, an average of 100 plants/m^2 were present. Herbicides for the control of narrow-leaved weeds in maize show poor performance. To this end, we have obtained a research and development licence in 2023. To this end, we have obtained a research and development licence in 2023. In the trial, we tested the efficacy of the herbicide Sempra (a.s. halosulfuron methyl), which alone gives unsatisfactory efficacy results, while combinations of the herbicide with other products give satisfactory results. In practice, this still means that the efficacy is too low for successful control of Yellow Nutsedge.

Rastni substrat in voda onesnaženi s tobamovirusi so lahko vir okužbe rastlin

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Virus rjave grbančavosti plodov paradižnika (tomato brown rugose fruit virus; ToBRFV) in virus lisavosti in mozaika paradižnika (tomato mottle mosaic virus; ToMMV) sta nedavno odkrita tobamovirusa, ki predstavljata veliko grožnjo svetovni pridelavi paradižnika in paprike. Za tobamoviruse je značilno, da so sposobni dolgotrajnega preživetja na različnih površinah in pod različnimi okoljskimi pogoji. Prenašajo se predvsem z okuženimi semeni, sadilnim materialom in mehansko. Naš cilj pa je bil preveriti ali je možna pot prenosa teh dveh tobamovirusov na rastline tudi preko vode ali rastnega substrata. Ugotovili smo, da lahko ToBRFV v vodi, shranjeni pri sobni temperaturi, preživi do štiri tedne, njegovo RNA pa je mogoče v vodi zaznati vsaj štiri mesece. Pokazali smo, da lahko s ToBRFV okužena voda, ki se uporablja za namakanje, okuži rastline paradižnika prek korenin po enem do šestih mesecih izpostavljenosti. Poleg tega smo potrdili, da je s ToBRFV ali ToMMV kontaminiran rastni substrat lahko vir inokuluma za posajene sadike paradižnika in sadike, vzgojene iz semen. Ti rezultati kažejo na novo epidemiološko pot ToBRFV in ToMMV prek vode in rastnega substrata. Rezultati

zapolnjujejo obstoječe vrzeli v znanju in kažejo na potrebo po nadzoru prisotnosti novih tobamovirusov ter razkuževanju namakalne vode in rastnega substrata v pridelavi paradižnika in paprike, če pride do okužbe.

ABSTRACT

Growing medium and water contaminated with tobamoviruses can be a source of plant infection

Tomato brown rugose fruit virus (ToBRFV) and tomato mottle mosaic virus (ToMMV) are recently discovered tobamoviruses that pose a major threat to global tomato and pepper production. Tobamoviruses are characterised by their ability to survive over long periods of time on different surfaces and under different environmental conditions. They are mainly transmitted through infested seeds, planting material and mechanically. Our aim was to test whether these two tobamoviruses can also be transmitted to plants via water or growing medium. We found that ToBRFV can survive in water stored at room temperature for up to four weeks, and its RNA can be detected in water for at least four months. We have shown that ToBRFV-infested water used for irrigation can infect tomato plants via the roots after one to six months of exposure. In addition, we have confirmed that growing medium contaminated with ToBRFV or ToMMV can be a source of inoculum for planted and seed-grown tomato seedlings. These results suggest a new epidemiological route for ToBRFV and ToMMV via water and growing medium. The results fill existing knowledge gaps and point to the need to monitor the presence of new tobamoviruses and to disinfect irrigation water and growing medium in tomato and pepper production if infection occurs.

Izkušnje pri zmanjševanju poškodb na listih glavnatega zelja (*Brassica oleracea* var. *capitata* L.) od kapusovih bolhačev (*Phyllotreta* spp.)

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Kapusovi bolhači iz rodu *Phyllotreta* spp. so gospodarsko pomembni škodljivci na rastlinah iz družine križnic (Brassicaceae). Največ škode povzročijo z objedanjem mladih listov. Kapusovi bolhači na glavnatem zelju (*Brassica oleracea* var. *capitata*) povzročajo škodo predvsem v mesecu maju in juniju. Takrat sta na listih najpogosteje prisotna črni kapusov bolhač (*P. atra*) in velik progast bolhač (*P. nemorum*), v manjšem deležu najdemo tudi modrega kapusovega bolhača (*P. nigripes*) ter progastega bolhača (*P. undulata*). V letih 2018 in 2019 smo v Savinjski dolini preskušali različne pripravke za zmanjševanje populacije kapusovih bolhačev. V ta namen smo preizkušali različne biostimulante (AlgoPlasmin, PlanTonic, CutiSan, Boundary BX), lesni pepel, gnojila (Vitanica Si, Fertiactyl + Azur CaO) in kontaktne insekticidne pripravke na osnovi spinosada (Laser plus), lambda cihalotrina (Karate Zeon 5 CS), piretrina (Asset Five), azadirahtina (NeemAzal - T/S), piretrina (Flora Verde). V poskusu smo ocenjevali delež poškodovane listne površine mladih listov glavnatega zelja. Insekticida Karate Zeon 5 CS (a.s lambda cihalotrin) in Laser plus (a.s spinosad) sta v obeh letih preizkušanja imela najboljšo učinkovitost; posledično najmanjši odstotek poškodovane listne površine od kapusovega bolhača. Prav tako smo ugotovili, da učinkovito delujejo pripravki, ki sodijo v skupino

sredstev z nizkim tveganjem (AlgoPlasmin, CutiSan, lesni pepel). V prihodnje bo zaradi dejstev, da se s tržišča umikajo nekateri insekticidni pripravki nujno potrebno poseči po alternativnih pripravkih. Poleg tega bo smiselno, v ukrepe zmanjševanja poškodb od kapusovih bolhačev na listih glavnatega zelja, vključevati tudi privabilne posevke, upoštevati kolobar, saditi tolerantne (odporne) sorte in uporabljati prekrivke oziroma protiinsektne mreže.

ABSTRACT

Experiences in reducing the injuries on cabbage (*Brassica oleracea* var. c*apitata* L.) leaves caused by cabbage flea beetles (*Phyllotreta* spp.)

Cabbage flea beetles from the genus *Phyllotreta* spp. are economically important pests of plants from the cruciferous family (Brassicaceae). They cause the most damage by eating young leaves. Cabbage flea beetles on cabbage (*Brassica oleracea* var. *capitata*) cause damage mainly in the months of May and June. At that time, the *P. atra* and the *P. nemorum* are most often found on the leaves, in a smaller proportion also the *P. nigripes* and the *P. undulata*. In 2018 and 2019, we tested various preparations in the Savinjska Valley to reduce the cabbage flea beetles population. For this purpose, we tested various biostimulants (AlgoPlasmin, PlanTonic, CutiSan, Boundary BX), wood ash, fertilizers (Vitanica Si, Fertiactyl + Azur CaO) and contact insecticide preparations based on spinosad (Laser plus), lambda cyhalothrin (Karate Zeon 5 CS), pyrethrin (Asset five), azadirahtin (NeemAzal - T/S A) and pyrethrin (Flora Verde). In the experiments, we evaluated the proportion of damaged leaf surface of young leaves of cabbage. The insecticides Karate Zeon 5 CS (a.s. lambda cyhalothrin) and Laser plus (a.s. spinosad) had the best efficiency in both years of testing. as a result, the lowest percentage of leaf area damaged by the cabbage flea beetles. We also obtained the effectiveness of preparations based on low-risk methods (AlgoPlasmin, CutiSan, wood ash). In the future, due to the fact that insecticide preparations are being withdrawn from the market, it will be absolutely necessary to look for alternative preparations and use them to help reduce damage on cabbage leaves. In addition, it will make sense to include trap crops, take into account crop rotation, plant tolerant varieties and use anti-insect nets in measures to reduce damages to the leaves of the cabbage.

The use of inert and plant dusts to control onion thrips (*Thrips tabaci* Lindeman) and onion fly (*Delia antiqua* [Meigen]) in onion crops

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A two-year field experiment was conducted to study the non-chemical methods of controlling important insect pests in onion (*Allium cepa* L.), with a focus on two main insect pests, onion thrips (*Thrips tabaci*) and onion fly (*Delia antiqua*). The trials were performed in 2022-2023 in the Laboratory Field of Biotechnical Faculty in Ljubljana with

the yellow onion variety 'Sturon'. The treatments used were four types of inert dust (zeolite, quartz sand, diatomaceous earth, and wood ash of Norway spruce (*Picea abies*), plant dust (leaf powder of tree of heaven [*Ailanthus altissima*]), negative control (untreated plants) and positive control (onion, sprayed with insecticides Karate Zeon 5CS and Laser plus). The treatment applications were done in 7-10 days intervals and re-applied one day after in case of rain. During the growing season, the damage level because of the two pests was evaluated periodically, and the yields at harvest and after drying were also evaluated. In both years, the onion thrips damage was the lowest in positive control, and the severity of the attack was higher in 2022 than in 2023. The onion fly damage was high in quartz sand and positive control in 2022, with 1.9 rotten bulbs/ observation, while in 2023 the damage was lower. The productivity of onions in 2022 reached 11.5 t/ ha in the zeolite treatment, with the highest healthy yield (5.3 t/ ha) recorded in the positive control treatment. In 2023 the productivity of onion was doubled and similar at 23 t/ ha in quartz and positive control treatments, and the highest healthy onion was recorded in wood ash and diatomaceous earth treatments (both at 16.8 t/ ha). In both years, after drying, the highest percentage of healthy yield (63.4 and 89.5%) was achieved in treatment with wood ash. In general, the inert and plant dusts were less effective than insecticides in controlling onion thrips and onion flies, and the treatment of wood ash resulted in a higher dry yield of onion. Detailed information about the efficacy of inert and plant dusts in controlling pests in onions will be presented in this contribution.

IZVLEČEK

Uporaba inertnih in rastlinskih prahov za zatiranje tobakovega resarja (*Thrips tabaci* Lindeman) in čebulne muhe (*Delia antiqua* [Meigen]) na čebuli

Dveletni poskus je bil izveden z namenom preučevanja učinkovitosti nekemičnega zatiranja dveh vrst škodljivcev čebule (*Allium cepa* L.), tobakovega resarja (*Thrips tabaci*) in čebulne muhe (*Delia antiqua*). Poskus je potekal v letih 2022 in 2023 na Laboratorijskem polju Biotehniške fakultete Ljubljani na čebuli sorte 'Sturon'. Uporabljeni so bili štirje inertni prahovi (zeolit, kremenov pesek, diatomejska zemlja in lesni pepel smreke (*Picea abies*), rastlinski prah, pridobljen iz listov velikega pajesena (*Ailanthus altissima*), negativna kontrola (netretirane rastline) in pozitivna kontrola (rastline, škropljene z insekticidoma Karate Zeon 5CS in Laser plus). Nanašanje prahov na rastline je potekalo v 7-10-dnevnih intervalih, v primeru dežja pa smo tretiranje ponovili. Tekom rastne dobe smo redno pregledovali rastline na poškodbe zaradi navedenih škodljivcev, prav tako smo ocenili pridelek ob spravilu in po sušenju. V obeh letih so bile poškodbe, povzročene s strani tobakovega resarja, najmanjše v pozitivni kontroli, obseg poškodb pa je bil večji v letu 2022 kot v letu 2023. Škoda zaradi čebulne muhe (propadanje čebulic) je bila visoka v obravnavanju s kremenovim peskom in v pozitivni kontroli leta 2022, z 1,9 propadlimi čebulami/obravnavanje, leta 2023 pa je bila škoda manjša. Količina pridelka čebule v letu 2022 je znašala 11,5 t/ha v obravnavanju z zeolitom, največ zdravega pridelka (5,3t/ha), pa je bilo pobranega v obravnavanju pozitivna kontrola. V letu 2023 je bil pridelek podvojen in količinsko podoben v obravnavanjih s kremenovim peskom in pozitivna kontrola (23 t/ha), največ zdravega pridelka pa je bilo v obravnavanju z lesnim pepelom in diatomejsko zemljo (v obeh 16,8 t/ha). V obeh letih je bilo največ zdravega pridelka po sušenju (63,4 in 89,5 %) v obravnavanju z lesnim pepelom. Na splošno so bili inertni in rastlinski prahovi manj učinkoviti kot insekticidi pri zatiranju tobakovega resarja in čebulne muhe, v obravnavanju z lesnim pepelom pa smo ugotovili večji pridelek. Podrobne informacije o učinkovitosti inertnih in rastlinskih prahov v našem poskusu bodo predstavljene v prispevku.

Preučevanje sinergističnega delovanja različnih okoljsko sprejemljivih načinov zatiranja čebulne muhe (*Delia antiqua* [Meigen]) in tobakovega resarja (*Thrips tabaci* Lindeman) na čebuli

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Poskus smo izvedli leta 2023 na Laboratorijskem polju Biotehniške fakultete v Ljubljani, z namenom preučevanja učinkovitosti sočasne uporabe različnih okoljsko sprejemljivih načinov zatiranja čebulne muhe (*Delia antiqua*) in tobakovega resarja (*Thrips tabaci*) na čebuli. Njivo smo razdelili v tri bloke, v katerih smo posadili čebulček sorte Sturon. V vsakem bloku smo naključno razporedili 7 obravnavanj, in sicer: 1) negativna kontrola (netretirane rastline), 2) pozitivna kontrola (škropljenje z insekticidi), 3) čebulček, tretiran s pripravkoma na podlagi entomopatogene glive (EPG) in entomopatogenih ogorčic (EPN) v 7-10-dnevnih intervalih, 4) čebulček, posajen med belo deteljo, 5) čebulček, posajen med belo deteljo in škropljen s pripravkoma na podlagi EPG in EPN v 7-10-dnevnih intervalih, 6) obravnavanje z belo in svetlo modro lepljivo ploščo in atraktantom za tobakovega resarja/čebulno muho in 7) čebulček, tretiran s pripravkoma na podlagi EPG in EPN v kombinaciji z belo/svetlo modro lepljivo ploščo in atraktanti za tobakovega resarja/čebulno muho v 7-10-dnevnih intervalih. Med rastno dobo smo spremljali številčnost tobakovega resarja na svetlo modrih lepljivih ploščah in čebulne muhe na belih lepljivih ploščah, šteli propadle čebulice zaradi napada žerk čebulne muhe, ocenjevali obseg poškodb na listih čebule zaradi hranjenja tobakovega resarja, pridelek zdravih in propadlih čebul na njivi in 14 dni po spravilu pridelka. V prispevku bodo predstavljeni rezultati poskusa.

ABSTRACT

Investigation on synergism of different environmentally acceptable methods of controlling onion fly (*Delia antiqua* [Meigen]) and onion thrips (*Thrips tabaci* Lindeman) on onion

The experiment was conducted in 2023 at the Laboratory Field of the Biotechnical Faculty in Ljubljana, with the aim of studying the effectiveness of simultaneous use of various environmentally friendly methods for controlling onion fly (*Delia antiqua*) and onion thrips (*Thrips tabaci*) on onions. The field was divided into three blocks, where onion bulbs (variety Sturon) were planted. In each block, 7 treatments were randomly assigned, namely: 1) negative control (untreated plants), 2) positive control (spraying with insecticides), 3) onion bulbs treated with preparations based on entomopathogenic fungus (EPF) and entomopathogenic nematodes (EPN) at 7-10 day intervals, 4) onion bulbs planted among white clover, 5) onion bulbs planted among white clover and sprayed with preparations based on EPF and EPN at 7-10 day intervals, 6) treatment with white and light blue sticky traps and attractant for onion thrips/onion fly, and 7) onion bulbs treated

with preparations based on EPG and EPN in combination with white/light blue sticky traps and attractants for onion thrips/onion fly at 7-10 day intervals. Throughout the growing season, we monitored the abundance of onion thrips on light blue sticky traps and onion fly on white sticky traps, counted damaged bulbs due to the attack of onion fly larvae, evaluated the extent of damage on onion leaves caused by feeding of onion thrips, and also evaluated the yield of healthy and damaged onions in the field and 14 days after harvest. The paper will present the results of the experiment.

Preizkušanje učinkovitosti akaricidnih sredstev za zatiranje paradižnikove rjaste pršice (*Aculops lycopersici* Tryon, 1917) pri pridelavi paradižnika v zavarovanem prostoru

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Paradižnikova rjasta pršica (*Aculops lycopesici*) je polifagna vrsta, ki se pojavlja na predstavnikih iz družine razhudnikovk (Solanaceae). Najpomembnejša gostiteljska rastlina je paradižnik (*Solanum lycopersicum*), do večje škode prihaja predvsem pri pridelavi omenjene rastlinske vrste v zavarovanih prostorih. Na Primorskem pršica ni omejena zgolj na rastlinjake ampak povzroča škodo tudi na paradižniku, ki se prideluje na prostem. Paradižnikova rjasta pršica je izrazito termofilna vrsta, ki napada vse nadzemne dele rastline paradižnika. Večje izpade pridelka beležimo predvsem v sezonah z vročim poletjem. Omejevanje škode je kompleksno in temelji na izvajanju preventivnih ukrepov. Izjemnega pomena je higiena na pridelovalni površini, saj je priporočljivo odstranjevanje rastlinskih ostankov in prizadetih rastlin. Pomembno je tudi odstranjevanje nekaterih plevelov kot so pasje zelišče (*Solanum nigrum*) ali predstavnikov iz družine slakovk (Convolvulaceae). Učinkovitost kemičnega zatiranja je pogojena s pravočasnim odkrivanjem napada pršice. Za omejevanje paradižnikove rjaste pršice so trenutno registrirani izključno pripravki na osnovi žvepla, stransko delovanje pa imajo tudi nekatera druga akaricidna sredstva, ki so registrirana za zatiranje navadne pršice (*Tetranychus urticae*) na paradižniku. Da bi preverili učinkovitost različnih programov zatiranja paradižnikove rjaste pršice smo v letih 2022 in 2023 opravili škropilni poskus z več obravnavanji na paradižniku gojenem v zavarovanih prostorih. Ocena učinkovitosti zatiranja je temeljila na številu najdenih pršic na posameznih delih stebla rastlin. Dobljene podatke smo ovrednotili s pomočjo analize variance.

ABSTRACT

Efficacy trial of acaricidal products for the control of tomato russet mite (*Aculops lycopersici*Tryon, 1917) in greenhouse tomato cultivation

Tomato russet mite (*Aculops lycopesici*) is a polyphagous species that feeds on plants belonging to the family of Solanaceae. Tomato (*Solanum lycopersicum*) is the species main host. The major yield loss occurs in greenhouse tomato production. In the region of Primorska the pest is not related only to greenhouse cultivation but can spread in fields too. It feeds on the plant shoot system and prefers warm temperatures. As a result, the major yield loss occurs in years with hot summers. Yield loss delimitation is complex and

is based on the implementation of prevention measures. Hygiene on the cultivated area is very important because of that plant debris or infected plants should be removed. It is very important to control weeds such the common nightshade (*Solanum nigrum*) or other species belonging to the Convolvulaceae family too. The effectiveness of the chemical control depends on the pest detection time. For the control of the tomato russet mite in Slovenia there are registered only products based on sulphur. However, some acaricidal products that are registered against the glasshouse red spider mite (*Tetranychus urticae*) on tomatoes can be implemented too. In order to determine the efficacy of different acaricidal programs for the control of the tomato russet mite we performed an efficacy trial with several treatments by using different products in the years 2022 and 2023 on tomatoes cultivated in greenhouse. The trial efficacy rate was based on the number of mites found on stem clippings. The results were then evaluated by using the analysis of variance (ANOVA).

Vpliv antagonistične glive *Trichoderma* sp na pridelek vrtne solate (*Lactuca sativa* L.)

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V poljskem poskusu, ki je potekal na polju Biotehniške fakultete v Ljubljani, smo proučevali delovanje antagonistične glive *Trichoderma asperellum* na razvoj sadik in pridelek solate. Uporabili smo 0,35-% vodno suspenzijo spor glive. Rastline smo z glivo tretirali na dva načina: predhodno tretiranje sadik v gojitvenih ploščah (t1); zalivanje sadik po presajanju z 18 ml suspenzije (t2). Kontrolne rastline niso bile tretirane z glivo (k). V poskus smo vključili 2 sorti solate: 'Joliac' in 'Tourbillon'. Ocenjevali smo učinek tretiranja z glivo na rast sadik in tehnološko zrelo solato. Pri sadikah smo tehtali maso korenin, cele sadike, nadzemnega dela sadike in prešteli število polno razvitih listov. Pri tehnološko zreli solati smo izmerili višino in premer rozete, tehtali svežo maso rozete, korenin, maso tržnega dela rozete, suho snov, prešteli število odstranjenih listov ter pomerili višino in širino kocena. Učinek glive na sadike je bil različen. Pri sorti 'Joliac' je bila povprečna masa sadike za 36 % večja, povprečna masa nadzemnega dela pa za 48 % večja od netretiranih sadik. Pri sorti 'Tourbillon' ni bilo razlik. Pri tehnološko zreli solati sorte 'Tourbillon' so bile rozete najnižje pri tretiranju sadik z glivo (t1) in imele najkrajši kocen. Pri zalivanju z glivo po presajanju (t2) je imela sorta 'Tourbillon' za 35 % več odstranjenih in poškodovanih listov od sorte 'Joliac'. Ta pa je imela za 32 % več odstranjenih listov v t1 glede na t2. Jasnih vplivov tretiranja s pripravkom na pridelek solate ni bilo, razen potencialnega kasnejšega uhajanja v cvet pri sorti 'Tourbillon' v t1.

ABSTRACT

The effect of the antagonistic fungi *Trichoderma* sp. on the yield of lettuce (*Lactuca sativa* L.)

In the field trial conducted on the field of the Faculty of Biotechnology in Ljubljana, the effect of the antagonistic fungus Trichoderma asperellum on the development of seedlings and the yield of lettuce, was studied. A 0.35-% aqueous suspension of fungal spores was used. The plants were treated with the fungus in two ways: Pre-treatment of seedlings in plug trays (t1); irrigation of seedlings after planting with 18 ml of the suspension (t2). The

control plants were not treated with the fungus. Two lettuce varieties were included in the experiment: 'Joliac' and 'Tourbillon'. We evaluated the effect of the fungal treatment on seedling growth and technologicaly mature lettuce. We evaluated the mass of the seedling roots, the whole seedling, the above-grounf part of the seedling and counted the number of fully developed leaves. For technologically mature lettuce, we evaluated the height and diameter of the rosette, the fresh mass of the rosette, mass of the roots, mass of the marketable part, dry matter, the number of removed leaves and the height and width of the stem. The effects of the fungus on the seedlings were different. In the 'Joliac' variety the average weight of the treated seedling was 36 % higher and the average weight of the above-ground part was 48 % higher than untreated seedlings. There were no differences in the 'Tourbillon' variety. In the technologically mature lettuce of the 'Tourbillon' variety, the rosettes were the lowest and had the shortest stem when treated with the fungus (t1). When irrigated with the fungus after transplanting (t2), the 'Tourbillon' variety had 35 % more removed and damaged leaves than the 'Joliac' variety. The latter had 32 % more leaves removed in t1 compared to t2. There were no clear effects of treatment with the preparation on lettuce yield, except for the potential later bolting in the variety 'Tourbillon' in t1.

Uporaba antagonistične glive *Trichoderma sp*. pri pomanjkljivem namakanju vrtne solate (*Lactuca sativa*) in vpliv na kakovost pridelka

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V lončnem poskusu, ki smo ga izvedli od junija do avgusta 2023, smo ugotavljali kakovost pridelka solate, pri gojenju rastlin z optimalno in pomanjkljivo oskrbo z vodo in tretiranju rastlin z antagonistično glivo *Trichoderma* sp. Imeli smo tri načine tretiranja, namakanje sadik v gojitveni plošči 10 dni pred presajanjem; zalivanje substrata z glivo takoj po presajanju in kombinacijo obeh obravnavanj: zalivanje substrata takoj po presaditvi tretiranih sadik z glivo; kontrolne rastline niso bile tretirane. Vsako obravnavanje smo izvedli v 4 ponovitvah. Imeli smo 32 loncev: 16 rastlin (4 obravnavanja z glivo v 4 ponovitvah) je imelo optimalno oskrbo z vodo (100 % poljska kapaciteta – PK), 16 rastlin pa pomanjkljivo oskrbo z vodo (50 % PK). V tehnološki zrelosti smo izmerili maso cele rastline, tržnega dela, višino kocena, delež suhe snovi v listih in koreninah in vsebnost vitamina C. Tretiranje z glivo ni imelo vpliva na maso rozet, delež in maso tržnega dela, višino kocena in vsebnost suhe snovi. Deficitno namakanje je značilno povečalo vsebnost suhe snovi v koreninah; zalivanje sadik z glivo po presaditvi predhodno tretiranih sadik je značilno povečalo vsebnost vitamina C glede na rastline, kjer smo ali samo zalili po presaditvi ali pa so bile sadike predhodno tretirane z glivo *Trichoderma* sp.

ABSTRACT

The use of the antagonistic fungi *Trichoderma* sp. in deficient irrigation of lettuce (*Lactuca sativa* L.) and the effect on yield quality

In the pot experiment conducted from June to August 2023, the quantity and quality of the lettuce yield was investigated for plants, grown under optimal and deficit water supply and

treated with the antagonistic fungi *Trichoderma* sp. Three methods of treatment with the fungus were carried out: Soaking the seedlings in the plug tray 10 days before transplanting; irrigation of the substrate with the fungus immediately after transplanting; and a combination of both treatments: irrigation of the substrate immediately after transplanting the seedlings treated with the fungus; the control plants were not treated. Each treatment was carried out in 4 replicates. Of 32 pots, 16 plants (4 fungal treatments in 4 replicates) had an optimal water supply (100 % field capacity), 16 plants had a deficient water supply (50 % field capacity). At technological maturity the weight of the whole plant, the marketable part, the height of the stem, the percentage of dry matter in leaves and roots and the vitamin C content were measured. Treatment with the fungus had no effect on the mass of the rosettes, the proportion and weight of the marketable part, the height of the stem and the dry matter of leaves. Deficit irrigation significantly increased the root dry matter content; irrigation of the seedlings with the fungus after transplanting the previously treated seedlings significantly increased the vitamin C content compared to the plants in which either irrigation was applied only after transplanting or

Posterji

Inventarizacija koristnih organizmov za biotično varstvo rastlin

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Najdbe in identifikacije novih vrst koristnih organizmov (domorodnih, tujerodnih), kot so parazitoidi, plenilci in plenilske pršice, so pomembne v biotičnem varstvu rastlin za zatiranje gospodarsko pomembnih škodljivcev kmetijskih rastlin. S tem, ko najdemo in potrdimo nove vrste koristnih žuželk in pršic na ozemlju Slovenije, in v kolikor so tudi na EPPO seznamu, lahko le-te uvrstimo na Seznam domorodnih vrst koristnih organizmov, ki se smejo uporabljati v biotičnem varstvu. V sklopu terenskega dela in poljskih poskusov, ki potekajo v okviru programa strokovnih nalog s področja zdravstvenega varstva rastlin in ga finančno podpira Ministrstvo za kmetijstvo, gozdarstvo in prehrano ter Uprava RS za varno hrano, veterinarstvo in varstvo rastlin, smo vzorčili naravne sovražnike škodljivcev v raznolikih agroekosistemih. Identificirali smo več najezdnikov (Hymenoptera: Ichneumonidae) *Campoplex capitator* Aubert*, Diadegma armillata* (Graven.), *Sinophorus turionum* (Ratz.), *Tranosemella praerogator* (L.), *Venturia canescens* (Graven.), *Diadegma tenuipes* (Thomson) in *Parania geniculata* (Holmgren), ki so se ulovili v rumene vodne pasti, ter tri vrste muh goseničark (Diptera: Tachnidae) *Exorista larvarum* (L.) in *Eumea linearicornis* (Zetter.), ki sta parazitirali gosenice sovk (Lepidoptera: Noctuidae) ter *Compsilura concinnata* (Meigen) izlegla iz bube kapusovega belina *Pieris brassicae* L. (Lepidoptera: Pieridae). Nadalje smo potrdili prisotnost jajčnih parazitoidov *Telenomus turesis* Walker (Hymenoptera: Scelionidae), ki so se izlegli iz jajčnih legel stenice *Dolycoris baccarum* (L.) (Heteroptera: Pentatomidae). S prehranskimi vabami z umetnim jabolčnim medijem za vinske mušice okuženim z ličinkami in bubami plodove vinske mušice (*Drosophila suzukii*) ter dodanimi koščki banan smo ulovili parazitoida bub *Pachycrepoideus vindemmiae* (Rond.) (Hymenoptera: Pteromalidae) in larvalnega parazitoida *Leptopilina boulardi* (Barb., Ca. & Kel.) (Hymenoptera: Figitidae) vinskih mušic (Drosophilidae). Nobena od potrjenih vrst ni na EPPO seznamu, najdbe pa kljub temu pomembno prispevajo k poznavanju biotske pestrosti Slovenije, saj so navedene taksonomske skupine manj raziskane.

ABSTRACT

Inventory of beneficial organisms for biological control

Findings and identification of new species of beneficial organisms (native, non-native) such as parasitoids, predators and predatory mites can be important for the biological control of agricultural pests. By finding and confirming new species of beneficial insects and mites in Slovenia, if they are also on the EPPO Positive List, we can add them to the List of native species of beneficial organisms that can be utilized in biological control. As

part of field work and experiments carried out within the framework of expert tasks in the field of plant protection, financially supported by Ministry of Agriculture, Forestry and Food and the Administration of the Republic of Slovenia for Food Safety, Veterinary Sector and Plant Protection, we sampled the natural enemies of pests in various agroecosystems. We have identified several species of Ichneumonidae (Hymenoptera): *Campoplex capitator* Aubert, *Diadegma armillata* (Graven.), *Sinophorus turionum* (Ratz.), *Tranosemella praerogator* (L.), *Venturia canescens* (Graven.), *Diadegma tenuipes* (Thomson) and *Parania geniculate* (Holmgren), caught in yellow water traps. In addition, we identified three species of tachinid flies (Diptera: Tachnidae): *Exorista larvarum* (L.) and *Eumea linearicornis* (Zetter.), which hatched from moth caterpillars (Lepidoptera: Noctuidae) and *Compsilura concinnata* (Meigen) which developed on pupae of *Pieris brassicae* L. (Lepidoptera: Pieridae). Furthermore, we confirmed the presence of egg parasitoids *Telenomus turesis* Walker (Hymenoptera: Scelionidae) that developed on egg masses of the hairy shielbug *Dolycoris baccarum* (L.) (Heteroptera: Pentatomidae). Using sentinel traps baited with artificial food medium for drosophilids infested with larvae and pupae of *D. suzukii* with added banana slices we caught the pupal parasitoid *Pachycrepoideus vindemmiae* (Rond.) (Hymenoptera: Pteromalidae) and larval parasitoid of the fruit flies (Drosophilidae) *Leptopilina boulardi* (Barb., Ca. & Kel.) (Hymenoptera: Figitidae). None of the confirmed species is on the EPPO Positive List. Nevertheless, these findings contribute significantly to the understanding Slovenia's biodiversity, as the mentioned taxonomic groups are less well studied.

First overview of EPPO positive biocontrol agents present in Serbia

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The European and Mediterranean Plant Protection Organization (EPPO) is an international organization responsible for cooperation and harmonization in plant protection in the European and Mediterranean region. As part of Yugoslavia, Serbia was a member of the organization from 1951 until it withdrew its membership in 1992. Serbia rejoined in 2004. The EPPO's first activities on biological control agents (BCAs) took place in 1997 and the first “positive list” was drawn up in 2001. It contains a list of BCAs that can be safely used in Europe and the Mediterranean region. The standard PM 6/3 - Biocontrol agents safely used in the EPPO region is the latest document with a list of BCAs and their short biology, which does not require a complete procedure for import and release and contains three appendices: Appendix I - Commercially or officially used biological control agents, Appendix II - Classical BCAs successfully established in the EPPO region, Appendix III - List of biological control agents removed from Appendices I or II. We searched the literature and databases for species listed in Appendices I and II that have ever been detected in Serbia. Of the 112 species listed in Appendix I, 45 have been recorded in Serbia, and of the 42 species listed in Appendix II, six have been recorded in Serbia. In

comparison, 38 species listed as indigenous biological control agents in Slovenia: 34 from Appendix I, two from Appendix II and two others.

Natural enemies associated with some agricultural pests in Montenegro

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Biological control is a proven and an essential component of Integrated Pest Management (IPM) where pest populations are controlled by using their natural enemies. Biological control in Montenegro is regulated by the Law on Plant Health Protection, specifically in Articles 49 and 50, but its application has not been established at the level of common and organized use yet. There is only ,,natural" influence of already existing natural enemies on certain agricultural pests. We consider that the first step in organisation and implementation of any future strategy of biological control in Montenegro is to summarize all available and published information regarding existing natural enemies associated with agricultural pests. We searched the literature and listed around 50 beneficial species (predators, parasitoids, entomopathogenic fungi) mainly related with citrus and olive pests that are officially recorded for the period 1961–2023. Thanks to the previous work particularly of academician Mijušković and Dr. Velimirović together with some recent data, this can be considered as the first comprenhesive natural enemies list of arthropod pests in Montenegro as well the basis for its comparison with the EPPO Positive List of biological control agents that can be used in agricultural production to control plant pests. In this context example of Slovenia can be cited where only the native natural enemies of plant pests that are on the EPPO Positive List of biological control agents can be used in agricultural production to control plant pests. Slovenian current list includes 38 species of beneficial insects, mites and entomopathogenic nematodes. This paper presents results of the project of the bilateral scientific and technological cooperation between Montenegro and Slovenia for 2023-2024 (“State and perspectives of biological protection in Montenegro and Slovenia”).

Prva najdba parazitoidov *Bracon hebetor* Say (Hymenoptera: Braconidae) in *Theocolax elegans* (Westwood) (Hymenoptera: Pteromalidae) v Sloveniji

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V letu 2023 smo v okviru spremljanja naravnih sovražnikov gospodarsko pomembnih škodljivcev v Sloveniji potrdili zastopanost dveh vrst parazitoidov, naravnih sovražnikov škodljivcev uskladiščenih žit. V vzorcih skladiščenega zrnja, ki smo jih analizirali v oktobru 2023, smo potrdili vrsti *Bracon hebetor* in *Theocolax elegans*. Parazitoida *B. hebetor* smo našli v vzorcu koruze, kjer se je kot primarni škodljivec pojavljal krhljev molj (*Plodia interpunctella*). Vrsto *Theocolax elegans* pa smo najprej potrdili v zrnju pšenice, napadenem od črnega žitnega žužka (*Sitophilus oryzae*), pozneje pa smo tega parazitoida našli tudi v vzorcih pšenice s koruznim žužkom (*Sitophilus zeamais*). V prispevku bo predstavljena bionomija obeh vrst koristnih žuželk in tudi možnost za njuno uporaba v biotičnem varstvu skladiščenega zrnja pšenice in koruze.

ABSTRACT

First record of parasitoids *Bracon hebetor* Say (Hymenoptera: Braconidae) and *Theocolax elegans* (Westwood) (Hymenoptera: Pteromalidae) in Slovenia

In 2023, as part of the monitoring of natural enemies of economically important insect pests in Slovenia, we have confirmed the occurrence of two parasitoid species, natural enemies of stored grain pests. In the samples of stored grain analyzed in October 2023, we have confirmed the species *Bracon hebetor* and *Theocolax elegans*. The parasitoid *B. hebetor* was found in a sample with corn grain where the Indian meal moth (*Plodia interpunctella*) was identified as the primary pest. *Theocolax elegans* species was first confirmed in wheat grain attacked by rice weevil (*Sitophilus oryzae*), and later this parasitoid was also found in wheat samples with maize weevil (*Sitophilus zeamais*). The paper will present the bionomics of both beneficial insect species and also the possibility of their use in the biological control of stored wheat and corn grains.

Je pisana polonica (*Harmonia axyridis* [Pallas], Coleoptera: Coccinellidae) že prevladujoča vrsta polonic v Sloveniji?

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Polonice spadajo med najbolj prepoznavne plenilce rastlinskih škodljivcev (zlasti žuželk in pršic). V zadnjih letih opažamo v agroekosistemih in v urbanem okolju prevladujoče pojavljanje pisane polonice (*Harmonia axyridis*) in bistveno manjšo številčnost domorodnih vrst polonic, na primer sedempike polonice (*Coccinella septempunctata*) in dvopike polonice (*Adalia bipunctata*). Glavni vzrok pripisujemo zlasti veliki agresivnosti pisane polonice, generalista, ki zaradi velike ješčnosti domorodnim polonicam odvzame vire hrane. V raziskavi smo preučevali razširjenost pisane polonice in domorodnih vrst polonic v agroekosistemih in urbanem okolju ter njihovo sezonsko dinamiko. V letu 2023 smo odvzeli 115 vzorcev. Prevladujoča vrsta je bila pisana polonica (44 %), kateri je sledila sedempika polonica (38 %). V sklopu raziskave smo potrdili zastopanost sedmih vrst polonic v Sloveniji.

ABSTRACT

Is the Harlequin Ladybird (*Harmonia axyridis* [Pallas], Coleoptera: Coccinellidae) already the Dominant Species of Ladybirds in Slovenia?

Ladybirds are among the most recognizable predators of plant pests (especially insects and mites). In recent years, we have observed the predominant occurrence of the Harlequin Ladybird (*Harmonia axyridis*) in agroecosystems and urban environments, with significantly lower numbers of native ladybird species such as the Seven-Spotted Ladybird (*Coccinella septempunctata*) and Two-Spotted Ladybird (*Adalia bipunctata*). The main cause is attributed to the high aggressiveness of the Harlequin Ladybird, a generalist that, due to its voracious appetite, deprives native ladybirds of food sources. The study investigated the distribution of the Harlequin Ladybird and native ladybird species in agroecosystems and urban environments, along with their seasonal dynamics. In the year 2023, we collected 115 samples. The predominant species was the Harlequin Ladybird (44%), followed by the Seven-Spotted Ladybird (38%). As part of the study, we confirmed the presence of seven ladybird species in Slovenia.

Preučevanje učinkovitosti parazitskih ogorčic polžev (*Oscheius myriophilus*, *Phasmarhabditis papillosa*) za zatiranje izbranih vrst polžev

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Med julijem in septembrom 2021 so raziskovalci zbrali 100 primerkov španskega lazarja, *Arion vulgaris*, z namenom njihove disekcije in iskanja parazitskih ogorčic polžev. Molekularne tehnike so bile uporabljene za identifikacijo ogorčic, kar je potrdilo prisotnost vrste *Oscheius myriophilus*. Za testiranje virulentnosti slovenskih sevov *O. myriophilus* in *Phasmarhabditis papillosa* ter njihovih učinkov na prehranjevalno vedenje španskega lazarja, mrežastega slinarja (*Deroceras reticulatum*) in vinogradnega polža (*Cernuella virgata*) so bila izvedena laboratorijska biotestiranja z ogorčicami, vzgojenimi *in vivo*. Ogorčice so bile uporabljene v različnih odmerkih od 10 do 500 ogorčic/polža. Rezultati so pokazali, da sta ogorčici vrst *O. myriophilus* in *P. papillosa* povzročili signifikantno smrtnost španskega lazarja (82,5 % ± 2,5 % pri 15 °C), medtem ko sta bila manj učinkoviti pri zatiranju drugih dveh preučevanih vrst polžev v poskusu. Ogorčice so bile bolj virulentne pri nižjih temperaturah (15 °C) kot pri višjih temperaturah (20 °C). Obe vrsti ogorčic sta vplivali na zmanjšano stopnjo hranjenja preučevanih vrst polžev.

ABSTRACT

Studying the efficacy of parasitic nematodes of slugs (*Oscheius myriophilus*, *Phasmarhabditis papillosa*) for controlling selected slug species

Between July and September 2021, researchers collected 100 specimens of the Spanish slug, *Arion vulgaris*, and dissected their cadavers to examine them for parasitic nematodes. Molecular techniques were used to identify the nematodes, which confirmed

the presence of *Oscheius myriophilus*, marking the first recorded instance of this nematode in a gastropod host. To test the virulence of Slovenian strains of *O. myriophilus* and *Phasmarhabditis papillosa*, and their effects on the feeding behavior of the Spanish slug, grey field slug (*Deroceras reticulatum*), and vineyard snail (*Cernuella virgata*), laboratory bioassays were conducted using nematodes grown in vivo. Nematodes were applied at various doses ranging from 10 to 500 nematodes/gastropod. The results showed that *O. myriophilus* and *P. papillosa* caused significant mortality (82.5 % ± 2.5 % at 15 °C) of the Spanish slug, while being less effective against the vineyard snail and grey field slug. Nematodes were more virulent at lower temperatures (15 °C) than at higher temperatures (20 °C) tested in the experiment. Additionally, both nematode species significantly reduced gastropod herbivory.

Susceptibility of *Aphelinus mali* (Haldeman) to different active ingredients commonly used in organic apple orchards in Trentino (North Italy)

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Aphelinus mali (Haldeman) is the most important biological control agent of woolly apple aphid (WAA) *Eriosoma lanigerum* (Hausmann), a serious pest of apples. This parasitoid is not very effective its own, because the first adult wasps emerge only when the WAA has already gone through one generation, and its innate capacity of increase is considerably lower than its host's. Furthermore, the amount of products used in apple orchards could compromise the effectiveness of *A. mali* on its biological control. The rate of parasitism reaches high levels (80-90%) in late summer when part of the damage has already been caused. In Trentino region (Italy) the first peak of flight of *A. mali* is in the post-flowering period, although limited in size and is essential for an exponential flight increase and the consequent culmination of the parasitisation ratio in summer, generally at the end of July. It is essential to avoid pesticides toxic to *A. mali* after flowering but also other active substances that can reduce *A. mali* activity. For these reasons, we tested several plant protection products to evaluate potential compatibility in integrated and organic pest management programs. The direct (topical sprays in Potter's Tower) and residual (leaf residue) effect of insecticides and fungicides on the adult stage of this parasitoid were investigated under laboratory conditions. The active ingredients used in trials were deltamethrin (as a chemical referent), azadirachtin, copper sulphate, sulphur, and calcium polysulfide. The products were tested at recommended field rates. A treatment with water was used as control in both experimental trials. The insects' mortality rate on direct effect in Potter Tower was different only for the deltamethrin at different control timing. Deltamethrin caused the highest mortality also in residual effect than the other products. After 3 and 7 days from the treatment no product were caused mortality.

Syrphid releasing vs *Eriosoma lanigerum*: preliminary results.

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In the last few years, one of the most worrying pests for apple production in the Southern Alps is woolly apple aphid (WAA), *Eriosoma lanigerum* Hausmann. It causes hypertrophy and tissue ruptures in roots and shoots of apple trees. This can reduce sap flow, vigour, tree productivity and fruit quality. Since the challenge facing agriculture in the coming years is to produce a good yield of healthy food using improved environmentally friendly practices, enhancing biological pest control is crucial. A great control of the WAA population is made by the parasitoid *Aphelinus mali* Haldeman but only for a short period of the season. Syrphidae is known to have high predatory potential on the population of aphids in orchards, i.e., *Ephisyrphus balteatus* De Geer is one of the most effective biocontrol agents against aphids in apple orchards. For these reasons, the ability of Syrphidae in controlling the population of WAA in apple orchards of Trentino (North Italy) was evaluated during the season 2023. The trial was carried out in three potentially high-infested orchards: two orchards were treated with beneficial insects, and one was non-treated (control). The orchards were organic managed, cultivated with Golden Delicious variety on M9 rootstock. In the treated orchards, pupae of *E. balteatus* and *Sphaerophoria ruepellii* Wiedemann of the Koppert B.V. company were released in March. WAA migration on trees and *A. mali* population were monitored on yellow sticky traps during the season. WAA infestation was assessed by visual observations of 50 marked shoots in each orchard from April to August, as well as the presence of predators. Preliminary results of one-year trial showed that Syrphidae release alone was not successful in reducing WAA infestation, but a positive effect could be observed as after one month from the release, Syrphidae abundance on WAA colonies was much higher in the treated orchards.

The use of acoustic technology for monitoring biodiversity in the Kopački rit Nature park (project WatchOut)

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Bioacoustic remote monitoring is a non-invasive approach, to track species in real time without disturbing the natural habitats, allowing for prompt intervention in the biodiversity protection. Use of offline sound recording devices such as AudioMoth, provides an efficient and precise method for tracking biodiversity on a larger scale. These low-cost, full-spectrum acoustic loggers are capable of recording across audible and ultrasonic frequencies. In addition to acoustic monitoring, we also use standard monitoring method and analyze data of various wildlife species such as birds, amphibians, insects, mammals, and others taxonomic groups over a three year period. Our objective is monitor approximately 50 different species of wild flora and fauna within the Nature Park "Kopački Rit" and 23 of target species are included in the Natura 2000 ecological network. Insects generate sounds with different organs and these sounds can be recorded with appropriate recording tools. Four insect species are included in this research. Sound production is well known in woodboring insects such as *Cerambyx cerdo* or *Lucanus cervus*, additionally, *Graphoderus bilineatus* and *Lycaena dispar*, two strictly protected insect species in Croatia, are also included as target species. We are developing regional convolutional neural networks (CNN) for specific species to facilitate their long-term monitoring with a particular emphasis on endangered, protected, and indicator species. These technologies enable highly accurate multi-label recognition of multiple calls in complex, noisy ecosystems. By utilizing artificial intelligence, we aim to develop a model that can forecast the behavior and distribution of protected animal species, determine the impact of climate change on observed species, and evaluate the effects of various anthropogenic activities on fauna conservation. Ultimately, our goal is to raise awareness about the importance of protecting natural habitats and biodiversity.

Povečanje učinkovitosti okoljsko sprejemljivih pristopov varstva rastlin s hkratno uporabo različnih metod

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Biotično varstvo je z ostalimi okoljsko sprejemljivimi načini zatiranja škodljivcev v zadnjih desetletjih pritegnilo veliko pozornosti. Različni pristopi, vključno z uporabo biotičnih agensov, vmesnimi posevki, biofumigacijo, lepljivimi ploščami in feromoni, so že precej raziskani. Čeprav študije ne poročajo o veliki učinkovitosti posameznih metod, se jih zaradi naraščajočih pritiskov za omejitev ali odpravo sintetičnih fitofarmacevtskih sredstev še vedno priporoča kot potencialno alternativo konvencionalnim praksam. Kljub manjši učinkovitosti posameznih pristopov, pa obstaja omejen nabor študij, ki poročajo o povečani učinkovitosti ob sočasni uporabi več takšnih metod. V raziskavi smo izvedli temeljit pregled literature za oceno sinergijskega potenciala sočasne uporabe dveh ali več okoljsko sprejemljivih metod, s poudarkom na perspektivah celostnega upravljanja in posnemanja kompleksnih naravnih sistemov. Ugotovitve kažejo na velik potencial in potrebo po nadaljnjih raziskavah na tem področju.

ABSTRACT

Enhancing the Efficiency of Environmentally Acceptable Plant Protection Approaches Through Simultaneous Use of Different Methods

In recent decades, significant attention has been directed towards biological control and other environmentally acceptable pest control methods. Various strategies, such as the deployment of biotic agents, intercropping, biofumigation, sticky traps, and pheromones, have undergone extensive investigation. While individual methods may not exhibit high efficacy, they are increasingly advocated as potential alternatives to conventional synthetic plant protection agents due to pressures to restrict or eliminate their usage. Despite the modest efficacy of individual approaches, a restricted body of literature suggests heightened effectiveness when multiple environmentally acceptable methods are employed concurrently. This research conducts a comprehensive literature review to evaluate the synergistic potential of utilizing two or more environmentally acceptable methods simultaneously, with a focus on integrated management and emulation of complex natural systems. The findings underscore significant potential and the necessity for further exploration in this domain.

Pregled gostiteljskih rastlin marmorirane smrdljivke (*Halyomorpha halys* [Stål, 1855]; Hemiptera: Pentatomidae) v zahodni Sloveniji

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Invazvna, tujerodna marmorirana smrdljivka (*Halyomorpha halys*) je izrazit polifag, ki napada vegetativne in reproduktivne organe številnih rastlinskih vrst. V izvornem okolju v Aziji ima več kot 100 gostiteljev, ki pripadajo 45 družinam, med njimi prevladujejo rastlinske vrste iz družin Rosacea in Fabacea. Njeni priljubljeni gostitelji so številne sadne vrste, poljščine in zelenjadnice, na katerih se hrani in povzroča pomembno gospodarsko škodo. V Sloveniji smo marmorirano smrdljivko prvič odkrili na Goriškem leta 2017, po letu 2019 pa jo uvrščamo med gospodarsko najpomembnejše škodljivce v pridelavi sadja v regiji. V letih 2019-2023 smo na območju zahodne Slovenije evidentirali potencialne gostitelje marmorirane smrdljivke ter ocenili njihov pomen za razvoj in rast populacij škodljivca na napadenem območju. V ta namen smo vsako leto v obdobju od marca do oktobra na različnih lokacijah v zahodni Sloveniji izvajali vizualne preglede rastlinskih vrst ter spremljali zastopanost posameznih razvojnih faz marmorirane smrdljivke. Poleg kmetijskih rastlin, na katerih smo pričakovali velike populacije stenic, smo pregledovali tudi mejice, gozdne robove, obrečno vegetacijo, urbane parke in vrtove. V 5-letnem obdobju smo evidentirali skupno 74 rastlinskih vrst iz 35 družin, ki so gostile več kot en stadij marmorirane smrdljivke. Največ gostiteljev je pripadalo družini rožnic (Rosacea), med njimi so bile vse gospodarsko pomembne sadne vrste, ki se pridelujejo v regiji. Mandelj (*Prunus dulcis*) in češnja (*Prunus avium*) sta bila najbolj zgodnja gostitelja odraslih stenic. Na marelici, breskvi, hruški in jablani, leski in oljki smo opažali velike populacije marmorirane smrdljivke in zastopanost vseh razvojnih stadijev, kar kaže na to, da so naštete sadne vrste njeni dobri gostitelji, hkrati pa tudi zelo izpostavljeni napadu škodljivca. V urbanem okolju so bili najpogostejši in hkrati celosezonski gostitelji ostrolistni javor (*Acer platanoides*), navadni cigarovec (*Catalpa bignonioides*) in navadna

pavlovnija (*Paulownia tomentosa*). Prehranjevanje nimf in občasno tudi odraslih stenic smo evidentirali tudi na plevelnih vrstah: *Amaranthus retroflexus, Clematis vitalba, Erigeron canadensis, Arctium lappa, Chenopodium album* in *Rumex obtusifolius*, ki so se razraščale na robovih kmetijskih zemljišč. Obrečna vegetacija, gozdni robovi in mejice s trdolesko (*Euonymus europaea*), navadno kalino (*Ligustrum vulgare*), rdečim drenom (*Cornus sanguinea*), amerikanskim javorjem (*Acer negundo*), navadno robinijo (*Robinia pseudoacacia*) in navadno lesko (*Corylus avellana*) so prav tako predstavljali pomemben alternativni prehranski vir marmorirane smrdljivke, prostor za ovipozicijo, kot tudi naravno zatočišče in rezervoar, ključen pri njeni nadaljnji širitvi na kmetijske površine.

ABSTRACT

Survey of host plants of brown marmorated stink bug (*Halyomorpha halys* [Stål, 1855]; Hemiptera: Pentatomidae) in Slovenia

The invasive, alien brown marmorated stink bug (*Halyomorpha halys*), is a highly polyphagous pest attacking vegetative and reproductive structures of many plant species. In its native range in Asia, it feeds on more than 100 host plants in 45 families, with a preference for the plants from the Rosaceae and Fabaceae families. Feeding on highly preferred hosts including field crops, vegetables, tree fruits, and ornamentals causes significant crop damage. *Halyomorpha halys* was first found in Slovenia in 2017, in Goriška region and has been considered most damaging agricultural pests in region since 2019. In the years 2019-2023, *H. halys host plants* survey *was performed in western Slovenia. At the same time, the impact of the individual host on pest development and population growth in endangered area was assessed. Each year, from March to October we conducted several visual inspections* of plant species at various locations in western Slovenia, to verify the presence of *H. halys* and its host use by different life stages. In additional to cultivated plants, which are known to be preferred *H. halys* hosts, also hedges, forest edges, riparian vegetation, urban parks and gardens were inspected. Over a 5-year period, a total of 74 plant species from 35 families have been recorded, with more than one life stage of *H. halys* present. The majority of host plants belong to the Rosaceae family, including all economically important fruit species grown in the region. Almond (*Prunus dulcis*) and sweet cherry (*Prunus avium*) were recorded as the early season hosts of adults. High populations of all life stages of *H. halys* observed on apricots, peaches, pears, apples, hazelnuts and olives, indicate that these fruit species are very suitable *H. halys* hosts and also highly vulnerable to its attack at the same time. In urban area, *Acer platanoides*, *Catalpa bignonioides* and *Paulownia tomentosa* were most frequently recorded host plants. Nymphs and occasionally also adults feeding was observed on some weed species: *Amaranthus retroflexus*, *Clematis vitalba*, *Erigeron canadensis*, *Arctium lappa*, *Chenopodium album* and *Rumex obtusifolius*, which grew at the edges of cultivated land. Riparian vegetation, hedges and forest edges with *Euonymus europaea*, *Ligustrum vulgare*, *Cornus sanguinea*, *Acer negundo*, *Robinia pseudoacacia* and *Corylus avellana* also represented an important alternative food source for *H. halys*, oviposition site, as well as a natural refugee and reservoir for spreading adults to the cultivated area

Fenolni odziv breskev na napad marmorirane smrdljivke (*Halyomorpha halys* [Stål])

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Rastline se na napad škodljivih organizmov odzovejo z obrambnih mehanizmi, med katere sodi tudi aktivacija fenolnega odziva. Ta ima med drugim za škodljive organizme lahko toksične ali odvračalne učinke. V raziskavi smo ugotavljali, kakšen je fenolni odziv kožice in mesa dveh sort breskev – 'Maria Marta' in 'Redhaven' na napad marmorirane smrdljivke (*Halyomorpha halys* [Stål]), ki je v zadnjih nekaj letih postala pomemben škodljivec breskev v Sloveniji. Povečan fenolni odziv smo analizirali v mesu breskev, predvsem v sorti 'Redhaven', kjer se je vsebnost skupnih fenolov (TAP) v coni poškodbe povečala za 6,9-krat v primerjavi z nepoškodovanim tkivom. Med posameznimi fenolnimi spojinami izstopa sinteza cianidin-3-glukozida v poškodovanem mesu, ki ga v nepoškodovanem tkivu nismo identificirali. Pri obeh sortah se je v mesu plodov v coni poškodbe značilno povečala tudi vsebnost klorogenske kisline. Njena vsebnost je bila pri sorti 'Maria Marta' 9,9-krat in pri sorti Redhaven 10,2-krat večja v poškodovanem tkivu v primerjavi z zdravim tkivom.

ABSTRACT

Phenolic response of peach fruit to brown marmorated stink bug's (*Halyomorpha halys* [Stål])) feeding

Plants react to the attack of harmful organisms with defense mechanisms, including the activation of the phenolic reaction. This defence can have toxic or deterrent effects on harmful organisms. In the study, the phenolic response of the skin and flesh of two peach cultivars - 'Maria Marta' and 'Redhaven' - to attack by the marmorated stink bug (*Halyomorpha halys* [Stål]), which has become an important pest of peaches in Slovenia in recent years, was determined. An increased phenolic response was analyzed in the flesh of peaches, especially in the variety 'Redhaven', where the content of total phenolics (TAP) in the damaged zone increased 6.9-fold compared to undamaged tissue. Among the individual phenolic compounds, the synthesis of cyanidin-3-glucoside in the damaged flesh stands out, which we could not identify in the undamaged tissue. In both varieties, the content of chlorogenic acid in the flesh also increased significantly in the damaged zone. The content was 9.9 times higher in the damaged tissue of the 'Maria Marta' cultivar and 10.2 times higher of 'Redhaven' than in the healthy tissue.

Učinkovitost tretiranja breskev s salicilno kislino pred in po obiranju na okužbo z glivo *Monilinia laxa*

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Salicilna kislina (SA) je rastlinski hormon, ki ima pomembno vlogo pri aktivaciji obrambe rastlin, zato se jo v zadnjih letih veliko preizkuša kot alternativno, okolju prijaznejšo spojino za varstvo rastlin pred škodljivimi organizmi. V študiji smo preverjali, kakšen je učinek tretiranj s SA pred (škropljenje) in po obiranju (pomakanje) na okužbo z glivo *Monilinia laxa*. Rezultati so pokazali, da na zmanjšanje stopnje okužbe z glivo *M. laxa* na plodovih breskve vpliva le tretiranje plodov po obiranju. Na breskvah, ki so bile tretirane po obiranju, se je gliva v povprečju širila med 1,8 in 3,9 mm/dan počasneje, kar je pomenilo v povprečju 34 % manjšo stopnjo okužbe po petih dneh. Na plodovih, ki smo jih po obiranju dodatno tretirali s pomakanjem v raztopino SA, smo zaznali značilno manjšo sporulacijo (7,8%) v primerjavi z nepomočenimi plodovi (68,9%).

ABSTRACT

Effectiveness of treatment the peach with salicylic acid before and after harvest on infection with the fungus *Monilinia laxa*

Salicylic acid (SA) is a plant hormone that plays an important role in activating plant defenses and has been widely tested in recent years as an alternative, more environmentally friendly compound to protect plants from harmful organisms. In the study, the effect of pre-harvest (spraying) and post-harvest (dipping) treatment with SA on infection with the fungus *Monilinia laxa,* was investigated. It was found that only post-harvest dipping reduced the intensity of infection with the *M. laxa* fungus. In peaches, treated after harvest, the fungus spread more slowly (between 1.8 and 3.9 mm/day), which meant an average 34% reduction in infection intensity after 5 days. In fruit treated after harvest by additional dipping in SA solution, sporulation was also significantly lower (7.8%) then in untreated peaches (68.9%).

Traktorski sesalnik za žuželke – izdelava in uporaba v izbranih privabilnih posevkih

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Privabilni posevki so poznani kot okoljsko prijazni načini zmanjšanja škodljivosti izbranih vrst organizmov v varstvu rastlin. Vendar je njihovo delovanje omejeno, če škodljivca zatem na takem posevku ne uničimo. S tem namenom smo v letu 2023 na laboratorijskem polju Biotehniške fakultete testirali traktorski sesalnik za žuželke, ki smo ga v dveh predhodnih letih samostojno izdelali. Glavni delovni sklopi take naprave so električni generator – agregat kot vir električne energije, ki je gnan preko priključne gredi traktorja, frekvenčni pretvornik, ki vzdržuje nastavljeno frekvenco električnega toka oz. vrtljaje motorja sesalnega ventilatorja in asinhronski elektromotor za pogon sesalnega ventilatorja ter sesalnika. Sesalnik je sestavljena iz ogrodja z napo ter ventilatorja s cevmi in šobami za izstopni zrak. Uporabili smo radialni ventilator FAN 5500, ki ima pretok zraka 8000 m^3/h. Traktorski sesalnik smo testirali na štiri vrstah privabilnih posevkov: sončnici, soji, lucerni in sirku.

ABSTRACT

Tractor bug vacuum – its construction and application in selected trap crops

Trap crops are known as environmentally friendly ways of reducing the harmfulness of selected pest organisms in plant protection. However, their effectiveness is limited if the pest is not destroyed on such a crop afterwards. With this aim we tested in 2023 on Laboratory field of Biotechnical Faculty a tractor bug vacuum for insects, which we independently assemble in the previous two years. The main working parts of such device are an electric generator - an aggregate as a source of electricity, which is driven via the tractor's PTO shaft, a frequency converter that maintains the set frequency of the electric current or rotations of the suction fan motor and the asynchronous electric motor for driving the suction fan and the bug vacuum. The The bug vacuum consists of a frame with a hood and a fan with pipes and nozzles for outlet air. We used a radial fan FAN 5500, which has an air flow of 8000 m^3/h. We tested the tractor bug vacuum on four types of trap crops: sunflower, soybean, alfalfa and sorghum.

Evaluation of alternative products to reduce the ascospore potential of *Venturia inaequalis*

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A low level of pathogen inoculum is a prerequisite to planning an effective protection strategy against apple scab. To date inoculum reduction approaches proven to be effective are treatments with urea, dolomitic lime and removing leaf litter from orchard. It was settled an experiment to evaluate alternative product applications to reduce the effectiveness of the apple scab inoculum in artificial leaves litters. Remedier, Trichoderma based product, urea, inorganic fertilizer and whey, organic amendant, were compared during a three-year study. A partial reduction of the ascospores production if compared to untreated leaves litters, it was achieved by autumn application of urea, spring application of Remedier and both autumn and spring applications of whey. From two years assessments for each tested product, the spore reduction was about 60% for urea, 50% for Remedier and 40% for whey. Trichoderma based product if investigated further, could represent an interesting option to reduce the apple scab inoculum especially in organic farming where there are no others means if excluded the costly mechanical operations.

Diffusion and host preference of *Orientus ishidae* (Hemiptera: Cicadellidae) in Norther Italy apple orchards

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Flavescence dorée (FD) is a serious grapevine disease associated with phytoplasmas belonging to the ribosomal subgroup 16SrV. The disease is widespread in the major European grape-growing areas where it causes considerable economic losses and is transmitted from grapevine to grapevine by the alien leafhopper *Scaphoideus titanus* Ball. Others potential vectors have been identified over the last few decades (e.g. *Dictyophara europaea*, *Allygus* spp.); one of these species included a non-European leafhopper, *Orientus ishidae* (Matsumura), found positive to FD in different European country, both in vineyards and wild host. Moreover, laboratory experiments have shown that it is capable of transmitting FD from bean to vine or from wild plant to wild plant (e.g. alder to alder). For this reason, the species has been monitored in Trentino (North-East Italy) vineyards since 2015, but so far the populations found have always been scarce. Unexpectedly, since 2019 abundant population of the mosaic leafhopper have been reported within apple orchards in Trentino. In 2022, the monitoring activities of the adult flight activity using yellow sticky traps was extended to other North Italian orchards confirming the widespread presence of *O.ishidae*. Furthermore, to explain the discrepancy between the monitoring data in vineyards and the high catches in apple orchards, we set up a laboratory experiment to investigate whether there was an insect preference between different host plants in 2022 and 2023. The parameters taken into account were mortality and the 'nymph-adult' development time in two cultivated host (apple and grapevine) and two wild plants (hazelnut and hornbeam). On apple trees, mortality was not statistically different from wild hosts, whereas on vines a very high value was found (97% of individuals dead by the end of the experiment). Finally, apple tree and hornbeam turned out to be the host on which the shortest development time to the adult stage was recorded compared to the other substrates. These data show that *O.ishidae* is better adapted and more widespread on apple trees/wild species than on grapevines in Italy, although there is still no certain information on its danger in apple orchards (e.g. its role as a vector of phytoplasma).

Test preizkušanja metode (TPS): PCR v realnem času za določanje glive *Phyllosticta citricarpa*

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Phyllosticta citricarpa je karantenska askomicetna gliva, ki povzroča bolezen črne pegavosti na agrumih, kar povzroča veliko gospodarsko škodo. Bolezen je razširjena predvsem v vlažnih subtropskih območjih Afrike, Avstralije, jugo-zahodne Azije, južne Amerike. V letu 2019 so prisotnost glive potrdili tudi v bolj sušnem območju severne Afrike, v Tuniziji, kar predstavlja veliko tveganje za nasade agrumov v Evropski uniji. Na ravni EU so predpisane posebne zahteve za trženje in uvoz plodov in sadik, zato morajo biti diagnostične metode visoko občutljive in specifične. Z namenom zanesljivega določanja glive *P. citricarpa*, smo razvili PCR v realnem času, ki temelji na genu TEF-1. V okvirju EUPHRESCO projekta CBS Detect, smo organizirali test preizkušanja ustreznosti metode (TPS), kjer smo novo razvito metodo (Pc-TEF1) in metodo PC, ki temelji na regiji ITS ovrednotili. V sklopu TPS smo pripravili in testirali homogenost in stabilnost tarčne in ne-tarčne DNA gliv. V TPS je sodelovalo 13 laboratorijev iz članic EU, Tunizije in Brazilije. Obe metodi PCR v realnem času sta se izkazali za visoko občutljivi (99%) in specifični (98%). Rezultati TPS so pokazali visoko ponovljivost tako med laboratoriji (reproducibility > 98%), kot tudi znotraj laboratorijev (repeatability > 95%). Obe metodi sta se izkazali za primerni za določanje *P. citricarpa* v simptomatičnih in ne-simptomatičnih vzorcih, zato smo jih uporabili tudi v okviru projekta CBS Epidemiology (EFSA). V sklopu projekta se zbirajo vzorci zraka in vzorci deževnice pod krošnjami dreves, v nasadih simptomatičnih limonovcev v Tuniziji. Z dosedanjo analizo vzorcev zraka, smo pokazali časovno variabilnost v relativni količini spor *P. citricarpa*. Epidemiološka študija nam bo omogočila boljše razumevanje širjenja glive po sredozemskem prostoru in s tem pravočasno ukrepanje v primeru izbruha bolezni v Evropskih nasadih.

ABSTRACT

Test performance study (TPS): real time PCR for detection of fungus *Phyllosticta citricarpa*

Phyllosticta citricarpa is a quarantine fungus that causes Citrus black spot (CBS) disease, which can generate significant economic losses. It is most common in subtropics humid geographic areas in Africa, Southeast Asia, Australia and South America. In 2019, the presence of *P. citricarpa* was confirmed in semi-drier parts of Africa (Tunisia). This presents higher risk for citrus production in Europe, as Tunisia is in mediterranean basin. Special rules apply in EU, for the import and marketing of fruits and seedlings plants. Therefore, we need diagnostic methods with high sensitivity and specificity. In order to ensure reliable detection of *P. citricarpa*, we developed new real time PCR (qPCR) method, based on TEF 1 gene. In EUPHRESCO CBS Detect project, we organized test performance study (TPS), where new qPCR method (Pc-TEF1), and PC method that is based on detection of ITS region were evaluated. For TPS we prepared target and non-target DNA, and tested stability and homogeneity of samples. Altogether 13 laboratories from EU, Tunisia and Brazil participated in TPS. Both qPCR methods had high reproducibility (>98%) and repeatability (>95%). Both methods proved to be suitable for detection of *P. citricarpa* in symptomatic and non-symptomatic samples. Furthermore, we used this methods in CBS Epidemiology (EFSA) project. As part of a project, samples are collected in symptomatic orchards in Tunisia. Spores are collected from air and from rainwater under citrus canopies. Analysis of air samples showed that the relative amount of *P. citricarpa* spores in air varied in time. In the future, this epidemiologic study will help

us to better understand epidemics of *P. citricarpa* and help us to reduce the risk in case of its introduction to Europe.

Ustreznost referenčne knjižnice masnih spektrov naprave Bruker MALDI Biotyper® za identifikacijo najpomembnejših za rastline patogenih bakterij

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Namizni masni spektrometer MALDI Biotyper® sirius RUO, proizvajalca Bruker, omogoča masno spektrometrijo z ionizacijo z lasersko desorpcijo in masnim analizatorjem na čas preleta ionov. Spektre, ki jih posname po laserskem obstreljevanju ustrezno tretiranih čistih kultur bakterijskih izolatov, primerja z referenčnimi spektri v svoji knjižnici in glede na podobnost identificira bakterijske izolate. Identifikacija je mogoča le za bakterije, ki so v knjižnici zastopane, zanesljivost in taksonomski nivo identifikacije posameznih bakterij pa je odvisen od njihove raznolikosti in kakovosti referenčnih spektrov. V okviru uvedbe metode na Nacionalnem inštitut za biologijo smo v prvem koraku izvedli pregled zastopanosti karantenskih in drugih za Slovenijo pomembnih bakterijskih povzročiteljev bolezni rastlin v referenčni knjižnici našega instrumenta, MBT Compass Library Revision K (2022). Analiza rezultatov je pokazala, da referenčna knjižnica pokriva 12 od 14 preverjanih rodov in 15 od 32 vrst za rastline patogenih bakterij. Knjižnica se je izkazala za ustrezno za identifikacijo do nivoja vrst za organizme rodu *Curtobacterium*, *Erwinia*, *Pantoea*, *Pseudomonas*, *Rhodococcus* in *Xylella*, ter kot pogojno ustrezna za posamezne vrste rodov *Clavibacter*, *Ralstonia* in *Xanthomonas*. Na nivoju rodu lahko z obstoječo knjižnico identificiramo bakterije rodov *Agrobacterium*, *Dickeya* in *Pectobacterium*. Za identifikacijo bakterij rodu *Liberibacter* in *Xylophilus* vključena knjižnica ni primerna, saj zanje ne vsebuje spektrov. V teku je eksperimentalno preverjanje zanesljivosti identifikacije za izbrane bakterijske vrste ter dopolnjevanje knjižnice s kreiranjem lastnih knjižničnih vnosov. Tako smo po praktičnem preizkušanju do sedaj obstoječo knjižnico že dopolnili z vnosi za bakterije *Pantoea stewarti* subsp. *indologenes*, *Ralstonia solanacearum*, *Ralstonia pseudosolanacearum* in *Xylophilus ampelinus*.

ABSTRACT

Evaluating the Bruker MALDI Biotyper® for Plant Pathogenic Bacteria Identification: A Study on Its Reference Library's Suitability

The MALDI Biotyper® sirius RUO, a bench-top mass spectrometer from Bruker, utilizes laser desorption ionization mass spectrometry coupled with a time-of-flight ion mass analyzer. This instrument identifies bacterial isolates by comparing their mass spectra, obtained post-laser bombardment of treated pure cultures, with reference spectra in its database. The effectiveness of identification is contingent on the diversity of bacteria in the library and the accuracy of the reference spectra. In an initial phase, the National Institute of Biology assessed the comprehensiveness of the MBT Compass Library Revision K (2022) in representing quarantine and significant plant pathogenic bacterial pathogens relevant to Slovenia. Our analysis revealed that the library covers 12 of 14 genera and 15 of 32 species of the plant pathogenic bacteria examined. For species-level

identification, the library adequately supports genera such as *Curtobacterium*, *Erwinia*, *Pantoea*, *Pseudomonas*, *Rhodococcus* and *Xylella*. For *Clavibacter*, *Ralstonia* and *Xanthomonas* species-level identification is conditionally feasible, depending on specific species. At the genus level *Agrobacterium, Dickeya* and *Pectobacterium* are identifiable with the current library. However, spectra for *Liberibacter* and *Xylophilus* are absent, rendering the library unsuitable for their identification. Ongoing experimental validation is assessing the reliability of identifications for selected bacterial species. Concurrently, efforts are being made to augment the library with our own entries. We have already expanded the database to include *Pantoea stewartii* subsp. *indologenes*, *Ralstonia solanacearum*, *Ralstonia pseudosolanacearum*, and *Xylophilus ampelinus*. This ongoing work underlines the library's potential and limitations in identifying plant pathogenic bacteria, providing valuable insights for its practical application and enhancement.

Dolgotrajna stabilnost predpripravljenih reagentov omogoča poenostavitev izvedbe izotermne reakcije LAMP za zaznavanje bolezni rastlin na terenu

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Izotermna amplifikacija (LAMP) za testiranje rastlinskih bolezni na kraju samem je zaradi svoje praktičnosti vse bolj priznana. Čeprav je testiranje LAMP uporabniku prijazno in primerno za grobe materiale, priprava reagentov in kontrol brez kontaminacije ostaja izziv, zlasti v terenskih razmerah. Ta postopek tradicionalno zahteva dodatne korake in opremo. V projektu Q-Entry (V4-2023) smo želeli poenostaviti testiranje na terenu in zmanjšati tveganje kontaminacije z izvedbo celovite študije stabilnosti vnaprej pripravljenih oligonukleotidov in pozitivnih kontrolnih materialov za test LAMP, za zaznavanje bakterij *Ralstonia spp*. Ta študija temelji na našem predhodno razvitem standardiziranem protokolu (Lenarčič *in sod*., 2014; Pirc *in sod.*, 2021). Vnaprej smo pripravili mešanico šestih oligonukleotidnih začetnikov in kontrolno DNK znanega izolata *R. solanacearum* ter jih razporedili v testne trakove. V obdobju dveh let smo te materiale testirali vsake tri mesece, pri čemer smo predhodno pripravljenim mešanicam dodali 2x Isothermal Master Mix (OptiGene) in reakcije izvajali pri konstantni temperaturi 60°C z instrumentom GenieII (OptiGene). Rezultate smo ovrednotili s primerjavo kvalitativnih rezultatov in časa do pozitivne reakcije v različnih časovnih intervalih z začetnimi ugotovitvami. Naši rezultati potrjujejo stabilnost predhodno pripravljenih reagentov in kontrolnega materiala za najmanj dve leti, če so shranjeni pri temperaturi ≤ -15 °C. Ta stabilnost omogoča njihovo predhodno pripravo, s čimer se učinkovito ločijo naloge, za katere sta koristna nadzorovano okolje in specializirana oprema (za delo z majhnimi volumni), od dejanskega izvajanja testov na terenu. Zato ta pristop poenostavi postopke, saj zmanjša število potrebnih korakov na kraju samem, s tem pa poveča praktičnost diagnostike rastlinskih bolezni na terenu.

ABSTRACT

Enhancing Field Efficiency of isothermal LAMP: Stability of Pre-mixed Test Reagents for Advanced Preparation and Streamlined Pest Identification

The adoption of isothermal Loop-Mediated Isothermal Amplification (LAMP) for on-site testing of plant diseases is increasingly recognized for its practicality. Although LAMP testing is user-friendly and accommodates crude sample materials, preparing reagents and controls without contamination remains a challenge, especially in field conditions. This process traditionally requires additional steps and equipment, posing operational complexities. In the Q-Entry project (V4-2023), we aimed to simplify field testing and reduce contamination risks by conducting a comprehensive stability study of premixed oligonucleotides and positive control materials for the LAMP test targeting *Ralstonia* spp. This study builds upon our standardized protocol previously developed (Lenarčič *et al*., 2014; Pirc *et al*., 2021). We prepared a blend of six LAMP oligonucleotide primers and control DNA from a known *R. solanacearum* isolate in advance, arranging them into testing strips. Over a two-year period, we tested these materials every three months, adding 2x Isothermal Master Mix (OptiGene) to the premixed primers, and conducting reactions at a constant temperature of 60°C using a GenieII instrument (OptiGene). We evaluated the results by comparing the qualitative outcomes and the time to positivity at various intervals with the initial findings. Our results affirm the stability of both premixed reagents and control material for a minimum of two years when stored at temperatures ≤ -15 °C. This stability enables their advance preparation, effectively segregating tasks that benefit from a controlled environment and specialized equipment (for handling small volumes) from the actual test execution in the field. Consequently, this approach simplifies field operations by reducing the number of steps required on-site, thereby enhancing the efficiency and reliability of plant disease diagnostics.

Poskus poenostavitve metode določanja DNK črtnih kod

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Metoda določanja DNK črtnih kod je že dobro uveljavljenja metoda za določanje različnih organizmov in se uspešno uporablja tudi na področju varstva rastlin. Metoda temelji na pomnoževanju, sekvenciranju in analizi določenih odsekov genoma nižjih taksonomskih kategorij. Primerjava dobljene sekvence s podatki v bazi sekvenc nam omogoča identifikacijo izbranega organizma do vrste. Poleg kvalitetne DNK in primernih začetnih oligonukleotidov je za uspešno identifikacijo organizma pomembna tudi kakovostna in primerno obvladovana baza sekvenčnih podatkov, s katero naše sekvence primerjamo. Evropska organizacija za varstvo rastlin (EPPO) je za potrebe identifikacije številnih reguliranih škodljivih organizmov izdala standard (PM7/129 (2)), v katerem opisuje uporabo metode določanja DNK črtnih kod za te namene. Na Kmetijskem inštitutu Slovenije smo v letih 2022 in 2023 v okviru projekta Q-entry preučevali možnosti časovne in finančne optimizacije protokola in standarda za identifikacijo nekaterih domorodnih žuželk. Raziskovali smo možnosti zamenjave klasične izolacije DNK s komercialnim kompletom, z enostavnejšo pripravo DNK in direktnim PCR brez predhodne izolacije DNK. Poleg tega smo ugotavljali vpliv ohranjenosti organizma ter morebitni vpliv medija, v katerem se organizem nahaja (etanol, lepilo) na uspešnost pomnoževanja in identifikacije.

ABSTRACT

An attempt for simplification of DNA barcoding method

DNA barcoding is a well-established method for identification of different organisms and is also successfully used in plant protection. The method is based on amplification, sequencing and sequence analysis of specific parts of the genome of lower taxonomic categories. Comparing the sequence obtained with the sequences in the sequence database allows us to identify the selected organism down to the species level. In addition to high-quality DNA and appropriate oligonucleotides, a high-quality and properly managed sequence database with which we compare our sequences is essencial for successful organism identification. For the purpose of identification of numerous regulated harmful organisms, the European Plant Protection organization (EPPO) has issued standard (PM7/129 (2)), which describes the use of the DNA barcoding for these purposes. In the frame of the Q-entry project, we examined the possibilities of optimizing the time and cost of the protocol and standard for the detection of some native pests. We studied the possibilities of replacing commercial kit, with simpler DNA preparation and direct PCR without prior DNA extraction. Additionally, we examined the effects of preservation of the organism and the possible effect of the medium in which the organism is located (ethanol, glue) on the success of amplification and identification.

Usmeritve dela v okviru CRP projekta »Ukrepi za preprečevanje nadaljnjega širjenja zlate trsne rumenice«

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V vinogradih povzroča velik upad pridelka in krčenje vinogradov fitoplazma Grapevine flavescence dorée (FD) iz skupine 16SrV, povzročiteljica zlate trsne rumenice. Trta (*Vitis*) je lahko okužena z različnimi izolati fitoplazem iz skupine 16SrV, od katerih so za

nekatere dokazali, da lahko povzročijo epifitocije, saj jih med trtami zelo učinkovito raznaša ameriški škržatek (*Scaphoideus titanus*). Iz drugih gostiteljskih rastlin lahko na trto izolate fitoplazem iz skupine 16SrV zanesejo nekatere druge žuželke, ki sesajo rastlinski sok. Med najbolj skrb vzbujajočimi je vzhodnjaški škržatek (*Orientus ishidae*), ki je polifag in se je od prve najdbe leta 2004 razširil po celotni Sloveniji. Velike populacije vzhodnjaškega škržatka smo odkrili v nasadih lesk (*Corylus avellana*) in v njih potrdili prisotnost fitoplazem 16SrV skupine. Prisotnost fitoplazem iz skupine 16SrV smo potrdili tudi v gojenih leskah, ki zaradi okužbe propadajo. Ker je za učinkovito preprečevanje širjenja bolezni zlate trsne rumenice nujno dobro poznavanje njene epidemiologije, se v okviru CRP projekta osredotočamo na raziskovanje alternativnih gostiteljev in prenašalcev fitoplazme FD. V ta namen proučujemo pomen samoniklih in gojenih lesk kot rezervoar za prenos fitoplazme FD na trto ter preverjamo zastopanost in okuženost drugih možnih prenašalcev fitoplazme FD v Sloveniji. V okviru projekta spremljamo bionomijo vzhodnjaškega škržatka, njegov potencial za širjenje fitoplazem med leskami in iz lesk na trto ter možnost njegovega zatiranja z insekticidi. Poleg tega v okviru projekta preverjamo možnost zaznave prisotnosti fitoplazme FD pred pojavom značilnih vizualnih bolezenskih znamenj v vinogradu z namenom vzpostavitve ukrepov, preden se bolezen v vinogradu razširi. Za dosego tega cilja preverjamo možnost zaznave prisotnosti fitoplazme FD z molekularnimi testi v preimaginalnih stadijih najpomembnejšega prenašalca te fitoplazme med trtami – ameriškem škržatku. Za namen zgodnjega prepoznavanja sprememb v rastlinah, ki so posledica okužbe s fitoplazmo FD, pa raziskujemo možnost daljinskega zaznavanja z metodo hiperspektralnega slikanja z letalom.

ABSTRACT

Directions of the CRP project »Measures to prevent further spread of Grapevine flavescence doree phytoplasma«

The phytoplasma Grapevine flavescence dorée (FD) of group 16SrV causes many problems in vineyards. Grapevine (*Vitis*) can be infected with various isolates of 16SrV phytoplasma, some of which have been shown to be epidemic, as they can be spread very efficiently among grapevines by *Scaphoideus titanus*. 16SrV phytoplasma isolates can be transmitted from other hosts to grapevines by some other plant sap-sucking insects. One of the most worrying insects is *Orientus ishidae*, a polyphage that has spread throughout Slovenia since its discovery in 2004. We have discovered large populations of *O. ishidae* in hazelnut (*Corylus avellana*) orchards and confirmed the presence of 16SrV phytoplasmas in them. Infection with this phytoplasma was also confirmed in decaying cultivated hazelnut bushes. Since a good knowledge of the epidemiology of FD disease is essential to effectively prevent the spread of the pathogen, the project focuses on the investigation of alternative hosts and vectors of FD phytoplasma. Therefore, we investigate the importance of wild and cultivated hazelnuts as a reservoir for the transmission of FD to grapevines and expand the knowledge about other possible vectors of FD phytoplasma in Slovenia - and their infection status in relation to this phytoplasma. Within the project, we are investigating the bionomy of *O. ishidae*, its potential for spreading phytoplasma among hazelnuts and from hazelnuts to grapevines, and the possibilities of its control with insecticides. In addition, we are investigating the possibility of detecting the presence of FD phytoplasma before the characteristic visual signs appear in the vineyard in order to take action before the disease spreads in the vineyard. To achieve this goal, we are investigating the possibility of detecting the presence of FD phytoplasma by molecular tests in the nymphal stages of the main vector of this phytoplasma in grapevines – *S. titanus*. For early detection of changes in plants due to infection with FD phytoplasma, we are investigating the possibility of remote sensing by the method of hyperspectral imaging with airplanes.

Bionomija ameriškega škržatka (*Scaphoideus titanus* Ball) v jugovzhodni Sloveniji

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Ameriški škržatek (*Scaphoideus titanus* Ball) je glavni prenašalec zlate trsne rumenice (Grapevine Flavescence dorée (FD)) na vinski trti. Spada v družino malih škržatkov (Cicadellidae), izvorno razširjen iz Severne Amerike. Prvič je bil v Sloveniji najden leta 1983 na Primorskem, na območju JV Slovenije pa leta 2005. Za preprečevanje širjenja zlate trsne rumenice je ključnega pomena, da se prenašalca pravočasno zatira s fitofarmacevtskimi sredstvi. V prispevku se osredotočamo na potek ugotavljanja navzočnosti ameriškega škržatka in spremljanje razvoja v vinorodni deželi Posavje. Podatki so bistvenega pomena za določanje optimalnega termina zatiranja ličink in odraslih škržatov. S pomočjo različnih metod smo spremljali začetek izleganja iz jajčec, prehode med posameznimi stopnjami ličink in začetek ter vrh pojava odraslih žuželk. Spremljanje je potekalo na dveh lokacijah: na Vinjem Vrhu ter Bizeljskem. Vremenske podatke za določanje temperaturnih pragov smo beležili z vremenskimi postajami Adcon, ki so postavljene v neposredni bližini opazovalnih lokacij.

ABSTRACT

Bionomics of the American Grapevine Leafhopper (*Scaphoideus titanus* Ball) in south-eastern Slovenia

The American grapevine leafhopper (*Scaphoideus titanus Ball*) is the main vector of the grapevine Flavescence dorée (FD) in vines. It belongs to the leafhopper family (Cicadellidae) originating in North America. In Slovenia, the first populations were detected in 1983 at the Primorska region. In 2005, it was discovered in the southeast region of Slovenia. To prevent the spreading of the grapevine Flavescence dorée, it is crucial to suppress the vector in a timely manner with the use of plant protection products. In this paper, we focus on the process of identifying the presence of the American grapevine leafhopper and monitoring its development stages in the winegrowing region of Posavje. This data is key to determine the optimal timing for usage of plant protection products for larva and adults. By using different methods, we monitored the beginning of the hatching from the eggs, each larval stages as well as the beginning and the peak of emergence of an adult. This process took place in two locations, Vinji Vrh and the Bizeljsko. We recorded the weather data to determine the temperature thresholds with the use of the Adcon weather stations that had been positioned in the near vicinity of the observation locations.

Preliminary results of root knot nematodes monitoring in Croatia over two years (2022 - 2023)

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Root-knot nematodes (RKN, *Meloidogyne spp.)* belong to the economically most important group of plant-parasitic nematodes which consists of approximately 100 species, many of which can be considered dangerous invasive pests in agriculture. In order to prevent the introduction or limit the spread on European territory, certain nematode species have been placed on the quarantine list (EU and EPPO). The EU list of quarantine RKN includes *M. enterolobii* (A1), *M. chitwoodi* and *M. fallax* (A2) and the EPPO list includes *M. ethiopica* (A1) and *M. enterolobii*, *M. luci*, *M. graminicola, M. chitwoodi*, *M. fallax* and *M. mali* (A2). Identification of *Meloidogyne* species based on morphological characteristics is a very difficult task, which is why molecular techniques such as polymerase chain reaction (PCR) are a widely used tool for their identification. In 2022 and 2023, the survey to identify *M. chitwoodi* and *M. fallax* was carried out in potatoes while identification on other vegetables was also carried out as part of an early warning programme for RKN. Visual inspections and sampling were carried out in the indoor and outdoor growing areas on the mainland and in the coastal regions of Croatia and the collected samples were analysed in The Nematology laboratory at Centre for Plant Protection - CAAF. During this period, 87 soil samples of potatoes were analysed, 5 of which were positive for the presence of RKN. As part of an early warning programme, a total of 42 samples were analysed, 31 of which were positive for the presence of RKN. Molecular identification revealed that the most prevalent species were *M. incognita* and *M. hapla.* The species *M. chitwoodi* and *M. fallax* were not identified in any of the samples. Identification the pests present in the growing area is crucial for the next steps in pest control.

Uspešno izkoreninjenje ogorčice koreninskih šišk *Meloidogyne luci*

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Leta 2015 je bila v Sloveniji med rednim nadzorom v okviru programa preiskav v rastlinjaku v vasi Šmartno pri Ljubljani najdena ogorčica koreninskih šišk (RKN) *Meloidogyne luci*. Okužene rastline paradižnika so kazale simptome propadanja, klorozo listov in velike šiške na koreninah. Okuženost z ogorčicami je bila visoka, saj je bilo več kot 80 % rastlin močno okuženih. Razširjene so bile v dveh rastlinjakih na približno 1.000 m^2. Pregledali smo korenine paradižnika in izolirali samice RKN za identifikacijo vrste z

uporabo izocimskih vzorcev. Istovetnost ogorčic *M. luci* je bila potrjena z analizo zaporedja mtDNA. Ta vrsta škodljivca je bila v Sloveniji ugotovljena že leta 2003 v Dornberku (Primorska). Najdba vrste *M. luci* pri Ljubljani leta 2015 pa je predstavljala novo najdbo na drugem območju, približno 100 km oddaljenem od lokacije iz leta 2003. Ker ima vrsta *M. luci* zelo široko gostiteljsko območje enokaličnic in dvokaličnic, vključno s pomembnimi kmetijskimi rastlinami, kot so paradižnik, paprika in krompir, predstavlja resno grožnjo za kmetijsko pridelavo, če se razširi na druga pridelovalna območja. Zato so bili za okuženo območje odrejeni strogi fitosanitarni ukrepi, vključno z uporabo pripravka Dazomet v letu 2015. Ves okužen rastlinski material iz prizadetega rastlinjaka je bil uničen. Strogi fitosanitarni ukrepi so veljali več let, okuženo območje pa je bilo vsako leto nadzorovano. Na okuženi površini so bili izvedeni ukrepi postopne eradikacije z uporabo tehnoloških pristopov v kombinaciji s fitofarmacevtskim sredstvom na osnovi aktivne snovi fluopiram – Velum prime (Bayer). Pridelovalec je lahko gojil: (i) rastline, ki so slabši gostitelji oz. niso gostitelji vrste *M. luci:* paprika (*Capsicum annum)* in feferoni (*Capsicum annuum*), (ii) odporne kultivarje paradižnika (*Solanum lycopersicum*) na ogorčice *M. luci*, in (iii) srednje dobre gostiteljske rastline: jajčevec (*Solanum melongena*). Strogi ukrepi za varstvo rastlin in tesno sodelovanje z lastnikom okuženih rastlinjakov so omogočili uspešno izkoreninjenje; tako v letih 2022 in 2023 nismo več zaznali prisotnosti *M. luci* na tej lokaciji.

ABSTRACT

Successful eradication the root knot nematode *Meloidogyne luci*

In 2015, root knot nematode (RKN) *Meloidogyne luci* was found in Slovenia in a greenhouse in the village of Šmartno near Ljubljana during a RKN field survey. The infested tomato plants showed symptoms of decline, leaf chlorosis and large galls on the roots. The nematode infestation was high as more than 80 % of plants were heavily infested. They were spread over approximately 1,000 m^2 in two greenhouses. Tomato roots were examined and RKN females were isolated for species identification using isozyme patterns. Identity of *M. luci* was confirmed with sequence analysis of mtDNA. This pest species was already found in Slovenia in 2003 in Dornberk (Primorska region). However, finding of *M. luci* near Ljubljana in 2015 represented a new finding at different region approximately 100 km apart from the 2003 location. As *M. luci* has a very broad host range of monocotyledonous and dicotyledonous plants, including important agricultural crops such as tomatoes, peppers and potatoes, it poses a serious threat to agricultural production if it spreads to other growing areas. Strict phytosanitary measures were therefore ordered for the infested area, including the application of Dazomet in 2015. All infested plant material from the affected greenhouse was destroyed. The strict phytosanitary measures were in place for several years and the infested area was monitored every year. The following eradication measures were implemented: use of the plant protection product Velum prime (Bayer) with the active ingredient fluopyram, cultivation of: (i) plants that are poor hosts or non-host plants for *M. luci* (i.e. peppers *Capsicum annum*, chillies *Capsicum annuum*), (ii) tomato varieties that are resistant to *M. luci* (*Solanum lycopersicum*) and (iii) medium-good hosts: (i.e. aubergines (*Solanum melongena*). Strict plant protection measures and close cooperation with the owner of the infested greenhouses led to a successful eradication of *M. luci* at this site. In 2022 and 2023, we were no longer able to detect the presence of *M. luci.*

Molecular identification of the root knot nematodes *Meloidogyne* spp. in the autonomous province of Vojvodina in Serbia

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The root knot nematodes (RKN) of the genus *Meloidogyne* are among the most destructive plant-parasitic polyphagous organisms. They are distributed worldwide and infest the root system, causing abnormal swellings, called galls, which lead to a reduction in crop yield and quality of plant products. Molecular identification of RKN was carried out in the frame of the official *Meloidogyne* survey as part of the activities of the Annual Plant Health Programme, which is financially supported by the Directorate for Plant Health of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia. The molecular equipment was financially supported by Provincial Secretariat for Agriculture, Water Management and Forestry in the frame of project "Development and implementation of molecular methods of identification in Plant Nematology". Soil and plant material samples were collected in 2023 in 7 districts of the province Vojvodina in Serbia in greenhouses and open fields. A total of 45 samples came from vegetables and ornamental plants and 26.7% (12 samples) were infested with *Meloidogyne* spp. Twelve samples (populations) were identified using a combination of morphological approach based on perineal patterns and molecular approach with PCR and species-specific primers. Three *Meloidogyne* species were determined on 12 locations in 5 districts: *Meloidogyne incognita* (9 samples), *M. hapla* (2 samples) and *M. arenaria* (1 sample). The results showed that *M. incognita* is the predominant RKN species in the province of Vojvodina in Serbia. The correct identification of RKN species is the first step towards efficient pest control that ensures healthy plants and good yields. Therefore, a national survey of RKN in Serbia is also planned for the future.

Predstavitev raziskovalnega projekta: pomen hlapnih izločkov izbranih vrtnin pri posredni obrambi rastlin pred polži (J4-50135)

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Polži predstavljajo gospodarsko pomembne škodljivce v kmetijstvu. Številne rastlinske vrste ob napadu škodljivega organizma začno sproščati hlapljive snovi, ki privabljajo naravne sovražnike herbivorov. Hlapljive snovi imajo pomembno vlogo v multitrofičnem

sistemu, ki ga sestavljajo rastlina, herbivor in njegov naravni sovražnik. Delujejo kot neke vrste kemični signali, ki neposredno vplivajo tako na herbivora kot tudi na njegovega naravnega sovražnika. Zaradi rastlinskih poškodb se v nadzemnih in podzemnih organih vzpodbudijo kvantitativne in kvalitativne spremembe v določenih metabolitih. Med številnimi obrambnimi odzivi sta pomembni sinteza antioksidantov in aktivacija antioksidativnih encimov. V projektu želimo ugotoviti ali nadzemski deli rastlin solate (*Lactuca sativa*) in zelja (*Brassica oleracea* var. *capitata*), ki jih poškodujejo različne vrste polžev; španski lazar (*Arion vulgaris*) in mrežasti slinar (*Deroceras reticulatum*) inducirajo izločanje hlapljivih snovi v koreninskem sistemu, in kakšno vlogo imajo te snovi na usmerjenost gibanja parazitskih ogorčic polžev (*Phasmarhabditis papillosa*, *Oscheius myriophila*). Predpostavljamo, da mukus polžev in poškodbe nadzemnih delov zaradi obžrtja inducirajo askorbatno-glutationski cikel in z žveplom prodobljeno odpornost (SIR). Ugotoviti želimo ali imajo povišane vsebnosti glutationa v rastlinah vpliv na kemotaksično gibanje ogorčic in odvračilen učinek na polže. V ta namen bomo v rastlinah vzpodbudili SIR s predhodnim tretiranjem rastlin s sulfatom. Cilji projekta: (1) z našo raziskavo želimo obogatiti obstoječe znanje iz področja multitrofičnega komuniciranja med organizmi; (2) glavni namen raziskave je predvsem ugotoviti kdo je glavni komunikator s parazitskimi ogorčicami polžev (POP) – rastlina ali polž; (3) v primeru potrditve teze, da rastlina ali polž proizvajata semiokemikalije, ki delujejo privabilno na POP bo mogoče v prihodnje razviti feromonske kapsule na podlagi glavne aktivne snovi, ki bi privabile POP h koreninam rastlin v večjem številu in s tem bi poskrbeli za njihovo večjo zaščito; (4) optimizacija načinov biotičnega varstva rastlin pred škodljivimi organizmi in njihova implementacija v pridelavo živeža; (5) razvoj optimiziranih postopkov za vzorčenje in analizo semiokemikalij na izbranih organizmih. Poznavanje komunikacije med rastlinami, herbivori in njihovimi naravnimi sovražniki je ključnega pomena pri učinkovitejši implementaciji in optimizaciji biotičnega varstva v sisteme pridelave živeža.

ABSTRACT

The significance of volatile compounds of selected vegetables in the indirect defence of plants against slugs (J4-50135)

Slugs represent economically significant pests in agriculture. Many plant species, upon being attacked by harmful organisms, begin emitting volatile substances that attract natural enemies of herbivores. These volatile substances play a crucial role in a multitrophic system consisting of plants, herbivores, and their natural enemies. They act as a form of chemical signals that directly impact both the herbivore and its natural enemy. Plant injuries trigger quantitative and qualitative changes in specific metabolites in both aboveground and underground plant organs. Among various defense responses, the synthesis of antioxidants and activation of antioxidative enzymes are crucial. In this project, we aim to determine whether aboveground parts of lettuce (*Lactuca sativa*) and cabbage (*Brassica oleracea* var. *capitata*), damaged by different species of slugs—Spanish slug *(Arion vulgaris*) and field slug (*Deroceras reticulatum*)—induce the secretion of volatile substances in the root system and what role these substances play in directing the movement of parasitic nematodes of slugs (*Phasmarhabditis papillosa*, *Oscheius myriophila*). We hypothesize that slug mucus and damage to aboveground parts induced by feeding stimulate the ascorbate-glutathione cycle and sulfur-induced resistance (SIR). We aim to determine whether elevated levels of glutathione in plants affect the chemotactic movement of nematodes and act as a repellent to slugs. To achieve this, we will induce SIR in plants by pre-treating them with sulfate. Project objectives: (1) to enrich existing knowledge on multitrophic communication among organisms through our research; (2) to primarily determine the main communicator with parasitic nematodes of

slugs – whether it is the plant or the slug; (3) ff the hypothesis that the plant or the slug produces semiochemicals that attract slug parasitic nematodes is confirmed, it may lead to future development of pheromone capsules based on the main active substance, attracting slug parasitic nematodes to plant roots in larger numbers for enhanced protection; (4) optimization of methods for biological control against harmful organisms and their implementation in food production; (5) development of optimized procedures for sampling and analyzing semiochemicals in selected organisms. Understanding communication between plants, herbivores, and their natural enemies is crucial for more effective implementation and optimization of biotic protection in food production systems.

Vpliv cikla askorbinske kisline, glutationa in hlapnih spojin iz korenin solate na usmerjenost gibanja parazitskih ogorčic žuželk in polžev

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V poskusu v rastlinjaku smo preučevali vpliv s strunami poškodovanih korenin solate na antioksidativni obrambni sistem rastline ter gibanje parazitskih ogorčic, ki napadajo žuželke/polže. Dokazali smo obstoj hlapnih organskih spojin, ki so jih izločile korenine solate. Rezultati raziskave so pokazali, da strune s hranjenjem korenin solate negativno vplivajo na vsebnost fotosinteznih pigmentov ter povzročijo reaktivne kisikove vrste že pred pojavom vidnih simptomov. Ascorbat-glutation sistem je bil prepoznan kot rdeči center v obrambnem odzivu proti strunam. Ugotovili smo, da so entomopatogene ogorčice bolj gibljive od parazitskih ogorčic polžev. Snov 2,4-nonadienal je delovala kot repelent za vse preučevane vrste ogorčic. Raziskava poudarja pomembnost razumevanja tritrofičnih interakcij v tleh za obvladovanje škodljivcev v kmetijskih sistemih.

ABSTRACT

Utilizing the ascorbate-glutathione system and emitted volatiles from insect-damaged lettuce roots as cues for guiding parasitic nematodes targeting insects and slugs

In a glasshouse experiment, the effects of wireworm-damaged lettuce roots on the antioxidative defense system and movement of insect/slug parasitic nematodes were studied. Lettuce seedlings were grown with or without wireworms, and antioxidants and photosynthetic pigments were analyzed. Volatile organic compounds emitted from lettuce roots were investigated, and certain compounds were selected for a chemotaxis assay with nematodes. Results showed that wireworm-damaged roots negatively affected photosynthetic pigment contents and induced reactive oxygen species even before visible symptoms appeared. The ascorbate-glutathione system was identified as a redox hub in defense response against wireworms. Entomopathogenic nematodes were found to be more mobile than slug parasitic nematodes towards chemotaxis compounds, and 2,4-nonadienal repelled all tested nematodes. The study highlights the importance of

understanding belowground tritrophic interactions for pest management in agricultural systems.

Preizkušanje naravnih sredstev za obvladovanje črne žilavke kapusnic (*Xanthomonas campestris*) na zelju

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Obvladovanje bakterijskih bolezni rastlin je težavno tako na njivi kot v skladišču. Raba antibiotikov je v kmetijstvu prepovedana, na kapusnicah pa smo omejeni še z uporabo bakrovih pripravkov. Uporaba bakra se bo v prihodnosti dodatno omejila zaradi fitotoksičnosti, negativnega vpliva na opraševalce in druge koristne organizme, tla in vodo ter zmanjšuje mikrobno biodiverziteto v tleh. V kmetijstvu predstavljajo ksantomonade (*Xanthomonas*) največjo skupino rastlinskih škodljivih bakterij, ki povzročajo največ težav na gospodarsko najpomembnejših poljščinah. Črna žilavka kapusnic, ki jo povzroča bakterija *Xanthomonas campestris* pv. *campestris*, je zagotovo ena tistih bolezni, ki jih je izjemno težko obvladovati in povzroča vedno več težav v pridelavi kapusnic. Ob vseh omejitvah se postavlja vprašanje o možnostih učinkovitega obvladovanja bolezni. Na KIS smo v letu 2023 izvedli poskus uporabe naravnih sredstev na pojav črne žilavke pri sorti zelja Ljubljansko okroglo. Zelje je bilo posajeno na površini, kjer že 10 let niso rasle kapusnice. Za preizkušanje smo uporabili sirotko (10 %, Planika), čisti sev bakterije *Lactobacillus plantarum* (2,5 x 10^8 CFU/ml, pripravek Lactosil 3.0, CSL) in efektivne mikrobe (1:20 Plant Forte, 1:100 EM-5, Micronatura). Tretiranja smo izvajali v presledku 14 dni skozi vso sezono (julij-september), z izjemo zadnjega meseca pred spravilom glav. V prispevku prikazujemo rezultate, kjer smo učinkovitost sredstev preverjali na pojavnosti bakterije na rastlinah v času rastne sezone ter ob spravilu pridelka s spremljanjem pojava črnih žil v strženu, kar vpliva na skladiščno stabilnost. Ocenili smo tudi vpliv na količino pridelka.

ABSTRACT

Bio-based products for management of black rot of crucifers (*Xanthomonas campestris*) on white cabbage

Bacterial diseases of plants pose a challenge in plant protection both on the field and during storage. Antibiotics are prohibited and we are limited in use of copper-based products on crucifers. Use of copper doses will be further reduced in the near future, as copper has adverse effects on plant health, pollinators and beneficial organisms, soil and water quality, and microbial diversity. Among plant pathogenic bacteria, Xanthomonads are the most widespread and damaging of all, affecting many economically important crops. Black rot of cabbage, caused by *Xanthomonas campestris* pv. *campestris*, is one of the most difficult diseases to control and a major constraint for cabbage production. Given the current restrictions, effective management options for this disease are needed. In 2023, we conducted an experiment at KIS to test the efficacy of bio-based products against black rot in the Ljubljansko okroglo cabbage variety. We used whey (10%, Planika), a pure culture of *Lactobacillus plantarum* (2.5 x 10^8 CFU/ml, Lactosil 3.0, CSL), and effective microorganisms (1:20 Plant Forte, 1:100 EM-5, Micronatura). The products

were applied every 14 days throughout the season (July-September), except for the last month before harvest. Here we present the results, where we evaluated the effect of the treatments on the incidence of the black rot during the growing season and at harvest by assessing the incidence of black rot in the stem, which affects the storability of the crop. We also assessed the effect of the treatments on the yield.

Preučevanje insekticidnega delovanja različnih inertnih prahov proti najpomembnejšim škodljivcem zelja

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V letih 2022 in 2023 smo na laboratorijskem polju Biotehniške fakultete v Ljubljani, izvajali poljska poskusa, kjer smo preučevali okolju prijaznejšo metodo uporabe inertnih prahov za zatiranje škodljivcev na zelju. S poskusoma smo želeli preučiti ali izbrani prahovi delujejo insekticidno ter tako ugotoviti ali je učinkovitost le-teh dovolj visoka, da bi lahko predstvaljala eno izmed alternativ v IVR, kot nadomestilo rabi fitofarmacevtskih sredstev. Poskus je tako v letu 2022 kot tudi v letu 2023 zajemal površino velikosti 240 m^2. Odločili smo se za setev sorte zelja 'Sweety F1'. Parcelo smo razdelili v tri bloke, znotraj katerih smo naključno razporedili 7 različnih obravnavanj (prašiv). Rastline smo posipali z zeolitom, kremenovim peskom, diatomejsko zemljo, lesnim pepelom ter pajesenom. V poskus sta bili vključeni tudi pozitivna kontrola (Karate Zeon 5 CS) ter negativna kontrola (ne tretirane rastline). Vse rastline smo tekom rastne dobe tretirali tudi z fungicidom za zatiranje črne listne pegavosti kapusnic (ORTIVA). Ocene učinkovitosti izbranih inertnih prahov smo določali s pomočjo ocenjevalnih lestvic Evropske organizacije za varstvo rastlin. Odločili smo se, da bomo ovrednotili indekse poškodb najpomembnejših skupin škodljivcev na zelju, in sicer kapusovih bolhačev (*Phyllotreta* spp.), kapusovih stenic (*Eurydema* spp.) in gosenic metuljev. Z popisom poškodb smo v letu 2022 začeli z 18. 5. 2022 ter zaključili 12. 7. 2022. Ocene poškodb smo v letu 2022 zabeležili šestkrat, leta 2023 pa petkrat. Iz rezultatov lahko izpostavimo, da je bilo obravnavanje pozitivne kontrole najmanj poškodovano ter tudi z najvišjim donosom pridelka pri vseh skupinah škodljivih organizmov (bolhači, stenice, gosenice). Sledila sta mu obravnavanja diatomejske zemlje in lesnega pepela z zadovoljivimi rezultati. V letu 2023 smo poskus ponovili z enako zasnovo kot v letu 2022 (naključna razporeditev obravnavanj). Podobno kot v letu 2022 je bilo tudi v letu 2023 obravnavanje pozitivne kontrole najboljše pri vseh ocenjevanih parametrih. Sledila sta mu obravnavanja posipana z lesnim pepelom in pajesenom. V prispevku vam bomo podrobneje predstavili učinkovitost izbranih inertnih prahov in se dotaknili možnosti uporabe le-teh na vsakodnevni ravni, kot alternativo že obstoječim metodam varstva rastlin.

ABSTRACT

Investigation on the insecticidal efficacy of various inert dusts against the most important pests of cabbage

In the years 2022 and 2023, we conducted field experiments on the laboratory field of the Biotechnical Faculty in Ljubljana, focusing on the environmentally friendly methods of using different inert dusts as an alternative to commercially available substances to control various cabbage pests. The experiments aimed to investigate the insecticidal properties of this selected dusts and determine if their efficacy is sufficiently high to serve as an alternative Integrated Pest Management (IPM) strategy, replacing conventional pesticide use. The experimental area, measuring 240 m^2, was sown with the 'Sweety F1' cabbage variety. The field was divided into three blocks, with seven different treatments (dusts) randomly assigned within each block. The plants were treated with zeolite, quartz sand, diatomaceous earth, wood ash, and *Ailanthus altissima* leaves dust. Positive control (Karate Zeon 5 CS) and negative control (untreated plants) were included in the experiment. Throughout the growing season, all plants received fungicide treatment (ORTIVA) to control *Alternaria sp*. The efficacy of the chosen inert dusts was assessed using evaluation scales from the European and Mediterranean Plant Protection Organization. Damage indices for key cabbage pests, including *Phyllotreta spp*., *Eurydema spp*. and various lepidopteran larvae, were recorded from May 18, 2022, to July 12, 2022, and repeated six times in 2022 and five times in 2023. Results highlighted that the positive control treatment exhibited the least damage and achieved the highest crop yield across all evaluated pest categories (*Phyllotreta spp*., *Eurydema spp*. and various lepidopteran larvae). Following closely were treatments with diatomaceous earth and wood ash, which showed satisfactory results. The experiment was replicated in 2023 with the same design as in 2022 (random treatment allocation). Similar to 2022, the positive control treatment outperformed others in all evaluated parameters in 2023. Subsequent treatments with wood ash and *Ailanthus altissima* leaves dust followed suit. In this contribution, we will provide a detailed presentation of the efficacy of the selected inert dusts and discuss their potential for everyday use as an alternative to more common plant protection methods.

Zatiranje porove zavrtalke in čebulne muhe v čebuli z izvlečkom korenjeve cime

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Porova zavrtalka (*Phytomyza gymnostoma* Loew, Agromyzidae) in čebulna muha (*Delia antiqua* [Meigen], Anthomyiidae) sta poleg resarjev najpomembnejša škodljivca čebule v Sloveniji. Za njuno zatiranje je na razpolago vse manj učinkovitih registriranih insekticidov, zato je bil namen naše naloge v poljskem poskusu, poleg razpoložljivih pripravkov, preučiti tudi druge okoljsko sprejemljive načine varstva čebule. Znano je, da naj bi vmesni posevki s korenjem odvračalno vplivali na čebulno muho, zato smo v

poskusu preizkušali uporabo rastlinskega izvlečka korenjeve cime proti obravnavanima škodljivcema. Poskus je potekal v letih 2022 in 2023 na območju Infrastrukturnega centra Ptuj na sorti čebule 'Holandska rumena'. Poleg izvlečka korenjeve cime, ki smo ga nanašali v obliki škropiva in agrogela, smo v preizkušanje vključili še škropljenje s sirotko in insekticidi (Asset five - a. s. piretrin, Laser plus - a.s. spinosad in Benevia - a. s. ciantraniliprol). Izbrane pripravke smo prvič uporabili ob pojavu simptomov dopolnilnega hranjenja porove zavrtalke na listih čebule ter nanos ponovili čez 10-14 dni. V kontrolnem obravnavanju rastlin nismo škropili. Učinkovitost posameznega obravnavanja smo ugotavljali na podlagi spremljanja značilnih poškodb na rastlinah, premera čebulic in tržne mase pridelka. Med obravnavanji in kontrolo pri oceni poškodb ni bilo statistično značilnih razlik kljub temu, da je bil v kontroli v povprečju največji delež poškodovanih rastlin. Prav tako nismo zaznali razlik v pridelku, saj v masi pridelka in premeru čebulic med obravnavanji ni bilo statistično značilnih razlik. GLM statistični model je pokazal značilen vpliv leta na pridelek. Le-ta je bil v letu 2023 v povprečju za več kot 30 % manjši kot v letu 2022, predvsem zaradi čebulne plesni. Ugotavljamo, da v obeh letih poteka poskusa populacija porove zavrtalke ni bila dovolj številčna, da bi povzročila večjo škodo na rastlinah, kar bi odražalo razlike med posameznimi obravnavanji.

ABSTRACT

Control of the Allium leaf miner and the onion fly with carrot leaf extract

The allium leaf miner (*Phytomyza gymnostoma* Loew, Agromyzidae) and the onion fly (*Delia antiqua* [Meigen], Anthomyiidae) are the most important pests of onions in Slovenia alongside thrips. The registered insecticides available for their control are becoming less and less effective. Therefore, the aim of our study was to investigate other environmentally acceptable strategies against onion pests in addition to the existing preparations. It is known that intercropping carrots has a deterrent effect on the onion fly, so we tested the use of a carrot leaf extract against these pests. The field trial was conducted in 2022 and 2023 at the Infrastructure Center Ptuj on the onion variety 'Holandska rumena.' In addition to the carrot leaf extract, applied as a spray and hydrogel, we also included spraying with whey and insecticides (Asset five - a. i. pyrethrin, Laser plus - a. i. spinosad, and Benevia - a. i. cyantraniliprole). We applied the selected treatments for the first time when symptoms of supplementary feeding by *P. gymnostoma* appeared on the onion leaves and repeated the application after 10-14 days. No spraying was done in the control treatment. The effectiveness of each treatment was assessed based on monitoring typical damage to plants, bulb diameter, and marketable yield. Despite the fact that the control had the highest average percentage of damaged plants, there were no statistically significant differences in damage assessment between treatments and the control. Similarly, no differences in yield were observed, as there were no statistically significant differences in yield mass and bulb diameter between treatments. The GLM statistical model showed a significant impact of the year on the yield, i.e. in 2023 the average yield was more than 30 % lower than in 2022, which was mainly due to downy mildew. We find that in both years of the experiment, the population of the allium leaf miner was not sufficiently numerous to cause significant damage to the plants, reflecting differences between individual treatments.

Vpliv komercialnih pripravkov na podlagi antagonističnih mikroorganizmov na pridelek paprike ob prisotnosti patogena *Verticillium dahliae* Kleb. (verticilijska uvelost)

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V letu 2023 smo na Laboratorijskem polju Biotehniške fakultete preučevali potencialni vpliv antagonističnih mikroorganizmov na pridelek paprike 'Blondy F1', tipa babura ob prisotnosti/odsotnosti patogene glive *Verticillium dahliae*. Uporabili smo 3 pripravke, in sicer Trifender Pro (gliva *Trichoderma asperellum* sev T34), Prestop (gliva *Gliocladium catenulatum)* in Serenade ASO (bakterija *Bacillus amyloliquefaciens*). Tretiranje s pripravki je bilo izvedeno pred presajanjem sadik na prosto (namakanje sadik 10 dni pred sajenjem) ali po saditvi (zalivanje rastlin 6 dni po presajanju na polje). Pri obravnavanjih s patogenom *V. dahliae*, smo z njim rastline inokulirali tako, da smo platoje s sadikami paprike namakali v suspenziji spor 3 dni pred sajenjem na polje. Poskus z 11 obravnavanji je bil izveden v 4 blokih in s 6 ponovitvami. Rezultati kažejo, da pripravki z antagonisti lahko malenkost pozitivno delujejo na sam pridelek paprike v primerjavi z negativno kontrolo (brez dodanih pripravkov). V kontrolnem obravnavanju Trifender PRO je bila povprečna masa 7 % večja kot v negativni kontroli, pri Prestopu 2 % in pri Serenade 4 %. Najslabši pridelek (16 in 17 % manjši kot v negativni kontroli) smo zabeležili pri kontroli *Verticillium,* kjer je bil inokuliran le patogen ter v kombinaciji *Verticillium* z naknadnim zalivanjem s pripravkom Trifender, sledi še kombinacija *Verticillium* z naknadnim zalivanjem s pripravkom Serenade (8 %) ter kombinaciji s patogenom s predhodnim namakanjem sadik v pripravka Serenade (6 %) ter Prestop (5 %). Leto ni bilo ugodno za izvajanje poskusa, saj je poleg toče, rastline paprike prizadela tudi povodenj, zato so rezultati zelo različni, čeprav je bil poskus razdeljen v bloke.

ABSTRACT

The effect of commercial products based on antagonistic microorganisms on the yield of pepper in the presence of the pathogen *Verticillium dahliae* Kleb. (*Verticillium* wilt)

In 2023, we investigated the potential effects of antagonistic microorganisms on the yield of 'Blondy F1' babura type pepper in the presence/absence of the pathogenic fungus *Verticillium dahliae* in the Laboratory field of the Biotechnical Faculty . We used 3 commercial microbial products, namely Trifender Pro (fungus *Trichoderma asperellum* strain T34), Prestop (fungus *Gliocladium catenulatum*) and Serenade ASO (bacterium *Bacillus amyloliquefaciens*). Treatment with the microbial products was carried out before planting the seedlings outdoors (soaking the seedlings 10 days before planting) or after planting (watering the plants 6 days after planting in the field). In the treatments with the pathogen *V. dahliae*, the plants were inoculated with it by soaking plateaus with pepper seedlings in a spore suspension 3 days before planting out in the field. The trial with 11 treatments was carried out in 4 blocks and with 6 replicates. The results show that preparations with antagonists can have a slightly positive effect on the pepper yield compared to the negative control (no added microbial products). The average mass of the control treatment Trifender PRO was 7% higher than that of the negative control, Prestop 2% and Serenade 4%. The worst yield (16% and 17% less than the negative control) was

recorded for the *Verticillium* control, in which only the pathogen was inoculated, and for the combination of *Verticillium* followed by irrigation with Trifender, followed by the combination of *Verticillium* followed by irrigation with Serenade (8%) and the combination with the pathogen by pre-soaking the seedlings in the suspension of Serenade (6%) and Prestop (5%). The year was unfavorable for conducting the trial, as the pepper plants were affected by hail and flooding, so that the results were very different, although the trial was divided into blocks.

Validacija visokozmogljivega sekvenciranja z nanoporami za ugotavljanje prisotnosti karantenskih škodljivih virusov v vzorcih paradižnika

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Kmetijstvo se sooča s številnimi izzivi, kot so hitro prilagajanje na podnebne spremembe, naraščanje prebivalstva in povečan pretok blaga, kar pomeni tudi večjo možnost širjenja rastlinskih bolezni in škodljivcev. Karantenski povzročitelji bolezni, ki v EU niso navzoči ali so navzoči v omejenem obsegu, predstavljajo veliko tveganje za kmetijstvo, zaradi svoje invazivnosti ob vnosu v novo okolje in negativnih vplivov na gospodarstvo, biotsko raznovrstnost in družbo. Med njimi so številni virusi, za katere ni niti vpeljanih niti razvitih ustreznih tarčnih diagnostičnih metod, s katerimi bi lahko zanesljivo in pravočasno določili prisotnost patogena, kar je nujno za učinkovito preprečevanje širjenja bolezni. Ker bi bil razvoj posameznih tarčnih metod za vse te viruse časovno in cenovno precej potraten, smo v diagnostiko vpeljali metodo visokozmogljivega sekvenciranja z nanoporami z uporabo naprave MinION (Oxford Nanopore Technologies), s katero lahko določimo nukleotidno zaporedje vsem nukleinskim kislinam v preiskovanih vzorcih in tako znotraj ene preiskave netarčno zaznamo tudi morebitne viruse. Celoten postopek smo validirali v skladu s smernicami evropske in mediteranske organizacije za zaščito rastlin (EPPO PM7/98 in PM7/151) na primeru določanja virusa blage lisavosti paradižnika (tomato mild mottle virus; rod *Ipomovirus*) v listih paradižnika in s tem pripravili podlago za vključitev tega diagnostičnega postopka na seznam akreditiranih metod po ISO 17025. Rezultati naše validacije, ki jih bomo predstavili v prispevku, so na voljo tudi ostalim laboratorijem v EPPO podatkovni bazi (https://dc.eppo.int/validation_data/validationlist), pripravili pa smo tudi diagnostični protokol, ki bo kot primer vključen v EPPO smernice in na ta način v pomoč pri vpeljavi te metode tudi v druge diagnostične laboratorije.

ABSTRACT

Validation of high-throughput sequencing with nanopores for detection of quarantine viruses in tomato samples

Agriculture is facing many challenges, such as rapid adaptation to climate change, population growth and increased movement of goods, which also means a greater potential for the spread of plant diseases and pests. Quarantine pathogens, which are

absent or present to a limited extent in the EU, pose a major risk to agriculture due to their invasiveness when introduced into a new environment and their negative impacts on the economy, biodiversity and society. They include a number of viruses for which no appropriate targeted diagnostic tests have been introduced or developed to reliably and timely identify the presence of the pathogen, which is essential to effectively prevent the spread of the disease. As the development of individual targeting tests for all these viruses would be time consuming and costly, we have introduced a high-throughput nanopore sequencing using MinION (Oxford Nanopore Technologies), which can determine the nucleotide sequence of all nucleic acids in samples, and thus detect potential viruses in a non-targeted manner and in a single assay. The whole procedure was validated according to the guidelines of the European and Mediterranean Plant Protection Organisation (EPPO PM7/98 and PM7/151) on the example of the detection of tomato mild mottle virus (genus Ipomovirus) in tomato leaves, thus providing the basis for the inclusion of this diagnostic procedure in the list of accredited methods according to ISO 17025. The results of our validation, which will be presented in this paper, are also available to other laboratories in the EPPO database (https://dc.eppo.int/validation_data/validationlist) and we have also prepared a diagnostic protocol that will be included as an example in the EPPO guidelines and thus help to introduce this method to other diagnostic laboratories.

Razkritje potencialno nevarnega novega virusa paradižnika iz rodu *Cucumovirus*

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Paradižnik, ki je ena najpomembnejših vrtnin, lahko okuži več kot 300 virusov; ta številka pa z uporabo visoko zmogljivega sekvenciranja (HTS) v zadnjih letih strmo narašča. Leta 2018 je bil v okviru programa preiskav za newdelhijski virus kodravosti listov paradižnika (ToLCNDV) v zahodni Sloveniji vzorčen paradižnik, ki je bil pritlikav, na listih pa so bili opaženi nekrotični madeži. V vzorcu paradižnika nismo potrdili prisotnosti ToLCNDV, zato smo celokupno RNA izolirano iz vzorca analizirali z HTS z Illumina sekvenatorjem. Z HTS smo v vzorcu ugotovili prisotnost nukleinskih kislin južnega virusa paradižnika (STV), virusa Y krompirja (PVY) in nukleinske kisline novega virusa iz rodu *Cucumovirus*, kar smo potrdili tudi s testi na osnovi PCR. S pomočjo filogenetske analize in analize BLAST treh RNA, smo ugotovili, da je največja podobnost novega kukumovirusa z različnimi kukumovirusi. Rod *Cucumovirus* je eden od šestih rodov družine *Bromoviridae*. Kukumovirusi imajo tridelni genom, ikozaedrične virione in se prenašajo z listnimi ušmi na neperzistenten način. Trenutno so iz rodu *Cucumovirus* opisane štiri vrste virusov. Nov kukumovirus smo od drugih virusov, ki so bili prisotni v

vzorcu, ločili po mehanski inokulaciji različnih testnih rastlin. Nato smo ugotovili, da se lahko ta virus mehansko prenese na *S. lycopersicum, S. melongena, N. benthamiana, N. rustica, N. tabacum* 'White Burley' in *Capsicum annuum*. Na mehansko okuženih testnih rastlinah smo opazili različna bolezenska znamenja, vključno z upočasnjeno rastjo, mozaikom in deformacijami listov, klorozami in nekrozami. V teku so nadaljnje raziskave z namenom nadaljnje karakterizacije tega virusa. To odkritje dopolnjuje obstoječe znanje o virusih, ki lahko okužijo paradižnik in poudarja pomen stalnega spremljanja paradižnikovih virusov.

ABSTRACT

Unveiling a potentially dangerous novel cucumovirus of tomatoes

Tomato is one of the most important vegetable crops. More than 300 viruses are associated with tomato production, and with the use of high-throughput sequencing (HTS) the number of tomato viruses is constantly increasing. In 2018, as part of an official survey for tomato yellow leaf curl New Delhi virus (ToLCNDV), a plant with stunted growth and necrotic spots on the leaves was sampled in western Slovenia. The sample tested negative for ToLCNDV was further analysed by HTS of total RNA on the Illumina platform. The results of the HTS and confirmatory PCR-based tests showed the presence of southern tomato virus (STV), potato virus Y (PVY), and a possible new species of the genus *Cucumovirus*. Phylogenetic and BLAST analyses of three RNAs obtained from a new cucumovirus showed the highest similarity to different cucumoviruses. The genus *Cucumovirus* is one of six genera of the family *Bromoviridae*. Cucumoviruses have a tripartite genome, icosahedral virions and are transmitted by aphids in a non-persistent manner. To date, four species have been recognised as members of the genus *Cucumovirus*. The new virus was separated from other viruses after mechanical inoculation of different test plants. We have shown that the new virus can be transmitted mechanically to *Solanum lycopersicum, S. melongena, Nicotiana benthamiana, N. rustica, N. tabacum* 'White Burley' and *Capsicum annuum*. Inoculated test plants showed various symptoms, including stunted growth, leaf mosaic and deformation, chlorosis, and necrosis. Our efforts are now focused on the detailed characterization of the new virus. This discovery adds to the existing knowledge of the tomato virome and emphasizes the importance of continuous monitoring of tomato viruses.

Agrotis bigramma (Esper) – captures in pheromone traps for *Spodoptera frugiperda* (J.E. Smith)

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The fall armyworm *Spodoptera frugiperda* (J.E. Smith) was monitored for the first time in Montenegro during 2023. Bucket trap with a specific sexual pheromone diffuser to attract males was used. Traps were set up in the second half of June at six localities in the southern part of Montenegro (area of Zeta and Malesia) in maize and pepper crops and in the first half of July in three locations in the northern of Montenegro (area of Bijelo Polje) in corn crops. Monitoring lasted until the end of the first decade of October. Traps were inspected at 15-20 days intervals. In all localities traps captured various non-target insects

(wasps, bumblebees, moths, beetles, flies) during summer time. At the beginning of September, presence of moths from family Noctuidae was noted in all localities in the area of Zeta and Malesia, and in one locality in the north. More than 20 specimens were captured in some traps. External morphological features indicated that all captured specimens belongs to the genus *Agrotis*. In order to identify the species, slide preparation of male genitalia were made from 15 moths. It was determined that all specimens belons to the great dart, *Agrotis bigramma* (Esper) which was the first finding in Montenegro. Until end of monitoring there were no more captures of *A. bigramma* in localities in the northern part of Montenegro, while in the southern part occured again in October. During this monitoring targeted *S. frugiperda* was not found, but non- target noctuid *A. bigramma* which could be confused with the target species was captured in substantial numbers during September and October.

Daljinsko zaznavanje črne listne pegavosti (*Alternaria* spp.) v krompirju

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Črna listna pegavost krompirja (*Alternaria* spp.) je bolezen krompirja pogosta v letih s pogostimi suhimi obdobji v rastni dobi. Daljinsko zaznavanje s pomočjo brezpilotnih letalnikov, multispektralnega slikanja in strojnega učenja predstavlja praktičen pristop za zgodnje odkrivanje te bolezni. V raziskavi, izvedeni v letu 2022 na Mengeškem polju v osrednji Sloveniji, smo na petih sortah krompirja v ekološki in konvencionalni pridelavi preverjali možnost zaznavanja črne listne pegavosti krompirja. Za slikanje smo uporabili multispektralno kamero (MicaSense RedEdge-M), nameščeno na brezpilotnem letalniku. Kasneje je bila opravljena obdelava slik, vključno s ortorektifikacijo, pretvorbo v reflektanco in georeferenciranjem z uporabo visokonatanančne GPS naprave (Stonex S9i). Dejansko stanje okuženosti krompirja v poskusu je bilo opravljeno vizualno. Za klasifikacijo smo uporabili algoritem XGBoost, ki uporablja vnaprej izračunane značilke, izpeljane iz neobdelanih vrednosti multispektralnih posnetkov. Te značilke so bile samodejno izračunane z uporabo specializiranih knjižnic, ki vključujejo različne spektralne indekse, in nato uporabljene pri treniranju modela strojnega učenja. Metode razložljive umetne inteligence, kot sta SHAP (SHapley Additive exPlanations) in UMAP (Uniform Manifold Approximation and Projection for Dimension Reduction), so bile uporabljene za dodatno interpretacijo rezultatov klasifikacij. Rastline so bile razdeljene v dva razreda - zdrave in okužene rastline. Testni set podatkov za validacijo modela je vseboval 40 podatkov, od tega 21 zdravih in 19 okuženih rastlin, medtem ko jih je bilo v set za trening modela dodeljeno 120, 63 zdravih in 57 okuženih. Za oceno uspešnosti modela smo uporabili metrike, vključno z F1 oceno, natančnostjo, odzivnostjo in AUC-ROC. Model XGBoost kaže skupno F1 oceno 0,825, kar kaže na uravnotežene napovedi glede na sorte krompirja. Napovedovanje črne listne pegavosti pri sorti Levante kaže optimalne rezultate z F1 oceno 1,000, medtem ko je model pri sorti Alouette dosegel nižjo uspešnost z F1 oceno 0,620. Kombinacija bližnje infrardečega in robno-rdečega spektralnega kanala se je

izkazala za najbolj pomembno pri odkrivanju črne listne pegavosti. Uporaba daljinskega zaznavanja se je izkazala za uspešno pri detekciji črne listne pegavosti krompirja.

ABSTRACT

Remote sensing for potato early blight (*Alternaria* spp.) detection

Early detection of potato early blight (*Alternaria* spp.) using remote sensing with unmanned aerial vehicles (UAVs), multispectral imaging (MSI), and machine learning is a practical approach, effective for identifying the disease in the field, especially during periods of dry conditions in the potato growing season. The field study, conducted in Mengeš field in central Slovenia in 2022, focuses on five potato varieties under both organic and conventional cultivation. Multispectral imaging was performed using a MicaSense RedEdge-M camera mounted on a UAV. Subsequent image processing includes orthorectification, conversion to reflectance values, and georeferencing using high-precision GPS (Stonex S9). The actual state of potato infection was determined through visual assessment. The XGBoost algorithm was utilized for modeling, employing precalculated features derived from raw multispectral data. These features were automatically computed using specialized libraries that incorporated various spectral indices, contributing to the machine learning model's training. Explainable AI techniques such as SHAP and UMAP (SHapley Additive exPlanations) in UMAP (Uniform Manifold Approximation and Projection for Dimension Reduction), were applied for additional clarification of classification results. Plants were categorized as healthy or infected, with a validation dataset comprising 40 instances (21 healthy, 19 infected) and a training dataset of 120 instances (63 healthy, 57 infected). Model performance was assessed using metrics including F1 score, accuracy, precision, recall, and AUC-ROC. The XGBoost model achieved an overall F1 score of 0.825, indicating balanced predictions across potato varieties. Notably, the prediction of early blight in the Levante variety shows optimal results with an F1 score of 1.000, while the Alouette variety exhibits relatively lower performance with an F1 score of 0.620. The combination of near-infrared and red-edge spectral channels proves crucial for detecting early blight. The use of remote sensing was successful in the detection of potato early blight.

Preučevanje sinergizma v kombinacijah različnih načinov zatiranja strun (*Agriotes* spp.) na njivi s krompirjem

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V raziskavi, ki je bila leta 2023 izvedena na Laboratorijskem polju Biotehniške fakultete v Ljubljani, smo v 25 različnih obravnavanjih preučevali kombinacije različnih (večinoma okoljsko sprejemljivih) načinov zmanjševanja poškodb strun na gomoljih krompirja. Njivo

smo razdelili v tri bloke, znotraj katerih smo naključno razporedili 5 obravnavanj prvega reda. Tako smo na ločene parcele jeseni posejali rjavo gorjušico (*Brassica juncea*) in abesinsko ogrščico (*Brassica carinata*) kot varovalna posevka. Omenjeni križnici smo pred sajenjem krompirja zmulčili in zaorali v tla. V tretjem in četrtem obravnavanju prvega reda smo tik pred sajenjem gomoljev na površje njive nanesli pripravka Nemakil in Rasti Soil Tonic in ju z brano rahlo zadelali v tla. Peto obravnavanje je predstavljal talni nanos insekticida teflutrin. Vsako od obravnavanj prvega reda smo razdelili v pet obravnavanj 2. reda, in sicer smo pri prvem in drugem obravnavanju 2. reda ob sajenju gomoljev in osipanju rastlin izvedli škropljenje s pripravkoma na podlagi entomopatogenih gliv oz. entomopatogenih ogorčic v 100 % odmerku. V tretjem obravnavanju 2. reda smo tik pred sajenjem po površju njive posuli zeolit, ob sajenju gomoljev in osipanju rastlin pa izvedli škropljenje s pripravkoma na podlagi entomopatogenih gliv ter entomopatogenih ogorčic v polovičnem odmerku. Četrto in peto obravnavanje 2. reda sta predstavljali negativna kontrola (netretirana površina) in pozitivna kontrola (ponovni talni nanos insekticida teflutrin). Med rastno dobo smo na vsaki od 25 parcel spremljali številčnost strun s talnimi izkopi. V več terminih smo v tleh navedenih parcel merili temperaturo tal in vsebnost vlage v tleh. Ob pobiranju pridelka smo gomolje razvrstili po velikosti (drobna frakcija, srednja frakcija, debela frakcija). Ob sortiranju pridelka smo na gomoljih iz različnih obravnavanj določali tudi obseg poškodb zaradi strun. V prispevku bodo predstavljeni potencialni sinergizmi med različnimi (večinoma okoljsko sprejemljivimi) načini zmanjševanja škodljivosti strun na gomoljih krompirja. Predstavljeni bodo tudi rezultati pridelka gomoljev v vseh 25 obravnavanjih.

ABSTRACT

Investigation on synergism in combinations of different methods of controlling wireworms (*Agriotes* spp.) in a potato field

In the research, which was conducted in 2023 at the Laboratory Field of the Biotechnical Faculty in Ljubljana, we have studied combinations of different (mostly environmentally acceptable) methods of reducing wireworms damage on potato tubers in 25 different treatments. We have divided the field into three blocks, within which we have randomly arranged 5 treatments of the first order, so we have sown in autumn brown mustard (Brassica *juncea*) and Abyssinian rape (*Brassica carinata*) as a cover crop in the separate plots. Before planting the potatoes, we have mulched and plowed the above-mentioned crucifers into the ground. In the third and fourth treatments of the first order, just before planting the tubers, we have applied products Nemakil and Rasti Soil Toni to the surface of the field and covered them lightly into the soil with a harrow. The fifth treatment was ground application of the insecticide tefluthrin. Each of the treatments of the first order was divided into five treatments of the second order, namely, in the first and second treatments of the second order, at planting and at hilling, spraying was carried out with products based on entomopathogenic fungi or entomopathogenic nematodes in a 100% concentration. In the third treatment of the second order, zeolite was applied on the surface of the field just before planting, and at planting and hilling, we have sprayed with products based on entomopathogenic fungi and entomopathogenic nematodes in a half dose (concentration). The fourth and fifth treatments of the second order were the negative control (untreated area) and the positive control (repeated application of the insecticide tefluthrin). During the growing season, in each of the 25 plots (treatments), we have monitored the abundance of wireworms with soil sampling. The soil temperature and soil moisture content were measured in the soil of the above-mentioned plots on several occasions. When harvesting, the tubers were divided by size (small, medium, large fraction). When sorting the potato tubers, we have also determined the level of wireworm injuries on tubers from different treatments. The paper will present the potential

synergisms between different (mostly environmentally acceptable) ways of reducing the harmfulness of wireworms on potato tubers. The results of potato yield in all 25 treatments will also be presented.

Poljsko preizkušanje insekticidnega delovanja inertnih in rastlinskih prašiv na koloradskega hrošča (*Leptinotarsa decemlineata* [Say]) na krompirju

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V dveletnem poljskem poskusu (2022-2023) smo preučevali insekticidno delovanje različnih naravnih prašiv za zatiranje različnih razvojnih stadijev (jajčna legla, ličinke L1-L2, ličinke L3-L4, odrasli osebki) koloradskega hrošča (*Leptinotarsa decemlineata*). Poskus je potekal na Laboratorijskem polju Biotehniške fakultete v Ljubljani. V obeh letih poskusa smo njivi razdelili v tri bloke, znotraj katerih smo naključno razporedili sedem obravnavanj, v katerih smo na nadzemske dele krompirja z nahrbtnim prašilnikom nanašali sledeča prašiva, in sicer: kremenov pesek, lesni pepel navadne smreke, zeolit, diatomejsko zemljo in prah iz listov velikega pajesena (*Ailanthus altissima*). V poskus smo vključili pozitivno kontrolo (škropljenje z registriranimi insekticidi) in negativno kontrolo (netretirane rastline). Prašiva smo v obeh letih nanašali v treh terminih. V posameznih obravnavanjih smo na rastlinah s standardno metodo šteli hrošče, mlajše in starejše ličinke in jajčna legla. Med rastno dobo smo spremljali tudi odstotek defoliacije rastlin krompirja. Pridelek gomoljev smo v vseh obravnavanjih razdelili v tri različne frakcije (drobni, srednji, debeli). V prispevku bodo predstavljeni rezultati vpliva preizkušanih naravnih prahov na različne razvojne stadije škodljivca in vpliva škodljivca na rastline (defoliacija, pridelek gomoljev).

ABSTRACT

Field testing of insecticidal activity of inert and plant dusts against Colorado potato beetle (*Leptinotarsa decemlineata* [Say]) on potato

In a two-year field experiment (2022-2023), we have studied the insecticidal activity of various natural dusts for the suppression of different developmental stages (eggs, L1-L2 larvae, L3-L4 larvae, adults) of the Colorado potato beetle (*Leptinotarsa decemlineata*). The experiment took place at the Laboratory Field of Biotechnical Faculty in Ljubljana. In both experimental years, we have divided field into three blocks, within which we have randomly arranged seven treatments, in which the following dusts were applied to the aerial parts of the potatoes with a backpack vacuum cleaner, namely: quartz sand, wood ash of common spruce, zeolite, diatomaceous earth and dust from the leaves of tree of heaven (*Ailanthus altissima*). A positive control (spraying with registered insecticides) and a negative control (untreated plants) were included in the experiment. Dusts were applied three times, in individual year. In individual treatments, we have counted number of adults,

young and old larve and egg cluster by using standard methods. During growing season, we have also monitored percentage of defoliation of potato plants. Potato yield was divided into three fractions (small, medium, large) in all treatments. In the paper we will presents the results regarding impact of tested natural dusts on different developmental stages of insect pest and the effect on plants (defoliation, yield).

Glivične bolezni sladkega krompirja v Sloveniji

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Sladki krompir (*Ipomoea batatas*) ali batata je rastlina iz družine slakovk (Convolvulaceae), ki izvira iz Južne in Srednje Amerike. V Evropi postaja vedno bolj priljubljena kultura za prehrano ljudi. Zaradi enostavne pridelave lastnih sadik z vegetativnim razmnoževanjem kupljenih gomoljev, predstavlja sladki krompir tveganje za vnos in razširjanje tujerodnih patogenov. Ker je pridelava sladkega krompirja v Sloveniji relativno nova, ni znano kakšne bolezni se pojavljajo v nasadih. Namen raziskave je opredeliti pomembnost in pojav glivičnih bolezni. Zelene dele rastlin in gomolje sladkega krompirja okužuje veliko število (več kot 30) različnih rodov gliv in oomicet z več patogenimi vrstami v posameznem rodu, med katerimi se pojavljajo *Ceratocystis fimbriata, Sclerotium rolfsii, Elsinoe batatas* in *Colletotrichum coccodes*. Številne glive in oomicete imajo lahko poleg sladkega krompirja tudi druge ekonomsko pomembne gostitelje. Povzročajo tako okužbe zelenih delov rastlin, ki zmanjšujejo pridelek, kot tudi gnilobe gomoljev, ki lahko pridelek popolnoma uničijo. V naši dvoletni raziskavi (2022 in 2023) smo ugotovili, da ni bilo večjih glivičnih težav na poljih s sladkim krompirjem, večinoma je šlo za rumenenje in venenje listov, pege na listih ter posamezne primere nekroze stebel in suhe gnilobe gomoljev. Na vseh vzorcih je bila prisotna velika pestrost vrst iz rodov *Alternaria* in *Fusarium*. Poleg tega pa smo iz listnih peg identificirali tudi vrsto *Colletotrichum coccodes*, ki ima širok krog (preko 50) drugih kmetijsko pomembnih gostiteljev. Tudi *Didymella glomerata*, ki smo jo potrdili v obeh letih vzorčenja na simptomih listov, je patogen s širokim naborom gostiteljev, a v literaturi ni poročil o patogenosti na sladkem krompirju. Rezultati raziskave potrjujejo hipotezo, da se na sladkem krompirju pojavljajo eksotične vrste gliv, ki so prvič zaznane v Sloveniji ali širše, in katerih patogenost bomo v nadaljevanju preučili z namenom boljšega razumevanja njihovega vpliva ne samo na pridelavo sladkega krompirja temveč tudi drugih kulturnih rastlin.

ABSTRACT

Fungi associating disease symptoms of Sweet Potato in Slovenia

Sweet potato (*Ipomoea batatas*) or batata (*Convolvulaceae*), originating from South and Central America, is becoming an increasingly popular crop for human consumption also in Europe. Due to the the ease of producing one's own seedlings through vegetative propagation of bought tubers, sweet potato poses a risk for the introduction and spread of nonnative fungi including plant pathogens. As sweet potato cultivation in Slovenia is

relatively new, the diseases occurring in the plantations are not well known. The purpose of this research is to identify fungi associating disease symptoms of potato in Slovenia.
Sweet potato (green parts, tubers) are affected by a large number (more than 30) of genera of fungi and oomycetes with multiple pathogenic species in each genus. Among the important pathogenic species are *Ceratocystis fimbriata, Sclerotium rolfsii, Elsinoe batatas,* and *Colletotrichum coccodes*. Many of these species are plurivorous, thus, able to occur or infect also other economically important hosts. On batata, they can cause severe diseases in the green parts of plants, reduce yields, rotting of tubers, and completely destroy the harvest. In our two-year study (2022 and 2023), we found no major fungal problems in sweet potato fields. However, yellowing and wilting of leaves, leaf spots, and occasional cases of stem necrosis and dry rot of tubers was observed. A wide variety of species from the Alternaria and Fusarium genera were present on the samples. Additionally, we isolated *Colletotrichum coccodes* from leaf spots, which has occurs on more than 50 other agriculturally important hosts. Occurrence of *Didymella glomerata*, isolated from leaf symptoms, was confirmed in both sampling years. It is a pathogen with a wide range of hosts; however, its pathogenicity on sweet potatoes has not yet been determined. The implication and relevance of the encountered species is further discussed and the pathogenicity of selected species described.

Potivirusi na sladkem krompirju v Sloveniji

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Sladki krompir (*Ipomoea batatas*) ali batata je rastlina iz družine slakovk (Convolvulaceae), ki izvira iz Južne in Srednje Amerike. Je šesta najpomembnejša prehranska kultura v svetovnem merilu, virusi pa predstavljajo ključni omejitveni faktor v njegovi pridelavi. Vegetativno razmnoževanje, nelegalni vnosi in pomanjkljiva kontrola sadilnega materiala so vzrok za številne in mešane okužbe z virusi. Zaradi bolezni, v veliki meri virusnih, se izgube pridelka gibljejo med 20 in 40 %. Pridelava sladkega krompirja, ki za človeka predstavlja bogat vir koristnih snovi, je v Sloveniji relativno nova in pretežno ljubiteljska, za gojenje pa je primerna celotna Slovenija. Razširjenost bolezni sladkega krompirja v Sloveniji ni poznana. Znano je, da sladki krompir okužuje več kot 30 virusov, med njimi tudi nekateri potivirusi, ki predstavljajo enega najštevilčnejših rodov rastlinskih virusov. Potiviruse prenašajo listne uši na neperzistenten način, za katerega sta značilna kratek čas prenosa in težavno obvladovanje okužb. Na sladkem krompirju najdemo šest potivirusov, med katerimi je najbolj razširjen virus peresaste lisavosti sladkega krompirja (sweet potato feathery mottle virus; SPFMV). V okviru strokovnih nalog s področja zdravstvenega varstva rastlin za leti 2022 in 2023 smo si zadali opredeliti razširjenost okužbe s potivirusi na sladkem krompirju v osrednji in SV Sloveniji in njihovo določitev s sekvenciranjem produktov PCR izbranih pozitivnih vzorcev.

ABSTRACT

Potyviruses on sweet potato in Slovenia

Sweet potato (*Ipomoea batatas*), also known as batata, is a plant from the morning glory family (Convolvulaceae) originating from South and Central America. It is the sixth most important food crop globally, with viruses being a key limiting factor in its production. Vegetative propagation, illegal introductions, and inadequate control of planting material are causes of numerous and mixed virus infections. Due to diseases, primarily viral diseases, sweet potato crop losses range from 20 to 40 %. The cultivation of sweet potato, which represents a rich source of beneficial compounds for humans, is relatively new and minor in extent in Slovenia. Anyhow, the conditions for its cultivation are suitable throughout the country. The prevalence of sweet potato diseases in Slovenia has not been studied before. It is known that more than 30 viruses can infect sweet potatoes, including some potyviruses, one of the most numerous genera of plant viruses. They are transmitted by aphids in a non-persistent manner, which is characterized by a short transmission period and challenging infection management. Six potyviruses can be found on sweet potatoes, with sweet potato feathery mottle virus (SPFMV) being the most widespread globally. As part of a study conducted in 2022 and 2023, we aimed to determine the prevalence of potyvirus infections in sweet potatoes in central and NE Slovenia and identify the species by sequencing of PCR products from selected positive samples.

Komuniciranje znanosti: prikaz testiranja rjave gnilobe krompirja na Dnevu odprtih vrat NIB

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Nacionalni inštitut za biologijo (NIB) je 29. septembra 2023, ko je potekala Evropska noč raziskovalcev, organiziral dan odprtih vrat, da bi premostil vrzel med znanstveno skupnostjo in javnostjo ter povečal razumevanje znanosti v javnosti. Na tem dogodku, ki se ga je udeležilo 550 srednješolcev iz vse Slovenije, so bila predstavljena raznolika raziskovalna prizadevanja, ki jih izvajamo na NIB in poudarjen praktični vpliv znanosti na vsakdanje življenje. Predstavitev je upoštevala strokovnost in raven znanstvenega znanja glede na ciljno skupino udeležencev. Ključni poudarek je bil obisk uradnega bakteriološkega laboratorija in testiranja gomoljev krompirja na bakterijo *Ralstonia solanacearum*, ki povzroča rjavo gnilobo krompirja. Uradna laboratorijska diagnostika te bakterije, ki jo izvajamo na NIB, preprečuje, da bi ta bakterija vstopila v Slovenijo in pri nas povzročila škodo. Prikaz, ki je potekal v naši karantenski postaji, je vključeval praktične prikaze poteka priprave vzorcev, informativni plakat in videoposnetek s časovnim zamikom, ki je prikazoval napredovanje bolezni. Uspeh dogodka je zaznamovala velika angažiranost udeležencev, ki je bila razvidna iz njihovega navdušenega sodelovanja in pronicljivih vprašanj. Obiskovalci so bili še posebej navdušeni nad tem, da so lahko oblekli laboratorijske plašče in iz prve roke spremljali raziskovalne procese, kar je poudarilo pomen izkustvenega učenja. Ko se po dogodku ozremo nazaj, se zavedamo ključne vloge učinkovitega komuniciranja, upoštevanja uspešnih strategij in tehnik komunikacij prilagojenih ciljni publiki, da znanost postane dostopna in navdihujoča za

mlajšo generacijo. Z deljenjem našega dela ne želimo le širiti znanja, temveč tudi spodbujati radovednost in vseživljenjsko strast do znanosti.

ABSTRACT

Engaging Young Minds: Demonstrating Potato Brown Rot Research at NIB Open Day

To bridge the gap between the scientific community and the public, the National Institute of Biology (NIB) hosted an open day on September 29th, 2023, coinciding with the European Researchers' Night. This event, attended by 550 high school students from across Slovenia, showcased diverse research endeavours at NIB, emphasizing the practical impact of science in daily life. The presentation considered the expertise and level of scientific knowledge of the target audience. A key highlight was the official bacteriology laboratory's demonstration of testing potato tubers for *Ralstonia solanacearum*, the bacterium responsible for potato brown rot. The official laboratory diagnosis of this bacteria, which we carry out at the NIB, prevents these bacteria from entering Slovenia and causing damage to our food production. This interactive session, held in our quarantine station, included hands-on experiences on how the tubers are prepared for testing, an informative poster, and a time-lapse video showing the disease's progression. The event's success was marked by the high engagement of attendees, evident from their enthusiastic participation and insightful questions. The opportunity for students to don lab coats and witness research processes firsthand resonated particularly well, underscoring the importance of experiential learning. Reflecting on the event, we recognize the critical role of effective communication and communication strategies adapted to the target audience in making science relatable and inspiring to the younger generation. By sharing our work, we aim not only to disseminate knowledge but also to ignite curiosity and a lifelong passion for science.

Effect of allelopathic weed extracts on the sunflower in two types of experiments

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Our agriculture is constantly faced with the challenges of achieving increasing crop yields and crop quality, but at the same time, sustainability and environmental protection also play a fundamental role in production planning. In the course of the integrated plant protection approach, not only is the economic benefit prioritized, but it is also achieved by preserving the valuable elements of the ecosystem, involving those with expertise, and based on prevention. In this system, the fight against weeds represents a significant proportion since the damage caused by weeds puts crop production yields in the field at particular risk. During our experiment - continuing a previous work - we examined the allelopathic effect of three domestically damaging weeds, *Ambrosia artemisiifolia* L., *Cirsium arvense* L. and *Datura stramonium* L., which are also responsible for causing severe damage to the sunflower chosen as the test plant. Our goal was to study further the allelopathic effect in a culture vessel study, which better models the environmental conditions and can provide a more complete explanation from a practical point of view as a

supplement to the previous Petri dish germination experiment. In the treatments, according to the concentrations (2.5%, 5%, 7.5%), the dried, homogenized shoot remains of the weeds were mixed with potting soil. For each weed, four replicates were used per concentration. The culture pots were placed in an illuminated thermostat at a constant temperature for 28 days and watered with tap water. After 28 days, the experiment was evaluated by recording the germination percentage after each week. When the experiment was dismantled, shoot and root length and shoot and root green mass data were recorded. After drying, dry weight data were also recorded, and a statistical evaluation was performed. *Ambrosia artemisiifolia* and *Cirsium arvense* were primarily inhibitory to root development. In addition, sunflower seedlings' root and shoot mass decreased due to the extracts made from the shoot residues of the *Cirsium arvense*, which can cause problems even in field conditions. As a result of the inhibitory effect, the development of the plants' vegetative parts is damaged, so there is no suitable assimilation and absorption surface. Later, this can be an additional disadvantage in sunflower development; plants in poor condition are less likely to regenerate sufficiently in case of other biotic or abiotic stress. *Datura stramonium* extracts not only negatively affected root length but also adversely affected the growth of shoot initiation. In light of the Petri dish and culture pot experiment results, it is worth paying attention to the practical and thorough control of the above weeds because they can cause significant damage through their allelopathic effect after they have multiplied and worked their plant residues into the soil.

Predicting oxygen distribution in silos and chambers filled with varied agricultural commodities

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In the context of post-harvest pest management in agricultural products, the adoption of modified atmospheres presents an eco-friendly alternative to conventional pesticides. This study focuses on nitrogen gas as a potential agent for insect control in stored commodities, utilizing computational simulations to investigate its penetration and distribution within two common storage configurations: chamber-contained pallets and silos. By employing the convection-diffusion equation, the simulations reveal insights into nitrogen distribution dynamics and duration required for oxygen reduction. The results highlight the influence of boundary conditions, commodity porosity, and convection effects on nitrogen dispersion. In chamber scenarios, boundary condition type significantly affects oxygen reduction time, while in silos, convection and diffusion interact to establish a consistent diffusion layer thickness. This research enhances the understanding of modified atmosphere techniques and their potential for sustainable pest management. It provides practitioners with valuable quantitative insights, paving the way for optimized modified atmosphere strategies in real-world agricultural contexts. Acknowledgments: This research is part of the project «Management of entomological infestations in the stored products by

using innovative technologies» (Project code: KMP6-0081034) that is co-funded by Greece and European Union by the Action «Investment Plans of Innovation» in Central Macedonia under the framework of the Operational Program «Central Macedonia 2021-2027».

Residual efficacy of graphene and the effect of grain type on its effectiveness for the control of major stored product insects

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The overuse and reliance on pesticides has caused insects to develop resistance that is recognized as a global problem with alarming trends of increased resistance making them ineffective. To address this problem extensive research is directed to find new and sustainable alternatives using chemical-free and resistance-free solutions for pest control. In this work, in a first bioassay, two graphene formulations (Gr1 and Gr2) were evaluated for their residual efficacy against two primary common colonizers, the rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) and the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) on soft wheat during a six-month period of storage. Graphene was applied at three dose rates: 0 (control), 500 and 1000 ppm and bioassays were carried out at 25 °C and 60% r.h. Mortality observations were taken every 7, 14 and 21 days of exposure for each month of storage. Both graphene formulations showed very good residual efficacy, maintaining their insecticidal performance throughout the six-month storage period. At 500 ppm graphene formulation Gr1 appeared to be more effective than Gr2 for *R. dominica*. Nevertheless, in most cases at 1000 ppm both formulations were equally effective for both insect species. In a second bioassay, the efficacy of three graphene formulations (XER, XEF and ML) against adults of three major stored grain beetle species, the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera:Tenebrionidae), the maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) and *S. oryzae* in three grain commodities was evaluated under laboratory conditions. The tested grains were soft wheat, paddy rice and maize. Graphene was applied at three dose rates: 0 (control), 500 and 1000 ppm and bioassays were carried out at 25 °C and 60% r.h. Mortality of the exposed adults was assessed after 7, 14 and 21 days of exposure, while progeny emergence was recorded 65 days after the last exposure interval. The grain type affected the insecticidal activity of graphene. All three graphene formulations were effective against the tested insect species and the increase of dose rate

notably increased insect mortality in all grain commodities. The results of the present study show that graphene is effective in a variety of grain commodities and can be utilized as a long-term protectant of agricultural products. The research work was supported by the Hellenic Foundation for Research and Innovation (HFRI) under the 4th Call for HFRI PhD Fellowships (Fellowship Number: 10814).

Evaluating Local Agricultural By-Products for Sustainable Compound Diets for Yellow Mealworm Larvae

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Agricultural by-products represent a significant reservoir of largely overlooked and underestimated resources. A practical approach to valorize and exploit these by-products and transform them into valuable nutrient sources is to employ them as insect feedstocks. However, for the sustainable and environmentally friendly bioconversion of these by-products by insects, it is essential to utilize locally available organic substrates. Thus, the primary aim of this research was to assess the suitability of 18 compound diets consisting of five agricultural by-products produced in Greece (i.e. oat by-product, brewer's spent grains, sunflower by-product, maize by-product, rice bran) as suitable feeding substrates for larvae of the yellow mealworm, *Tenebrio molitor* L. (Coleoptera: Tenebrionidae). More specifically, diets with varying protein levels (17.4, 20.3 and 22.6%) were formulated and evaluated in a laboratory bioassay. Briefly, 50 early-instar larvae were inserted in plastic vials and fed with the different diets, whereas their growth and performance was assessed over time. There were six replicates for each diet. The outcomes of the present study were promising for most tested diets, highlighting the potential of the agricultural by-products used as feed ingredients for *T. molitor* larvae. This experiment aims to enhance insect breeding efficiency at local level, while concurrently advancing the adoption of circular economy principles. This research is part of the project "EntoFEED" (Project code: KMP6-0077802) that is co-funded by Greece and European Union by the Action "Investment Plans of Innovation" in Central Macedonia under the framework of the Operational Program "Central Macedonia 2021 2027".

Contact efficacy of six inert dusts against adults of bean weevil (*Acanthoscelides obtectus* [Say], Coleoptera, Chrysomelidae)

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A set of laboratory experiments was conducted in 2023 in the Laboratory of Entomology of Biotechnical Faculty, to study the insecticidal activities of six inert dusts against the adults of bean weevil (*Acanthoscelides obtectus*). The inert dusts used were wood ash of silver fir trees (*Abies alba*), wood ash of Norway spruce trees (*Picea abies*), zeolite, quartz sand, Slovenian diatomaceous earth, and Silicosec®, a commercial brand of diatomaceous earth. Each of the inert dust was used in two concentrations, 10 and 20 g/m^2, and each combination was done in nine repetitions. Each dust was weighed directly into Petri dishes according to concentration, in which common beans (*Phaseolus vulgaris*) as the weevil's food source were then added and mixed with the dust. Fifteen adult weevils were introduced into each Petri dish to be in direct contact with the dust. An additional treatment of untreated beans was added as a negative control. Each experimental set was prepared six times, as they were stored in the six combinations of two storage temperatures of 20 and 25°C and two relative humidities (r.h.) of 55 and 75 % for two weeks, in the dark condition. The mortality of the weevil then was counted on days 1, 2, 3, 4 and 7 to determine the direct mortality. On the eighth day of the experiment, the live weevils were transferred into new Petri dishes without dust treatment along with a new food source, and the mortality was counted again for days 8-14 to determine the delayed mortality. The direct and delayed mortality values were then adjusted with the mortality in the control with Abbott's formula (Abbott, 1925). This poster presents the detailed results of this experiment, for each treatment combination and each storage condition, and the potential use of inert dusts in controlling bean weevils in the future.

IZVLEČEK

Kontaktno delovanje šestih inertnih prašiv na odrasle osebke fižolarja (*Acanthoscelides obtectus* [Say], Coleoptera, Chrysomelidae)

V letu 2023 je bil izveden niz laboratorijskih poskusov v Laboratoriju za entomologijo Biotehniške fakultete z namenom raziskati insekticidno delovanje šestih inertnih prahov na odrasle osebke fižolarja (*Acanthoscelides obtectus*). Uporabljeni inertni prahovi so bili lesni pepel navadne jelke (*Abies alba*), lesni pepel navadne smreke (*Picea abies*), zeolit, kremenov pesek, slovenska diatomejska zemlja in Silicosec®, tržna znamka diatomejske zemlje. Vsak od inertnih prahov je bil uporabljen v dveh koncentracijah, 10 in 20 g/m^2, vsaka kombinacija pa je bila ponovljena devetkrat. Prah je bil stehtan in dan v petrijevke glede na odmerjeno koncentracijo, v katere je bil dodan navadni fižol (*Phaseolus vulgaris*) kot vir hrane za fižolarja. V vsako petrijevko je bilo vnesenih 15 odraslih osebkov fižolarja, tako da so bili neposredno v stiku s prahom. Dodatno obravnavanje netretiranega fižolovega zrnja je predstavljalo negativno kontrolo. Vsaka od šestih kombinacij je bila nato shranjena na temperaturi 20 ali 25°C in na dveh vrednostih relativne zračne vlage (55 in 75 %) dva tedna v

temi. Smrtnost imagov smo ugotavljali 1., 2., 3., 4. in 7. dan. Osmi dan poskusa so bili živi imagi prestavljeni v petrijevke brez prahu s svežim zrnjem fižola. Smrtnost smo nato ugotavljali še od 8. do 14. dneva. Vrednosti direktne in zakasnjene smrtnosti smo pozneje korigirali z izračunom po Abbottovi formuli. V prispevku bodo predstavljeni rezultati poskusa za vsako obravnavanje pri vseh kombinacijah temperature in relativne zračne vlage, s poudarkom na diskusiji o potencialni uporabi inertnih prahov pri zatiranju fižolarja v prihodnosti.

Seasonal visualization of insect behavior and application of mating disruption in a feed mill

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In the present work, the seasonal distribution of stored product insects was recorded, spatially visualized, and evaluated in a feed production industry in Greece. Also, mating disruption method has been long regarded as a viable alternative control measure for *Ephestia* sp. and *Plodia interpunctella*, and have been utilized with success in several application scenarios. The installation of the trapping network took place in February 2022 and the insect recording lasted from February 2022 until April 2023. A total of 36 Dome traps (Trécé Inc.) were installed for trapping crawling insects. Oil (Storgard Oil, Trécé Inc.) was used as an attractive source and a killing agent. Also, for lepidopteran species 30 pheromone traps (Xlure-TRU, Russel IPM, UK) were used and for the mating disruption Dismate^{PE} (Deeside, Russel, UK) was applied. All insect samples taken were transferred to the Laboratory of Entomology and Agricultural Zoology at University of Thessaly for counting and identification. Additionally, the data were spatially visualized by using relevant Python libraries. This process enabled the identification of zones/areas in the building with the highest insect activity. Overall, the results indicated that in the winter months the captures were lower and mostly colonized specific areas, as compared with the summer months. For the Dome traps, the dominant stored product species were the rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), the tobacco beetle, *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae) and the confused flour beetle, *Tribolium confusum* Jacquelin du Val (Coleoptera: Tenebrionidae). For the mating disruption, the results showed that the total number of male moths captured in mating disruption-treated plots over each season was significantly lower than the respective number in untreated plots (control areas). Our results indicate that mating disruption can be an effective method and can be used as an insecticide-free control method for Lepidoptera in feed facilities. This research was carried out as part of the project «Integrated management of insect infestations in stored animal feed: Feed without pesticides» (Project code: KMP6-0088130) under the framework of the Action «Investment Plans of Innovation» of the

Operational Program «Central Macedonia 2021-2027», that is co-funded by the European Regional Department Fund and Greece.

Vpliv pestrosti prekrivnih dosevkov in obdelave tal na njihovo produktivnost in zmanjšanje zapleveljenosti

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Prekrivni posevki zagotavljajo številne ekosistemske storitve kot so ohranjanje kakovosti tal, kroženje hranil ter uravnavanje škodljivih organizmov. Zaradi večje zanesljivosti in izboljšanja njihovega učinka med sezonami se v zadnjem obdobju čedalje bolj uveljavljajo vrstno pestre mešanice prekrivnih dosevkov. V letih 2020 in 2022 smo na Kmetijskemu inštitutu Slovenije v Jabljah izvedli poljska poskusa, v katerih smo preučevali vpliv sistema obdelave tal na rast in razvoj dosevkov in plevelne vegetacije pri dveh monokulturnih vrstah dosevkov (oljna redkev in aleksandrijska detelja) ter dveh različno vrstno pestrih mešanicah (enostavna 5-vrstna in kompleksna 7-vrstna mešanica). Poskus je bil zasnovan v bločni postavitvi in split-plot zasnovi, kjer so bila glavna obravnavanja način obdelave pred setvijo (CN-konvencionalna s plugom in CS-ohranitvena s krožno brano), pod-parcele pa vrsta prekrivnega dosevka. Dvoletno preizkušanje je pokazalo precejšnjo sezonsko variabilnost tako v doseženi suhi biomasi, kakor učinku zmanjšanja zapleveljenosti. V letu 2020 je bila najbolj produktivna aleksandrijska detelja (2,9 t/ha v CN in 2,5 t/ha v CS), medtem ko smo v letu 2022 najvišje pridelke izmerili pri oljni redkvi in obeh mešanicah (0,82-0,91 t/ha). Tudi vpliv sistem obdelave tal na produktivnost dosevkov se je med letom razlikoval. Dosevki so leta 2020 v CN sistemu v povprečju dosegli 350 kg/ha višje pridelke suhe biomase kot v CS sistemu, medtem ko se le-ti leta 2022 niso razlikovali. V letu 2020, ko smo izmerili višje pridelke suhe mase dosevkov, se je pri vseh preučevanih vrstah biomasa plevela zmanjšala za več kot 90 %, medtem ko je bila stopnja učinkovitosti leta 2022 v razponu med 48 in 55 %. V naših poskusih mešanice dosevkov niso kontinuirano izkazovale višje stopnje učinkovitosti, smo pa ugotovili, da je bila pri aleksandrijski detelji zapleveljenost značilno večja v obeh letih preizkušanja. Prav tako smo v letu 2020, za katerega so bili značilni bolj ugodni rastni pogoji, pri obeh mešanicah ugotovili večji zatiralni učinek na plevele, v primerjavi z obema monokulturnima vrstama.

ABSTRACT

Productivity and weed suppression of single cover crop species and mixtures influenced by tillage practice

Cover crops (CC) provide numerous ecosystem services, such as maintaining soil quality, nutrient cycling and regulating harmful organisms. Diverse CC mixtures have been suggested to enhance these functions and achieve more stable inter-seasonal performance and effectiveness. In 2020 and 2022, a field experiment was conducted at the Agricultural Institute of Slovenia in Jablje to investigate the impact of soil management

systems on the CC productivity and weed development by using two monoculture CC species (oilseed radish and crimson clover) and two levels of species-rich CC mixtures (a simple 5-species and a complex 7-species mixture). The experiment was designed in a randomized block split-plot arrangement. Tthe main treatments were the tillage method (CN-conventional with plowing and CS-conservation with circular harrowing), while the subplots represented the type of CC mixture. The two-year trial showed considerable seasonal variability in both CC dry biomass as well as weed suppression effectiveness. In 2020, crimson clover was the most productive (2.9 t/ha in CN and 2.5 t/ha in CS), while in 2022, the highest yields were observed for oilseed radish and both of the CC mixtures (0.82-0.91 t/ha). The impact of soil management systems on the CC productivity of varied between years. In 2020, CC in the CN system, achieved 350 kg/ha higher dry biomass yields compared to the CS system, while in 2022, there was no significant difference. In 2020, characterized by favorable growing conditions and higher CC yields , weeds biomas decreased by more than 90% for all studied CC, while the weed suppresion rate in 2022 ranged from 48 to 55%. In our experiments, CC mixtures did not consistently demonstrate higher efficiency, but significantly higher weed infestation was observed in crimson clover in both years. In 2020, characterized with favorable growing conditions, both CC mixtures also exhibited a greater weed suppression effect compared to the both monoculture CC species.

Preživetje semen pelinolistne ambrozije (*Ambrosia artemisiifolia* L.) in trikrpe ambrozije (*Ambrosia trifida* L.) v tleh

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Pelinolistna ambrozija (*Ambrosia artemisiifolia* L.;AMBAR) in trikrpa ambrozija (*Ambrosia trifida* L.; AMBTR) sta najbolj razširjeni neofitni vrsti iz rodu Ambrosia. Rastline pelinolistne ambrozije proizvajajo precejšnje količine alergenega peloda, medtem ko je trikrpa ambrozija zaenkrat še redka, vendar ima bistveno večjo tekmovalno sposobnost. Namen naše raziskave je bil ugotoviti kakšna je kalivost in preživetje semena obeh vrst ambrozije glede na različno globino zakopa v tla. Seme smo nabrali leta 2015 in ga stratificirali pri 4° C približno dva meseca. V jeseni istega leta smo namestili 100 semen obeh vrst ambrozije v polietilenske mrežaste vrečke in zakopali v trajno travinje na globino 5 cm in 25 cm. Semena smo izkopali spomladi leta 2023 in preverili parametere njihove kalivost ter jih primerjali s standardnim vzorcem hranjenim na temperaturi 4°C. Pri tem smo ugotovili značilen vpliv plevelne vrste in globine zakopa na preživetje in kalivost semen. Vzorca AMBAR in AMBTR, ki sta bila skladiščena na hladnem sta po sedmih letih skoraj v celoti ohranila vitalnost (96 % in 90 %). Pri semenih AMBAR in AMBTR, zakopanih na globini 5 cm, pa smo ugotovili značilno višje zmanjšanje skupnega števila celih semen (47 % in 60 %). Na globini tal 25 cm je bil delež zmanjšanja števila semen bistveno nižji in je znašal 20% pri AMBAR in 32 % pri AMBTR. Kljub precejšnjim izgubam semena zaradi fizioloških procesov in predacije, je bil pri obeh vrstah delež kalivosti semen, ki so v zemlji preživela zelo visok in je pri AMBAR znašal 90 %, pri AMBTR pa kar 95 %. Naši rezultati bodo prispevali k razumevanju populacijske dinamike plevela, pri čemer visoki deleži kalivosti v tleh nakazujejo, da so tla pomemben rezervoar talne semenske banke, ki ohranja dolgoročno kalivost obeh vrst ambrozije.

ABSTRACT

Seed viability of common ragweed (*Ambrosia artemisiifolia* L.) and giant ragweed (*Ambrosia trifida* L.) in the soil

Common ragweed (*Ambrosia artemisiifolia* L.; AMBAR) and giant ragweed (*Ambrosia trifida* L.; AMBTR) are the most widespread neophytic species of the genus Ambrosia. Common ragweed plants produce significant amounts of allergenic pollen, while giant ragweed is not as widespread, but has significantly greater competitive ability. The purpose of our research was to determine the germination and survival rate of common and giant ragweed seeds under different burial depths in the soil. Seeds were collected in 2015 and stratified at approximately 4°C for about two months. In the fall of the same year, 100 seeds of both ragweed species were placed in polyethylene mesh bags and buried in permanent grassland at depths of 5 cm and 25 cm. The seeds were excavated in the spring of 2023 and their germination parameters were compared with a weed seed sample stored at a constant temperature of 4°C. We found a significant influence of weed species and burial depth on weed seed survival and germination rate. Compared to the stored samples of AMBAR and AMBTR, which preserved vitality almost entirely after seven years (96% and 90%), seeds buried at a depth of 5 cm showed a significantly higher reduction in the total number of intact seeds (47 % and 60 %). At a soil depth of 25 cm, the level of seed reduction was substantially lower, amounting to 20 % less seeds for AMBAR and 32 % for AMBTR. Despite significant seed losses due to physiological processes and seed predation, the germination rate of seeds that survived in the soil was very high ranging from 90 % for AMBAR and up to 95% for AMBTR. Our results are important for understanding the weed seed demography and longevity of weed seeds in the soil. Furthermore, high soil germination rates suggest that soil is an important reservoir that maintains the long-term germination of both ragweed species.

Vpliv sistema obdelave tal na velikost in raznovrstnost talne plevelne semenske banke

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V zadnjih letih se je povečalo zanimanje za uporabo manj intenzivnih sistemov obdelave tal, ki imajo zaradi različnih načinov in intenzivnosti posegov v tla, vpliv tudi na stanje dinamiko talne semenske banke. Ker je na voljo malo podatkov o količini in sestavi talne semenske banke v obdobju neposredno po spremembi načina obdelave tal, smo med leti 2020 in 2022 na površinah Kmetijskega inštituta Slovenije v Jabljah izvedli vzorčenje talne semenske banke. V raziskavi smo preučevali odziv semenske banke v zgodnjem obdobju prehoda iz konvencionalnega v manj intenzivne sisteme obdelave tal. Viabilno semensko banko smo določili v dveh terminih (spomladi in jeseni) s kalilnimi testi v mrežniku Kmetijskega inštituta Slovenije v Ljubljani. V poskus so bili vključeni trije sistemi obdelave tal: konvencionalna (CN), konzervirajoča (CS) in brez obdelave (NT), vzorčenje tal pa je bilo izvedeno na treh globinah: 0-5 cm, 5-10 cm in 10-20 cm. V primerjavi z jesensko sezono smo v spomladanskem terminu vzorčenja ugotovili značilno večjo talno semensko banko. Plevelna združba, ki je bila določena v semenski banki v jesenskem terminu, je imela večjo relativno številčnost vrst v združbi (E) v primerjavi s spomladansko. Tako spomladanska kot jesenska plevelna združba sta imeli podobno

število plevelnih vrst (D). Zaradi večje intenzitete obdelave v CN in CS sistemu je bilo v primerjavi z NT sistemom opaženo manjše število vrst v obeh terminih. Nasprotno pa je bila manjša relativna številčnost vrst v združbi v intenzivnejšem sistemu obdelave. Rezultati raziskave so pokazali, da ima uvedba različnih sistemov obdelave dokaj hiter vpliv tako na velikost kot sestavo plevelne semenske banke. Priporočljivo je, da bi se študije semenske banke obravnavale kot pomemben postopek v okviru integriranega uravnavanja plevelne populacije, ki bi preprečila večje izzive pri zatiranja plevela v obdobju prehoda v manj intenzivne sisteme obdelave.

Ključne besede: plevelna semenska banka, obdelava tal, vrstna pestrost, raznolikost plevela

ABSTRACT

Influence of tillage system on the size and diversity of the soil weed seed bank

In recent years an increase in interest in the use of less intensive tillage systems have been observed, due to different methods and intensity of tillage regime and also have impact on the dynamics of the soil seed bank. Since small amount of information is available of the size and composition of weed seed bank in the period immediately after the alteration of tillage regime, sampling of soil seed bank was performed in years 2020-2022 at the Agricultural institute of Slovenia in Jablje. We examined the viable weed seed bank response in the early transition period from conventional to less intensive tillage systems. The viable weed seed bank was determined at two cropping periods (spring and autumn), in the germination experiments, performed in a net greenhouse at the Agricultural institute in Ljubljana. Three tillage systems were included in the experiment: conventional (CN), conservation (CS) and no-tillage (NT), while soil sampling was carried out at three sampling depths: 0-5 cm, 5-10 cm in 10-20 cm. Significantly larger soil seed bank was observed in the spring, compared to the autumn sampling period. Weed community determined in the viable weed seed bank in autumn cropping period had a higher species evenness (E) compared to spring cropping period. Spring and autumn weed community have a similar number of weed species (D) in all tillage systems. Due to greater soil disturbance level in the CN and CS tillage system a decrease in species richness was observed in both cropping periods compared to NT system. In contrast, species evenness was lower in more intensive tillage systems. The results of the study showed that the introduction of different tillage systems had an immediate impact on both size and composition of the weed seed bank. We recommend that seed bank studies should be considered as an important element of integrated weed management to avoid greater weed control challenges in the process of transition to less intensive tillage systems.

Chemical control options against *Erysiphe graminis*

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The steady growth of the Earth's population will significantly increase the demand for cereals. Pathogens, including cereal powdery mildew (*Erysiphe graminis*), cause significant worldwide losses. 60–90% of the Hungarian wheat production area suffers from its damage. In average years, it causes 5–8% yield losses, reaching even 25–30% in case of

heavy infection rates. The yield reduction is high if both the flag leaf and the ear are infected. In order to avoid severe crop losses, more efficient control of powdery mildew is required. The experiment was carried out in 2021 using the MV KONDÁS wheat variety near the settlement Iklódbördőce. Seven large-plot treatments were set up with four replications, including untreated controls. The first treatment was performed in the second node formation stage on April 27. The second treatment was carried out on May 11. Two fungicides were used twice for the first, second and third treatments. Treatments four and five were also carried out in the second node formation stage using a single treatment. The sixth and seventh treatments were also treated with one spraying when the flag leaves were spread out. During the evaluation, the powdery mildew infection was examined as a surface percentage compared to the total green surface. After harvesting soybean as a pre-crop, the wheat was sowed in mid-October. The amount of precipitation was average, and the winter was mild and almost free of frost. A one-factor analysis of variance was used to evaluate the results. Two treatments have proven to be more effective in preventing powdery mildew damage. During the single treatments, it was proven that the protection performed in the second node formation stage was more effective. There was no significant difference in the yield between the untreated control and the treatment applied in the flag leaf stage.

Vpliv razdalje med šobami na škropilni letvi na pokritost klasov in listov jare pšenice (*Triticum aestivum* L)

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Običajna horizontalna razdalja med šobami na škropilni letvi je 50 cm. V zadnjem času se ponekod uporablja tudi 25 cm horizontalna razdalja med šobami, kar pomeni določene spremembe pri škropljenju. Potrebno je znižati škropilno letev oz. vertikalno razdaljo med šobami in ciljno površino na 25 cm, da je dosežena enakomerna prečna volumska porazdelitev škropilnih curkov. Zato je bil v letu 2002 narejen poljski poskus na Laboratorijskem polju Biotehniške fakultete na jari pšenici, sorta Valbona. Za škropljenje smo uporabili nošeno traktorsko škropilnico in 12 m škropilne letve. Poskusna zasnova so bili slučajni bloki s 4 ponovitvami in štirimi obravnavanji. V prvem obravnavanju je znašala tako horizontalna razdalja med šobami kot tudi vertikalna razdalja do ciljne površine 25 cm, medtem ko je bila v drugem obravnavanju vertikalna razdalja 50 cm pri 25 cm horizontalni razdalji med šobami. Tretje obravnavanje je vključevalo 50 cm horizontalno razdaljo med šobami in 25 cm vertikalno razdaljo in četrto obravnavanje 50 cm horizontalno razdaljo in 50 cm vertikalno razdaljo. Pri 50 cm horizontalni razdalji med šobami smo uporabili injektorske šobe z dvojnim asimetričnim curkom High Speed 110 04, medtem ko pri 25 cm horizontalni razdalji šobe iste izvedbe High Speed z oznako 110 02. Parametri škropljenja, kot so poraba vode, tlak in hitrost, so ostali pri vseh obravnavanjih nespremenjeni. V članku bodo predstavljeni rezultati pokritosti klasov in listov jare pšenice pri omenjenih obravnavanjih.

ABSTRACT

Influence of nozzle spacings on spraying boom on head and leaf coverage of spring wheat (*Triticum aestivum* L)

Broadcast nozzle spacing along a boom is 50 cm. Recently, a 25 cm nozzle spacing has also been used in some places, which means certain changes by spraying. A spraying boom or vertical distance between nozzles and target surface should be lowered in order to achieve uniform transverse volume distribution of spray patterns. Therefore, a field trial was carried out in 2022 on the Laboratory filed of Biotechnical Faculty on spring wheat, cultivar Valbona. Tractor mounted sprayer with 12 m wide spraying boom was used for spraying. Trial design were random blocks with four repetitions and four treatments. It the first treatment nozzle spacing as well as vertical distance from target surface amounted 25 cm, while in the second treatment vertical distance was 50 cm by 25 cm nozzle spacing. The third treatment contained 50 cm nozzle spacing and 25 cm vertical distance and the fourth treatment 50 cm nozzle spacing as well as 50 cm vertical distance. For 50 cm nozzle spacing we used injector nozzles with double asymmetric spray pattern High Speed 110 04, while for 25 cm nozzle spacing the same nozzle type High Speed with mark 110 02 were used. Spray parameters, such as water rate, pressure and speed, remained unchanged by all treatments. In the article results of head and leaf coverage of spring wheat will be presented by above mentioned treatments.

Učinkovitost uporabe 4 šob z dvojnim simetričnim curkom v ozimni pšenici

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V letu 2022 smo na Laboratorijskem polju BF izvedli poljski poskus, v katerem smo uporabili 4 različne šobe Avi Twin z oznakami 01, 02, 03 in 04 z dvojnim simetričnim curkom v posevku ozimne pšenice. Šobe z dvojnim curkom se uporabljajo predvsem za boljšo pokritost vertikalnih delov gojenih rastlin. Tlak škropljenja (3,0 bar) in vozna hitrost (6,0 km/h) sta bila ves čas konstantna. Učinkovitost šob smo definirali kot kakovost in količino nanosa na sprednji in zadnji strani klasa ter na listu zastavičarja (1. list) in nižje ležečemu listu (2. list). Za ugotavljanje kakovosti nanosa smo uporabili na vodo občutljive lističe, medtem ko za količino nanosa barvilo Helios 500 SC, ki je služilo kot tracer. Odtise kapljic smo izmerili s kamero in programom Wise Node, medtem ko smo količino tracerja analizirali s tekočinsko kromatografijo visoke ločljivosti (HPLC). Ugotovili smo, da s šobami 03 in 04 dosežemo večjo pokritost in večjo količino tracerja na klasih in listih ozimne pšenice kot pri šobah 01 in 02, kar je posledica večje porabe vode, ki jo omogočata šobi 03 in 04. Manjša pokritost je bila pri vseh uporabljenih šobah na zadnji strani klasa.

ABSTRACT

Performance of four symmetric double flat fan nozzles in winter wheat

In 2022 field trial was conducted on the laboratory field of BF, in which we used 4 different Avi Twin nozzles marks 01, 02, 03 and 04 with double symmetric jet in winter wheat.

Double flat fan nozzles are mainly used for better coverage of vertical crop plant parts. Spraying pressure of 3.0 bar and speed of 6.0 km/h were during the experiment constant. Nozzles performance in the trial we defined as deposit quality and deposit quantity on the front and the back side of wheat head, on the flag leaf (1st leaf) and lower lying leaf (2nd leaf). For the determination of deposit quality water sensitive papers were used, while for the deposit quantity dye Helios 500 SC which served as tracer. Deposit impressions were measured with camera and program Wise Node, while tracer quantity was analyzed with high-performance liquid chromatography (HPLC). We established that with the 03 and 04 nozzles higher coverage and higher tracer quantity were achieved on the wheat heads and leaves than with the 01 and 02 nozzles which is a consequence for more water consumption which is gained by nozzles 03 and 04. By all used nozzles lower coverage was on the back side of wheat head.

Laboratorijsko preizkušanje učinkovitosti antagonističnih gliv *Trichoderma* spp. na povzročitelje verticilijske uvelosti rastlin (*Verticillium* spp.)

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V laboratorijskih poskusih smo s pomočjo metode dvojnih kultur ugotavljali antagonistični potencial nekaterih izolatov različnih vrst gliv *Trichoderma* spp. (*T. atroviride, T. koningiopsis, T. harzianum, T. afroharzianum, T. gamsii*) proti izolatom dveh vrst fitopatogenih gliv iz rodu *Verticillium* (*V. nonalfalfe* in *V. dahliae*) pri dveh temperaturah (15 in 25 °C). Pri višji temperaturi, 25 °C, je prišlo do antagonističnih interakcij dosti prej kot pri nižji. Med preučevanimi *Trichoderma* spp. je bila ugotovljena velika razlika v njihovem antagonističnem potencialu, vendar je ta odvisen tudi od *Verticillium* vrste oziroma posameznega izolata. Če ugotovitve o odmiranju micelija *Verticillium* spp. povežemo z dobljenimi rezultati inhibicije rasti micelija zaradi delovanja *Trichoderma* spp., sta imeli pri obeh temperaturah in v kombinacijah z vsemi izolati *Verticillium* spp. največji antagonistični potencial glivi *T. afroharzianum* in *T. atroviride.*

ABSTRACT

Laboratory study on the efficacy of the antagonistic fungi *Trichoderma* spp. on the pathogens of *Verticillium* wilt of plants (*Verticillium* spp.)

In laboratory experiments, the antagonistic potential of some isolates of different fungal species of *Trichoderma* spp. was determined using the double culture method. (*T. atroviride, T. koningiopsis, T. harzianum, T. afroharzianum, T. gamsii*) against isolates of two species of phytopathogenic fungi of the genus *Verticillium* (*V. nonalfalfe* and *V. dahliae*) at two temperatures (15 and 25 °C). At a higher temperature, 25 °C, antagonistic interactions occurred much earlier than at a lower temperature. Among the *Trichoderma* spp. studied, a large difference in their antagonistic potential was observed, but this also depends on the *Verticillium* species or the individual isolate. If the findings on mycelial death of *Verticillium* spp. correlate with the results of inhibition of mycelial growth by the action of *Trichoderma* spp., the fungi *T. afroharzianum* and *T. atroviride* had the greatest

antagonistic potential at both temperatures and in combination with all isolates of *Verticillium* spp.

Raziskava prisotnosti oomicet rodu *Phytophthora* v slovenskem botaničnem vrtu

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Raziskava je bila osredotočena na prisotnost oomicet rodu Phytophthora v slovenskem botaničnem vrtu v okviru projekta Euphresco "Phytophthora v javnih vrtovih: razumevanje njenega prenosa in zmanjšanje tveganja". Phytophthora je rod oomicet, ki obsega približno 200 vrst, od katerih je večina agresivnih rastlinskih patogenov. V zadnjih 20 letih pojav novih invazivnih vrst rodu Phytophthora vzbuja zaskrbljenost glede njihovega vpliva na gozdne, kmetijske in naravne ekosisteme. Javni vrtovi in parki, ki so bogati z genetsko raznolikostjo rastlin in predstavljajo dragocene rastlinske zbirke, nenehno pridobivajo nove rastline, s čimer se povečuje tveganje za vnos oomicet. Take vrtove lahko obravnavamo kot rezervoarje vrst Phytophthora, še posebej, ker eksotične rastline iz različnih krajev povečujejo verjetnost hibridizacije med njimi in celo nastanka novih, bolj agresivnih genotipov. Cilj raziskave je identificirati prevladujoče vrste Phytophthora v slovenskem botaničnem vrtu z združevanjem tradicionalne metodologije in sodobnega pristopa sekvenciranja črtnih kod okoljske DNK. Julija 2023 smo vzorčili liste rododendrona, tla in vodo v parku. Iz listov smo izolirali oomicete Phytophthora z uporabo selektivnega medija P_5ARPH, jih morfološko analizirali in molekularno identificirali z uporabo pomnoževanja in sekvenciranja črtnih kod. Iz vzorcev vode smo s pomočjo metode vab z rododendronovimi listi zbrali izolate, ki so bili identificirani po postopku opisanem zgoraj. DNK izolirano iz vzorcev vode in tal smo uporabili v vgnezdenem PCR, s pomočjo katerega preverimo prisotnost ali odsotnost DNK organizmov rodu Phytophthora. Pozitivni vzorci so bili poslani v Združeno kraljestvo za sekvenciranje nove generacije (z Illumino), kjer analize še potekajo. Rezultati prvega vzorčenja kažejo na prisotnost oomicet rodu Phytophthora ne le na simptomatičnih rastlinah, temveč tudi v vodnih telesih ter zemlji v parku. Naša raziskava prispeva pomemben doprinos k skupnemu razumevanju vloge javnih vrtov in njihovega vpliva na raznolikost ter epidemiologijo patogenov rodu Phytophthora. Le-to bo omogočilo opis tveganja za okrasne rastlinske zbirke in olajšalo nadzor ter sprejem ukrepov upravljanja.

ABSTRACT

Study of *Phytophthora* presence in Slovenian botanical garden

The study focused on the presence of Phytophthora in the Slovenian botanical garden as part of Euphresco project "Phytophthora in Public Gardens: Understanding Pathways and Mitigating Risk". Phytophthora is a genus of Oomycetes with around 200 species, many of which are aggressive plant pathogens. Over the past 20 years, the emergence of new and invasive species of Phytophthora has raised concerns about the impact of these pathogens in forest, agricultural and natural ecosystems. Public gardens and parks, rich in

genetic diversity and home of valuable plant collections, constantly acquire new plants which increase the risk of Phytophthora introduction. These gardens can be seen as reservoirs of species, especially as exotic plants from diverse origins increase the probability of hybridization and generation of aggressive genotypes. The aim of this work was identifying the prevalent Phytophthora species in selected garden with combining traditional methodology and more modern approach of eDNA barcoding. In July 2023, we sampled rhododendron leaves, soil and water. Phytophthora isolates were obtained from leaves using the P_5ARPH selective medium, morphologically analysed, and identified molecularly sequencing of selected barcodes. From water samples isolates, which were further identified as described above, were obtained by performing leaf baiting method. DNA extracted from water and soil was used in nested PCR to verify the presence or absence of Phytophthora DNA. Phytophthora-positive samples were sent to the UK for Illumina next-generation sequencing; where the analysis is currently in progress. First sampling results indicate presence of various oomycetes from the genus Phytophthora not only on symptomatic plants but also in water bodies and soil. Our study brings important contribution to the understanding of the public gardens role and their impact on the diversity and epidemiology of Phytophthora pathogens. This will allow determining risk for ornamental plant collections and enable to prompt surveillance and management measures.

Razumevanje vedenja občanskih znanstvenikov pri varstvu gozdov

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Večina invazivnih gozdnih škodljivih organizmov se pogosto ustali predvsem v urbanih območjih, od koder se razširijo tudi v naravne habitate. Zgodnje odkritje potencialno invazivnih škodljivih organizmov je ključnega pomena za uspešno obvladovanje njihovih izbruhov. Občanska znanost, ki vključuje splošno javnost, ima potencial kot močno orodje za pasivno in aktivno spremljanje zdravja gozdov. Kljub temu pa zgodnje odkrivanje invazivnih škodljivih organizmov s strani občanskih znanstvenikov postavlja več izzivov. Nekateri škodljivi organizmi niso velike in svetle žuželke, ki bi bile privlačne za laike ali izkušene naravoslovce, prav tako pa je njihov negativni vpliv na drevesa običajno nespecifičen in lahko ostane neopažen vrsto let. To še posebej velja za škodljive organizme, ki se šele vzpostavljajo na novem območju. Njihovo odkrivanje s stani opazovalcev, ne glede na to ali so usposobljeni ali ne, je redek dogodek. Zato si prizadevamo razumeti, kateri občanski znanstveniki učinkoviteje prispevajo k spremljanju zdravja gozdov. S pomočjo podatkov iz spletnega portala iNaturalist nameravamo preučiti vedenje in motivacijo občanskih znanstvenikov pri njihovem prispevanju k spremljanju zdravja gozdov, vse to s ciljem oblikovanja učinkovitih projektov občanske znanosti za spremljanje zdravja gozdov.

ABSTRACT

Understanding behaviour of Citizen scientists in Forest Health

Most invasive species forest pests are primarily established in urban areas, from where they can spread and colonize natural habitats. Early detection of potential invasive pests

is a crucial step for successfully managing pest outbreaks. Citizen science, involving the general public has the potential to be a powerful tool for passive and active forest health surveillance. However, the early detection of invasive pests by citizen scientists poses several challenges. Some of the pests are not big and bright insects that are appealing to amateurs or experienced naturalists. Their impact on trees is usually nonspecific and can remain inconspicuous for years before severe symptoms become obvious. This is especially true when an invasive pest has just established itself in a new area. Detection by observers, whether trained or not, is a likely very rare event. For this reason, we want to understand which citizen scientists are likely to contribute efficiently to forest health monitoring. We will use iNaturalist as a data source to understand the behaviour and motivation of citizen scientists, contributing to forest health surveillance, in order to help design efficient citizen science forest health monitoring projects.

Primerjava dveh metod za detekcijo *Lecanosticta acicola*, *Dothistroma pini* in *D. septosporum*

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Drevesa iz rodu *Pinus* so ekološko in družbeno-ekonomsko pomemben del slovenskih gozdov. V zadnjih nekaj desetletjih njihovo zdravje in odpornost ogrožata dve bolezni borovih iglic, rjavenje borovih iglic, ki ga povzroča *Lecanosticta acicola*, ter rdeča pegavost borovih iglic, ki jo povzročata *Dothistroma pini* in *D. septosporum*. V Sloveniji smo rjavenje borovih iglic prvič zaznali leta 2008, rdečo pegavost borovih iglic pa že leta 1971. Vse tri glive na gostiteljskih rastlinah povzročajo podobne simptome, lahko pa so tudi hkrati prisotne. Ker se morfološko ne razlikujejo dovolj za identifikacijo do vrste, so za določitev patogena, ki na gostitelju povzroča simptome, potrebne robustne molekularne metode. Preverili in primerjali smo učinkovitost dveh različnih molekularnih metod detekcije s pomočjo specifičnih začetnih oligonukleotidov, polimerazno verižno reakcijo in polimerazno verižno reakcijo v realnem času,. Metodama smo določili kritične parametre in limito detekcije in s tem verificirali njuno implementacijo v diagnostiko gozdnih patogenov na območju Slovenije. Dodatno smo primerjali tudi kritične parametre obeh metod.

ABSTRACT

Comparison of two methods for detection of *Lecanosticta acicola*, *Dothistroma pini* and *D. septosporum*

Pine trees *Pinus spp.* are an ecologically and socio-economically important part of the Slovenian forests. Two pine needle diseases have been affecting vitality and future resilience of pine trees in the last few decades. The brown spot needle blight, caused by *Lecanosticta acicola* and the Dothistroma needle blight (DNB), caused by *Dothistroma pini* and *D. septosporum*. First detected in Slovenia in 1971 (DNB) and 2008 (*L. acicola*), the three fungi produce similar symptoms in the host plant and can even be present simultaneously. As they are morphologically not distinct enough for identification to the level of species, robust molecular methods are needed to identify the pathogen infecting

the host. We verified and compared the efficiency of two molecular methods for detection, a specific end-point PCR and a specific real-time PCR. We determined the critical parameters and the limit of detection for both methods, verifying the implementation of both protocols into the forest health diagnostics in Slovenia. Additionally, we compared the critical parameters of the two methods.

Preizkušanje alternativnih sredstev za zatiranje plevelne vegetacije na železniški infrastrukturi

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Po uvedbi prepovedi uporabe glifosata na železniški infrastrukturi v letu 2021, se na slovenskih železnicah soočajo z vse večjo zapleveljenostjo in zaraščanjem, kar povečuje stroške vzdrževanja, pospešuje degradacijo tirne grede in zmanjšuje varnost v železniškem prometu. Z namenom preučitve učinkovitosti nadomestnih pripravkov za zatiranje plevelne vegetacije smo na Kmetijskem inštitutu v letu 2022 izvedli poskus na zapleveljenem delu železniških tirov, na lokaciji Ljubljana – Moste. V preizkušanje smo vključili pripravke z aktivnimi snovmi flazasulfuron (FS), dikamba (DK), fluroksipir (FP), kombinacija flazasulfrona z dikambo (FD) in s fluroksipirom (FF) , pelargonsko kislino (PK) ter glifosat (GF) kot pozitivno kontrolo. Škropljenje smo izvedli jeseni (10. 10. 2022). Ocene učinkovitosti so bile izvedene 15 in 30 dni po aplikaciji, škropljene površine pa smo vizualno spremljali tudi v spomladanskem obdobju. Najvišje učinkovitosti proti širokolistnim plevelom po 30 dneh smo zabeležili pri postopkih GF (94 %), FF (66 %), proti plevelom iz družine trav pa pri postopku GL (92 %). Pri postopkih z uporabo glifosata in flazasulfrona ter kombinacij z flazasulfronom (FD, FF) je bil med 14 in 30 dnem opazen trend naraščanja učinkovitosti, pri ostalih pa je bil ta trend negativen. Pri pregledu parcel spomladi je bilo v postopku GL opazen močan vznik plevelov (predvsem ambrosia artemisiaefolia), v postopkih FS, FD in FF pa novega vznika plevelov skoraj nismo opazili. Pri ostalih postopkih smo poleg novega vznika opazili tudi obraščanje preživelih rastlin. Iz rezultatov je razvidno, da je je med preskušanimi enkratnimi jesenskimi aplikacijami, z učinkovitostjo glifosata primerljiva zgolj uporaba kombinacije flazasulfrona in fluroksipira. Najboljši dolgoročni učinek pa zagotavlja uporaba flazasulfrona samostojno ali v kombinaciji z dikambo ali fluroksipirom.

ABSTRACT

Testing of alternative herbicides for weed control on railway infrastructure

After the ban on the use of glyphosate on railway infrastructure in 2021, the Slovenian Railways are facing increasing weed infestation and overgrowth, which raises maintenance costs, accelerates the degradation of the track bed, and reduces safety in rail traffic. With the aim of comparing the effectiveness of alternative preparations for weed control, we conducted a trial in 2022 on a weedy part of the railway tracks at the location Ljubljana – Moste. The preparations tested included those with active substances flazasulfuron (FS), dicamba (DK), fluroxypyr (FP), a combination of flazasulfuron with dicamba (FD) and with fluroxypyr (FF), pelargonic acid (PK), and glyphosate (GF) as a positive control. Spraying was carried out in the autumn (October 10, 2022). Assessments

of efficacy were conducted 15 and 30 days after application, and the treated areas were also visually monitored during the spring. The highest effectiveness against broadleaf weeds after 30 days was recorded in the GF (94%) and FF (66%) treatments, and against grasses in the GL (92%) treatment. In treatments using glyphosate and flazasulfuron, as well as combinations with flazasulfuron (FD, FF), an increasing trend in efficacy was observed from 14 to 30 days, while with other treatments this trend was negative. Upon inspection of the plots in the spring, a strong emergence of weeds (especially ambrosia artemisiaefolia) was observed in the GL treatment, while in the FS, FD, and FF treatments, almost no new weed emergence was observed. In other treatments, besides new emergence, overgrowth of surviving plants was also noted. From the results, it is evident that among the single autumn application treatments tested, only the effectiveness of a flazasulfuron, when combined with fluroxypyr, matches that of glyphosate. But the best long-term effect is ensured using flazasulfuron alone or in combination with dicamba or fluroxypyr.

Analiza tehničnega stanja pršilnikov v občini Nova Gorica

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Na osnovi rednih pregledov naprav za nanos FFS smo analizirali stanje pršilnikov v občini Nova Gorica. Primerjali smo rezultate pregledov pršilnikov v letu 2018 in 2014. Leta 2018 je bilo pregledanih 449 pršilnikov. 61 pršilnikov oziroma 13,6 % je imelo vsaj eno napako. Na prvem mestu napak je poškodovan ali neustrezen manometer z 26,7 % deležem, sledijo pa zamašene šobe s 19,8 % deležem. Leta 2014 je bilo pregledanih samo 28 pršilnikov. Od tega je imelo 25 % pršilnikov vsaj eno napako. Največ napak je bilo zaradi poškodovanega manometra in kardanske gredi brez zaščite. Povprečna starost pršilnikov leta 2018 je bila 26 let, med proizvajalci pršilnikov pa prevladuje Agromehanika s 34,3 % deležem.

ABSTRACT

Analysis of the technical condition of air-assisted sprayers in the municipality of Nova Gorica

Based on regular inspections of pesticide application equipment, we analysed the condition of air-assisted sprayers in the municipality of Nova Gorica. We compared the results of air-assisted sprayer inspections in 2018 and 2014. In 2018, 449 air-assisted sprayers were inspected. 61 air-assisted sprayers or 13.6% had at least one defect. The most common defect was a damaged or inadequate manometer with a 26.7% share, followed by clogged nozzles with a share of 19.8%. In 2014, only 28 air-assisted sprayers were inspected. Out of all inspected air-assisted sprayers 25% of them had at least one defect. Most of the defects were due to a damaged manometer and cardan shaft without protection. The average age of air-assisted sprayers in 2018 was 26 years, and Agromehanika dominated among manufacturers with a 34.3% share.

Tehnične možnosti za manjšo porabo fitofarmacevtskih sredstev

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Evropska skupnost in Slovenija sta se na osnovi direktive 2009/128/ES zavezali, da bosta zmanjšali porabo fitofarmacevtskih snovi. Poleg različnih agronomskih možnosti za zmanjšanje porabe FFS, pa so na voljo tudi tehnične rešitve. Eden izmed prvih tehničnih ukrepov je redno umerjanje ali kalibracija naprav za nanašanje FFS. Kmetje to zelo poredko izvajajo, zamenjujejo pa tudi z obveznim pregledom naprave iz strani akreditiranih institucij. Reciklažni – tunelski pršilniki za trajne nasade omogočajo ponovno uporabo škropiva, ki ni pristalo na ciljni površini. V zgodnjih vegetativnih fazah vinske trte se lahko reciklira do 85 % škropiva, pri zadnjih škropljenjih v sezoni pa manj. Tak stroj je v tujini uvrščen na seznam naprav z visoko stopnjo redukcije drifta, saj je bistveno manjši tudi drift - zanašanje škropiva. V trajnih nasadih je možno ciljno nanašanje škropiva s tako imenovano PWM tehnologijo škropljenja. Ciljna vegetacija je določena z ultrazvočnim senzorjem, LIDAR kamero ali stereo kamero. PWM tehnologija (pulzno širinska modulacija) omogoča glede na zaznano vegetacijo različen oziroma potreben pretok skozi šobo ob istem tlaku in isti velikosti kapljic. Nekateri proizvajalci že ponujajo komercialne rešitve, ki pa imajo trenutno še dokaj visoko ceno. Namesto pesticidov lahko preventivno varstvo vinske trte pred peronosporo, oidijem - pepelovko in botritisom izvajamo z ultravijoličnimi žarki. UV-C ultravijolično sevanje je elektromagnetno sevanje v območju 200–280 nanometrov. To sevanje ima baktericiden učinek. Mikroorganizmi, ki so izpostavljeni UV-C sevanju, v nekaj sekundah postanejo neaktivni. Trenutno je ponudnik teh naprav francoski UV Boosting. V sadjarstvu in vinogradništvu so vse bolj pomembne nekemične metode zatiranja plevelov v pasu pod drevesi ali pod trto (vrstnem prostoru). Med nekemične metode zatiranja plevelov sodijo mehanski način, termični način, zastirka itd. Plevele v vrstnem prostoru trajnega nasada pa lahko zatiramo s pomočjo električne energije. Podjetje Zasso je razvilo napravo, ki uničuje plevele s fiksnimi in premičnimi elektrodami in 8000 V napetosti.

ABSTRACT

Technical possibilities for reducing use of pesticides

On the basis of Directive 2009/128/EC, the European Community and Slovenia undertook to reduce the use of pesticides. In addition to various agronomic options for reducing pesticides consumption, technical solutions are also available. One of the first technical measures is a regular calibration of pesticide application equipment. Farmers rarely do this, and they also confuse it with the obligatory inspection of the equipment by accredited institutions. Another technical measure, which is mostly used on permanent plantations, is a Recycling tunnel sprayer. It can reuse the spray that did not land on the target surface. Up to 85% of the spray can be recycled in the early vegetative stages of the vinegrape, but less in the last sprays of the season. In other countries such a machine is included on the list of equipment with a high level of drift reduction, as the drift of the spray - is significantly smaller. On permanent plantations, targeted application of the spray is possible with the so-called PWM spraying technology. Target vegetation is determined by ultrasonic sensors, LIDAR camera or stereo camera. PWM technology (Pulse Width Modulation) allows for a different or necessary flow rate through the nozzle at the same pressure and the same droplet size depending on the detected vegetation. Some manufacturers already offer commercial solutions, but at the moment they still have a fairly high price. Instead of pesticides, the preventive protection of grapevines against downy mildew, powdery mildew and botrytis can be carried out with ultraviolet rays. UV-C

ultraviolet radiation is electromagnetic radiation in the 200-280 nanometer range. This radiation has a bactericidal effect. Microorganisms exposed to UV-C radiation become inactive within seconds. Currently, the producer of these devices is the French UV Boosting. In fruit growing and viticulture, non-chemical methods of weed control in the belt under the trees or under the vine (row area) are increasingly more important. Non-chemical methods of weed control include mechanical methods, thermal methods, etc. Weeds in the row space can be suppressed with the help of electricity. The company Zasso has developed a device that controls weeds with fixed and movable electrodes and 8000 V voltage

KAZALO AVTORJEV / INDEX OF AUTHORS

Pokrovitelj

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