Slovensko **agronomsko društvo**

Slovenian Society of Agronomy

Novi izzivi v agronomiji 2023

PROGRAM SIMPOZIJA
IN POVZETKI PRISPEVKOV

New challenges in agronomy 2023

SYMPOSIUM PROGRAM
AND SUMMARIES

Laško 2023

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PROGRAM SIMPOZIJA IN POVZETKI PRISPEVKOV, ki niso objavljeni v zborniku

NEW CHALLENGES IN AGRONOMY 2023

SYMPOSIUM PROGRAM AND SUMMARIES

Laško, 2023

Simpozij Novi izzivi v agronomiji 2023 z mednarodno udeležbo
Laško, 26. in 27. januar 2023

PROGRAM SIMPOZIJA IN POVZETKI PREDAVANJ, ki niso objavljeni v zborniku kot celotni prispevki

Uredniki (po abecednem vrstnem redu):
dr. Barbara Čeh, dr. Peter Dolničar, prof. dr. Denis Stajnko, dr. Igor Šantavec in Igor Škerbot

Povzetki so recenzirani. Za jezikovno pravilnost odgovarjajo avtorji. S poslanim prispevkom se avtorji strinjajo s tiskano in spletno objavo. Uredniki zbornika ne odgovarjajo za vsebino komercialnih oglasov in sporočil.

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KAZALO

PROGRAM SIMPOZIJA NOVI IZZIVI V AGRONOMIJI 2023

26.–27. januar 2023

Četrtek, 26. januar 2023

8.00 – 9.00 Registracija z jutranjo kavico/čajem
9.00 – 12.00 Otvoritev, pozdravni govori in prva sekcija

Rodovitnost tal. Vodja: dr. Denis Stajnko

Ohranitveno kmetijstvo – zakaj, kje smo v Sloveniji in kako prilagodimo strategijo gnojenja
Rok MIHELIČ

25 years of «Oberacker» for a climate-friendly and soil-conserving agriculture of the future
Andreas CHERVET, Claudia MAURER in Wolfgang G. STURNY

Mineral Inducer Process technology, a tool for sustainable management of soils
Benoit Le RUMEUR

Compost – improving soil fertility and soil carbon
Werner VOGT-KAUTE, Aleš KOLMANIČ, Simon OGRAJŠEK, Snežana JAKŠIĆ in Milorad ŽIVANOV

Kompostiranje hmeljevine in karakteristike zrelega komposta
Barbara ČEH, Lucija LUSKAR, Julija POLANŠEK, Ana KARNIČNIK KLANČNIK in Žan TROŠT

15 minutni odmor

Vodja: dr. Igor Šantavec

Mikrobna biomasa ter številčnost bakterij, arhej in gliv v odvisnosti od obdelave tal
Anton GOVEDNIK, Rok MIHELIČ in Marjetka SUHADOLC

Vpliv sistema obdelave tal na izbrane lastnosti tal
Urša PEČAN, Rok MIHELIČ, Marina PINTAR in Damijana KASTELEC

Ugotavljanje količine izpustov CO_2 iz tal pri različnih sistemih obdelave tal
Anže ROVANŠEK in Robert LESKOVŠEK

Preliminarna ocena vpliva konvencionalne in ohranitvene obdelave tal na zbitost tal
Matic NOČ, Matjaž GLAVAN, Rok MIHELIČ, Marko ZUPAN, Vesna ZUPANC, Urša PEČAN, Luka ŽVOKELJ, Jure FERLIN, Slavko KRPIČ, Katarina KRESNIK, Davor MRZLIČ in Marina PINTAR

Predstavitev sponzorjev

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13.00 – 15.00 **Kmetijstvo širše** Vodja: dr. Barbara Čeh

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Anton TAJNŠEK

Emisije CO_2 in dihanje tal ob različnih agrotehničnih ukrepih ter v interakciji z okoljskimi dejavniki – nekateri rezultati dveh dolgoročnih poljskih poskusov
Klemen ELER, Rok MIHELIČ, Anton GOVEDNIK, Sara PINTARIČ, David LENARČIČ in Marjetka SUHADOLC

Kakovost silaže prezimnih strniščnih dosevkov in njihovih mešanic
Robert LESKOVŠEK in Branko LUKAČ

Analiza pridelka krme s travinja glede na režim košnje in leta z različnim vremenom
Anastazija GSELMAN, Uroš KOTNIK in Miran PODVRŠNIK

Preskušanje vrednosti za pridelavo različnih sort rožmarina (*Rosmarinus officinalis* L.) v celinskih razmerah Slovenije
Nataša FERANT

Kratka predstavitev posterjev

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Anže ROVANŠEK, Robert LESKOVŠEK, Mojca VEK in Irena BERTONCELJ

Privzem težkih kovin v konopljo na neonesnaženih tleh
Barbara ČEH, Bojan ČREMOŽNIK in David GERŠAK

Sestava talnih mikrobnih združb v odvisnosti od intenzivnosti obdelave tal v ekološkem sistemu pridelave
Sara PINTARIČ, Nataša ŠIBANC, Rok MIHELIČ, Klemen ELER in Marjetka SUHADOLC

Favna v kompostirajoči hmeljevini in zrelem kompostu
Ana KARNIČNIK KLANČNIK, Magda RAK CIZEJ in Barbara ČEH

Vpliv konvencionalne in ohranitvene obdelave tal na vodno bilanco tal v treh povodjih
Vesna ZUPANC, Matjaž GLAVAN, Rok MIHELIČ, Marko ZUPAN, Matic NOČ, Urša PEČAN, Luka ŽVOKELJ, Jure FERLIN, Slavko KRPIČ, Katarina KRESNIK, Davor MRZLIČ in Marina PINTAR

Vpliv obdelave medvrstnega prostora v vinogradu na status vode v tleh
Tanja ZRNEC DROBNJAK, Denis RUSJAN, Marko ZUPAN, Helena GRČMAN in Vesna ZUPANC

Vpliv spremembe cen kmetijskih inputov na ekonomsko učinkovitost pridelave poljščin
Ana HITI DVORŠAK in Barbara ZAGORC

Analiza registriranih traktorjev v Sloveniji
Tomaž POJE

Napredne tehnologije na primeru samovoznih silažnih kombajnov
Tomaž POJE

Prikaz vpliva višine snežne odeje na temperaturo tal – analiza za Mursko Soboto
Tjaša POGAČAR, Zala ŽNIDARŠIČ in Zalika ČREPINŠEK

Samooskrba in blagovna menjava z izbranimi rastlinskimi proizvodi v Sloveniji
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15.30 – 18.00 **Pridelovanje poljščin in vrtnin**. Vodja: Igor Škerbot

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Zrnate stročnice v prehrani ljudi – rezultati projekta EIP
Blaž CIGIĆ, Manca OZVATIČ, Darja KOCJAN AČKO, Silva GROBELNIK MLAKAR in Tomaž POLAK

Vpliv zeolita na pridelavo soje in ozimne pšenice v poljedelskem kolobarju na vodovarstvenih območjih
Marko FLAJŠMAN, Filip VUČAJNK, Darja KOCJAN AČKO in Rok MIHELIČ

Vpliv roka žetve na pridelke in kakovost ozimne pšenice
Aleš KOLMANIČ, Simon OGRAJŠEK in Andrej ZEMLJIČ

Primerjava rezultatov metod za oceno izpustov toplogrednih plinov, nastalih pri različnih načinih pridelave poljščin
Denis STAJNKO, Andi ŠPACAPAN, Erik RIHTER in Rok MIHELIČ

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Primerjava dveh metod ugotavljanja izpiranja dušika zaradi gnojenja s hlevskim gnojem v zimskem obdobju
Robert LESKOVŠEK

Kratka predstavitev posterjev

Vpliv globine sajenja in pinciranja na rast in pridelek melon
Kristina UGRINOVIĆ in Mojca ŠKOF

Izkušnje in stroški pridelave pri pridelavi solate in bučke ob uporabi različnih zastirnih folij
Barbara ZAGORC in Kristina UGRINOVIĆ

Vpliv načina zasnove posevka na razvoj rastlin in pridelek motovilca
Kristina UGRINOVIĆ, Damjana ŽNIDAR in Mojca ŠKOF

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Petek, 27. januar 2023

8.00 – 9.00 Registracija z jutranjo kavico/čajem in ogled posterjev

9.00 – 12.00 **Genetika, žlahtnjenje in semenarstvo**. Vodja: dr. Peter Dolničar

Uporaba tehnik tarčnega preurejanja genomov v podporo žlahtnjenju
Ester STAJIČ in Urban KUNEJ

Tvorba cvetnega prahu pri superiornih R linijah navadne pšenice (*Triticum aestivum* L.)
Primož TITAN

Pregled, inventarizacija in monitoring rastlinskih genskih virov za prehrano in kmetijstvo, ki se ohranjajo *in situ* na kmetijskih gospodarstvih
Jelka ŠUŠTAR VOZLIČ, Zlata LUTHAR, Gregor OSTERC, Valentina USENIK, Janko VERBIČ, Dea BARIČEVIČ, Stanko VRŠIČ, Anastazija JEŽ KREBELJ, Nataša FERANT, Igor ŠANTAVEC, Kristina UGRINOVIĆ, Katja ŠUKLJE ANTALICK, Andrej ZEMLJIČ in Branko LUKAČ

Uporaba različnih biotehnoloških pristopov v žlahtnjenju hmelja (*Humulus lupulus* L.)
Andreja ČERENAK, Sebastjan RADIŠEK, Lucija LUSKAR, Nataša ŠTAJNER in Jernej JAKŠE

Metode, postopki in rezultati preverjanja sortne pristnosti žit in križnic
Barbara PIPAN, Teja KRPAN, Romana RUTAR, Uroš BENEC, Darja VOUK, Lovro SINKOVIČ, Peter DOLNIČAR in Vladimir MEGLIČ

Optimizacija semenarjenja hibridnih sort zelja (*Brassica oleracea* var. *capitata* L.)
Katarina RUDOLF PILIH, Adriana PODRŽAJ, Kristina UGRINOVIĆ in Barbara ZAGORC

15 minutni odmor

Vodja: Jožica Dolničar

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Kratka predstavitev posterjev:

KIS Blegoš, KIS Mangart in KIS Tamar – nove slovenske sorte krompirja
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Lucija LUSKAR, Jernej JAKŠE in Andreja ČERENAK

Odziv tujih sort hmelja v slovenskih hmeljiščih
Barbara ČEH, Andreja ČERENAK in Monika OSET LUSKAR

Povezanost barve semenske ovojnice z barvo cvetov pri kompozitnih genskih virih navadnega fižola (*Phaseolus vulgaris* L.)
Eva PLESTENJAK, Vladimir MEGLIČ, Barbara PIPAN

Genetska raznolikost različnih fenotipov konoplje (*Cannabis sativa* L.)
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Uporaba multispektralnega slikanja za identifikacijo različnih sort krompirja (*Solanum tuberosum* L.)
Ana VOJNOVIĆ, Uroš ŽIBRAT, Janez LAPAJNE, Matej KNAPIČ, Peter DOLNIČAR in Vladimir MEGLIČ

12.00 – 13.00 Odmor za kosilo

13.00 – 15.00 **Varstvo rastlin.** Vodja: dr. Aleš Kolmanič

Učinkovitost uporabe hladne plazme na zmanjšanje vsebnosti mikotoksinov na koruznem zrnju
Aleš KOLMANIČ, Simon OGRAJŠEK, Breda JAKOVAC STRAJN, Gabrijela TAVČAR KALCHER, Janja BABIČ, Pia STARIČ, Matic RESNIK in Ita JUNKAR

Preživetje virusa rjave grbančavosti plodov paradižnika in njegov prenos z vodo
Ana VUČUROVIĆ, Katarina BAČNIK, Irena BAJDE, Jakob BRODARIČ, Adrian FOX, Ion GUTIÉRREZ-AGUIRRE, Miha KITEK, Denis KUTNJAK, Yue LIN LOH, Olivera MAKSIMOVIĆ CARVALHO FERREIRA, Maja RAVNIKAR, Elise VOGEL, Christine VOS in Nataša MEHLE

Spremljanje koruzne vešče (*Ostrinia nubilalis* Hübner) z avtomatsko vabo Trapview CONE-NET
Magda RAK CIZEJ in Franček POLIČNIK

Možnosti biotičnega zatiranja topolistne kislice (*Rumex obtusifolius* L.) na travinju z vnosom naravnega sovražnika *Pyropteron chrysidiformis* (Esper, 1782)
Primož ŽIGON, Andrej VONČINA, Špela MODIC, Jaka RAZINGER, Matej KNAPIČ in Robert LESKOVŠEK

Uporaba daljinskega zaznavanja za zgodnje odkrivanje strun (Coleoptera: Elateridae) in suše v koruzi
Eva PRAPROTNIK, Andrej VONČINA, Primož ŽIGON, Matej KNAPIČ, Nik SUSIČ, Saša ŠIRCA, Dominik VODNIK, David LENARČIČ, Janez LAPAJNE, Uroš ŽIBRAT in Jaka RAZINGER

Uporaba plinske plazme za obdelavo semen
Pia STARIČ, Katarina VOGEL-MIKUŠ, Aleš KOLMANIČ, Kristina UGRINOVIĆ in Ita JUNKAR

Kratka predstavitev posterjev:

Preučevanje uporabe izvlečka korenjeve cime za zatiranje čebulne muhe *Delia antiqua* (Meigen) in porove zavrtalke *Phytomyza gymnostoma* Loew v čebuli
Špela MODIC, Jaka RAZINGER, Eva PRAPROTNIK, IGOR NEKREP, Darko VERNIK, Anže PRAŠNIKAR in Primož ŽIGON

Glivične bolezni na sadikah in v nasadih šparglja
Urša PRISLAN, Janja ZAJC, Hans-Josef SCHROERS in Neja MAROLT

Določanje napada koruznega hrošča iz zraka
Uroš ŽIBRAT, Aleš KOLMANIČ, Andrej VONČINA, Matej KNAPIČ, Špela MODIC, Eva PRAPROTNIK in Jaka RAZINGER

Možnosti uporabe zmanjšanih odmerkov herbicidov pri pridelavi soje s konvencionalno in ohranitveno obdelavo tal
Aleš KOLMANIČ, Simon OGRAJŠEK, Andrej ZEMLJIČ in Manfred JAKOP

15.00 – 15.30 **Odmor za kavo in ogled posterjev**

15.30 – 17.30 **Okolje** Vodja: dr. Igor Šantavec

Sočasna proizvodnja električne energije in hrane - Agrofotovoltaika
Blaž GERMŠEK, Tomaž POJE, Miran KAVREČIČ in Tomi MEDVED

Uporaba prečiščene odpadne vode za namakanje: rezultati in spoznanja iz izvedenih poskusov
Špela ŽELEZNIKAR, Gašper LESKOVAR, Nina KACJAN MARŠIČ, Tjaša GRIESSLER-BULC, Damijana KASTELEC in Marina PINTAR

Nov spletni portal za prikazovanje sušnih razmer v Sloveniji
Andreja SUŠNIK, Marko PUŠKARIĆ, Andreja MODERC, Maja ŽUN, Živa VLAHOVIĆ

Odziv fenološkega razvoja rastlin na spreminjanje podnebja v Sloveniji
Gal OBLIŠAR, Urša VILHAR in Gregor GREGORIČ

Zgodnje določanje sušnega stresa vinske trte z brezpilotnimi letalniki in letalom
Uroš ŽIBRAT, Matej KNAPIČ, Andrej VONČINA in Klemen LISJAK

Kmetijski ukrepi za ohranitev habitata bele in črne človeške ribice
Rozalija CVEJIĆ, Miha CURK, Nina MALI, Janez MULEC, Metka PETRIČ, Marina PINTAR, Janko URBANC, Vesna ZUPANC in Mitja PRELOVŠEK

17.30 Zaključek simpozija

Prispevek korenin in poganjkov prekrivnih dosevkov k vezavi dušika in ogljika v različnih sistemih obdelave tal

Sergeja ADAMIČ[1], Anže ROVANŠEK in Robert LESKOVŠEK

Prekrivne dosevke v pridelovalne sisteme vključujemo zaradi njihovega pozitivnega vpliva na varovanje voda, izboljšanja stanja tal, vezave ogljika in dušika ter povečanja organske snovi v tleh. V letih 2020 in 2021 smo na Kmetijskemu inštitutu Slovenije izvedli poljski poskus, v katerem smo preučevali doprinos korenin in poganjkov različnih prekrivnih dosevkov na vezavo ogljika in dušika v različnih sistemih obdelave tal. Poljski poskus je bil izveden v bločni postavitvi z dvema obravnavanjema (konvencionalna in ohranitvena obdelava tal) in štirimi ponovitvami. V prvem letu je bila izvedena splošna primerjava vsebnosti ogljika in dušika v koreninah in steblih, v drugem letu pa smo vsebnosti ogljika in dušika primerjali tudi glede na sistem obdelave tal. Statistična analiza je pokazala, da sta v letu 2020 vrsta dosevka in vzorčeni del rastline (stebla in korenine) značilno vplivala na količino dušika ($p < 0,05$), medtem ko je na količino ogljika vplivala samo vrsta dosevka ($p < 0,05$). Rezultati analize so pokazali, da so bile največje vsebnosti dušika v rastlinah iz družine metuljnic. V steblih sta največ dušika vsebovali navadna grašica (3,4 %) in aleksandrijska detelja (3,2 %). Isti vrsti sta vsebovali tudi največ dušika v koreninah (grašica 2,8 % in aleksandrijska detelja 2 %). Najvišja vsebnost ogljika je bila zabeležena v steblih aleksandrijske detelje (42 %) in v koreninah lana (43,4 %). V letu 2021 sta tako na količino ogljika kot dušika značilno vplivala vrsta dosevka ($p \leq 0,05$) in vzorčeni del rastline ($p < 0,05$). V obeh sistemih obdelave tal je bila v rastlinah iz skupine metuljnic opažena večja vsebnost dušika v koreninah, ne pa v steblih. V konvencionalnem sistemu obdelave je bila vsebnost ogljika največja v steblih oljne redkve (43,8 %) in v koreninah lanu (45,2 %). V ohranitvenem sistemu obdelave tal je bila največja količina ogljika v steblih lana (44,3 %), v koreninah pa v vzorcu bele gorjušice (43,3 %). Največ dušika v steblih je v obeh sistemih obdelave vsebovala navadna grašica (3,1 % v konvencionalni obdelavi in 3 % v ohranitveni obdelavi). Tudi v koreninah navadne grašice v sistemu konvencionalne obdelave je bila največja vsebnost dušika (2,2 %), v ohranitvenem sistemu pa v koreninah še ene rastline iz družine metuljnic - aleksandrijske detelje (2,6 %). Rezultati te raziskave bodo bistveno pripomogli k oceni potenciala pridelave dosevkov za vezavo dušika in ogljika v koreninah in poganjkih.

Ključne besede: dosevek, vsebnost dušika, konvencionalna obdelava, ohranitvena obdelava

Primerjava nadzemnega in podzemnega dela izbranih vrst dosevkov
Comparison of shoots and roots of selected cover crops plants

[1] Mag. inž. hort., Kmetijski inštitut Slovenije, e-pošta: sergeja.adamic@kis.si

Cover crops roots and shoots contribution to nitrogen and carbon fixation in different tillage systems

Cover crops are becoming an important part of the cropping systems because of their influence on the water protection and improvement of soil health, including carbon sequestration, nitrogen fixation and soil organic matter increase. In 2020 and 2021, a field experiment was conducted at the Agricultural institute of Slovenia, to study the contribution of roots and shoots of various cover crops to carbon and nitrogen fixation in different tillage systems. The field experiment was carried out on the experimental field of Agricultural institute in Jablje and designed in a block design with two treatments (conventional and conservation tillage system) and four repetitions. In the first year, a general comparison of carbon and nitrogen content in shoots and roots was done, while in the second-year carbon and nitrogen content were also compared according to the tillage system. Statistical analysis showed that in 2020 the cover crop species and the part of sampled plant (shoots and roots) significantly influenced the amount of nitrogen ($p < 0.05$), while the amount of carbon was affected only by the cover crop species ($p < 0.05$). Results showed that the highest nitrogen content was in plants of Fabaceae family. Common vetch (3.4 %) and berseem clover (3.2 %) contained the highest share of nitrogen in the stems and roots (2.8 % for common vetch and 2 % for berseem clover). The highest carbon content was recorded in berseem clover stems (42 %) in the flax roots (43.4 %). In 2021 the amount of carbon and nitrogen was significantly influenced by the cover crop species ($p \leq 0.05$) and the part of sampled plant ($p < 0.05$). In both tillage systems higher nitrogen content was observed in the roots than in the stems of plants of Fabaceae family. In the conventional tillage system, the highest share of carbon was in oil radish stems (43.8 %) and in the flax roots (45.2 %). In the conservation tillage system, the highest share of carbon was in flax stems (44.3 %) and in the white mustard roots sample (43.3 %). Common vetch stems contained the most nitrogen in both tillage systems (3.1 % for conventional tillage system and 3 % for conservation tillage system). Also, in the common vetch roots under conventional tillage system the highest nitrogen content was observed (2.2 %) and in conservation tillage system berseem clover (2.6 %). The results of this research can be used to assess nitrogen and carbon content in cover crop plant parts (roots and shots) to estimate their contribution to carbon and nitrogen sequestration in arable crop production.

Key words: cover crop, nitrogen content, conventional tillage, conservation tillage

Noduli z bakterijami Rhizobium na koreninah bele lupine (Lupinus albus L.)
Rhizobium nodules on a white lupin roots (Lupinus albus L.)

Tehnologija induciranja mineralizacije - orodje za trajnostno gospodarjenje s tlemi

Benoit Le RUMEUR[1]

Tla zagotavljajo 95 % hrane za ljudi, zato je nujno ohraniti in povečati njihovo sposobnost za proizvodnjo zadostnih količin kvalitetne hrane na trajnosten način. Funkcije tal so: razgradnja organske snovi, kroženje hranil, zadrževanje in infiltracija vode ter uravnavanje bioloških procesov. Zbita tla in pomanjkanje organske snovi motita funkcije tal. Z dodajanjem mešanice elementov v sledovih se v tleh lahko izboljšajo biološki procesi (ang. Mineral Inducer Process – MIP; tehnologija induciranja mineralizacije).
Profesor Philippe Mora iz Laboratorija Bioemco, Univerze Pierre in Marie Curie (Francija) je pokazal, da tehnologija MIP spreminja razmerja med prevladujočimi populacijami mikroorganizmov v tleh in uravnovesi encimski profil tal s povečanjem pestrosti, ne da bi to povzročalo upad aktivnosti. Sestavine MIP delujejo kot katalizator interakcij med rastlinami, mikrofloro in deževniki.
Prof. Alicja Niewiadomska z Univerze Poznan je ocenila vpliv biostimulacije tal z MIP tehnologijo na asimilacijo dušika, biološko aktivnost tal in kemijske lastnosti, kakovost ter velikost pridelka pri lucerni in detelji. Rezultati kažejo pozitiven vpliv na organiziranost življenja v tleh ter na proizvodnjo in kakovost tako v razmerah laboratorijskih kakor terenskih meritev.
Leta 2017 se je začel dolgoletni poskus v izvedbi Fakultete za agrobiotehniške vede Osijek in CROSTRO, hrvaške podružnice Mednarodne organizacije za raziskovanje tal in minimalno obdelavo (ISTRO). V tem poskusu ekipa, ki jo vodi prof. dr. Danijel Jug, v klasičnem kolobarju proučuje vpliv MIP tehnologije na biostimulacijo tal v kombinaciji z različno obdelavo tal in gnojenjem. Po šestih letih rezultati kažejo, da ima uporaba biostimulatorja pozitiven učinek na organizacijo tal pri vseh načinih obdelave tal. Bistveno se je povečala zadrževalna sposobnost tal za vodo, spremenile pa so se tudi kemične lastnosti tal. Izboljšanje lastnosti tal in boljša dostopnost vode za rastline sta vodila k boljši izkoriščenosti vode in hranil. Povečevanje pridelka kljub zmanjšanju gnojenja s fosforjem in kalijem kaže, da je uporaba MIP tehnologije v celotnem kolobarju pozitivno vplivala na rodovitnost tal v primerjavi s kontrolo.
V poskusu v vinogradu so dr. Duilio Porro in sodelavci v San Michele all'Adige v Trentu (Italija) ugotovili, da je v tleh, kjer uporabimo MIP tehnologijo, večje število lasastih korenin v globljih plasteh tal in pozitivno vpliva na razvoj rastlin. To se je bistveno odrazilo tudi v večjem pridelku in boljših fizioloških in ekofizioloških parametrih. Vino, pridelano v vinogradih z uporabo MIP tehnologije, je imelo bolj izrazit sadni okus s cvetličnim pridihom. Elisol raziskovalni laboratorij v Franciji je pokazal, kako biostimulacija tal z MIP tehnologijo vpliva na organizacijo nematod.
Rezultati torej kažejo pozitiven vpliv vključevanja tehnologije MIP v pridelavo, pri čemer je biostimulacija tal način za izboljšanje produktivnosti tal in vodi v bolj trajnostno kmetovanje.

Ključne besede: talni mikroorganizmi, rizosfera, biostimulatorji, proizvodnja encimov, sprejem hranil v rastlino

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Mineral Inducer Process technology - a tool for sustainable management of soils

Because soils provide 95% of food for people, it is essential to preserve and develop its ability to produce quantity and quality in a sustainable way. Soil functions are: organic matter decomposition, nutrients circulation, water retain and release and biological processes regulation. Compacted soil and lack of organic matter may disturb this system. Technologies, based on trace elements mixtures (Mineral Inducer Process - MIP) applied to the soil improve biological processes.

Professor Philippe Mora from BIOEMCO laboratory at Pierre and Marie Curie University (France) showed that MIP technology modifies predominant populations of microorganisms in the soil and balances soil's enzyme profile by amplifying diversity without causing a drop-in activity. The MIP ingredients act as a catalyst on plant/microflora/earthworm interaction. Prof. Alicja Niewiadomska from Poznan University studied the assessment of the impact of soil biostimulation with MIP technology on nitrogen assimilation, soil biological activity and chemical properties, plant quality and yield in alfalfa and clover. The results demonstrate the positive effect of soil life organization on production and quality in both conditions Laboratory and field measurements.

A long-term trial realized by the Faculty of Agrobiotechnical Sciences Osijek and the CROSTRO, Croatian branch of the International Soil and Tillage Research Organisation (ISTRO) was set up in 2017. In this trial, the research team led by prof. dr. sc. Danijel Jug is crossing soil tillage, fertilization and soil biostimulation with MIP technology during a classical crop rotation. After 6 years, results show that the application of this biostimulant has a positive effect on the physical characteristics of the soil whatever tillage system was, compared to the untreated area with the same other technological arrangements. Water retention was significantly increased and chemical properties of the soil were also modified. The improvement of soil properties and water disponibility were heading to better utilization of water and nutrients uptake. The increasement of yield despite the reduction of P and K fertilization shows that MIP usage during a complete rotation restored soil productivity in comparison to control.

In the vineyard, dr. Duilio Porro and the research team from the Technology Transfer Centre of San Michele all'Adige in Trento (Italy), showed that the soil receiving MIP technology exhibits a larger number of fine roots in the deeper layers in comparison to control. The effect of the treatment positively influences plant development, and significantly reflects in higher yield and better physiological and ecophysiological conditions, without modification of nutritional status, enhancing the accumulation in the plant too. The wines obtained from the treated vines appear fruitier and more floral.

The ELISOL environment laboratory in France showed how soil biostimulation with MIP influence nematodes organization.

The results obtained using MIP technology, indicates that beside to soil tillage, fertilization, organic-mater management and field-crop rotation soil biostimulation is a way to improve soil productivity enhancing agricultural sustainability.

Keywords: soil micro-organisms, rhizosphere, bio-stimulant, enzymes production, plant uptake

Preučevanje potenciala prekrivnih dosevkov in njihovih mešanic za pomoč divjim opraševalcem v intenzivni kmetijski krajini

Sergeja ADAMIČ[1], Anže ROVANŠEK in Robert LESKOVŠEK

Opraševanje je ekosistemska storitev, ki je bistvenega pomena za kmetijstvo in ohranjanje biotske raznovrstnosti. Poleg klimatskih sprememb, je intenzifikacija kmetijstva glavni razlog za upadanje števila in pestrosti predvsem divjih opraševalcev. Glavni cilj EIP projekta POMOP s polnim nazivom »Pomoč opraševalcem v intenzivni kmetijski krajini za podporo biodiverziteti« je izboljšanje razmer za opraševalce, zlasti čmrlje, čebele samotarke, muhe trepetavke in metulje, v kmetijski krajini kot tudi varovanju drugih elementov biodiverzitete v njej. Eden od načinov za doseganje tega cilja je, da izkoristimo potencial dosevkov. V letu 2022 smo na Kmetijskem inštitutu Slovenije opravili osnovni izbor in analizo različnih rastlinskih vrst, ki bi bile primerne za uvrstitev v vrstno bogate mešanice prekrivnih dosevkov. Pri tem smo na podlagi pregleda literature ocenili privlačnost cvetov za žuželke in medonosni potencial posamezne vrste ter hkrati upoštevali njihove omejitvene dejavnike (čas od setve do začetka cvetenja, konkurenčna sposobnost, potencialna možnost širitve v naravne ekosisteme (invazivnost), potencialne nove plevelne vrste). Izbranih 50 vrst prekrivnih dosevkov smo razvrstili v tri glavne skupine: uveljavljene poljščine, manj razširjene poljščine in okrasne rastline ter zelišča, nato smo opravili osnovno preverjanje v poljskem poskusu, izvedenem po spravilu zgodnjega krompirja. V začetku avgusta 2022 smo dosevke posejali na poskusnem polju v Šentpavlu na Dolenjskem, ter jih primerjali z nekaterimi komercialno dostopnimi mešanicami iz tujine. Zaradi sušnih razmer smo v prvem mesecu po setvi poskus namakali, da smo zagotovili uspešen začetni razvoj posevkov. V poskusu smo spremljali čas cvetenja, kakor tudi druge lastnosti kot so: hitrost vznika in začetnega razvoja, razvoj listne površine in tvorjenje biomase. Pričakovano so imele najboljši začetni razvoj uveljavljene poljščine, kot so ajda, oljna redkev, bela gorjušica in lan, medtem ko so imele najslabši vznik okrasne rastline in zelišča. Tudi količina zrasle biomase je bila največja pri uveljavljenih poljščinah, poleg tega pa še pri aleksandrijski detelji, žametnici in mehiški sončnici. Med vsemi posejanimi dosevki so najhitreje zacveteli ajda, navadni riček in viseči grobelnik. Naši rezultati nakazujejo, da bi bile nekatere okrasne rastline in zelišča primerne za vključitev v ciljno naravnane vrstno bogate mešanice, saj imajo velik potencial privabljanja divjih opraševalcev. Ker pa imajo v primerjavi z nekaterimi uveljavljenimi poljščinami bistveno slabši začetni razvoj in konkurenčno sposobnost, jih nameravamo v prihodnjih letih vključiti v posebej izdelane mešanice za potrebe omenjenega projekta.

Ključne besede: prekrivni dosevek, kmetijstvo, vrstno bogate mešanice, biodiverziteta, opraševanje, medonosna čebela, divji opraševalci

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The potential of various cover crops and their mixtures to assist wild pollinators in an intensive agricultural landscape

Pollination is an important ecosystem service essential for agriculture and crucial for conservation of biodiversity. Beside climate change, the intensification of agriculture is the main reason for the decline in the number and diversity of wild pollinators. The main goal of the EIP-AGRI project POMOP with the full title »Supporting pollinators in intensive agricultural landscapes to promote biodiversity« is to improve the conditions for pollinators, especially bumblebees, solitary bees, flicker flies and butterflies in the intensive agricultural production, as well as to protect other elements of biodiversity. One way to achieve this goal is to exploit the potential of cover crops. In 2022, at the Agricultural Institute of Slovenia, we carried out a basic selection and analysis of different types of cover crops that would be suitable for inclusion in species-rich mixtures of cover crops. Based on the literature review, the attractiveness of the flowers and the honey-bearing potential of each species were assessed, while their limiting factors, such as the period from sowing until the beginning of flowering, competitive ability, potential possibility of expansion in the natural ecosystems (invasiveness) or potential new weed species were also considered. We classified the selected 50 species of cover crops into three main groups: established and less established cover crop agronomic species as well as ornamental plants and herbs. The performance of selected species was tested in a field experiment, carried out after early potato harvest. At the beginning of August 2022, selected cover crops species were sown in the field experiment at Šentpavel in Dolenjska and compared with some commercially available mixtures. Due to the dry conditions, the experiment was irrigated in the first month after sowing to ensure the basic conditions for successful initial development. During the vegetation, the flowering phenology, and their agronomic properties, such as the germination rate and initial development, leaf area increase and the biomass production, were evaluated. As expected, established cover crop species such as buckwheat, oil radish, white mustard and flax had the best germination rate and initial emergence, while ornamental plants and herbs had the most lessened emergence. The amount of developed biomass was also the highest in established agronomic cover crop species, as well as in berseem clover, marigold, and Mexican sunflower. Among all sown cover crops the beginning of flowering was the fastest in buckwheat, false flax, and sweet alyssum. Our results suggest that several tested ornamental plants and herbs showed a high potential to attract wild pollinators and can be considered as suitable mixing partner in targeted species-rich mixtures. However, since their germination rate, initial development and competitive ability are considerably reduced compared to established agronomic cover crop species, we intend to include them in specially prepared mixtures for needs of the above-mentioned project.

Keywords: cover crop, agriculture, diverse mixtures, biodiversity, pollination, honeybee, wild pollinators

Preučevanje potenciala prekrivnih dosevkov in njihovih mešanic za pomoč divjim opraševalcem v intenzivni kmetijski krajini
Sowing cover crops to support pollinators in intensive agricultural landscapes

Emisije CO_2 in dihanje tal ob različnih agrotehničnih ukrepih ter v interakciji z okoljskimi dejavniki – nekateri rezultati dveh dolgoročnih poljskih poskusov

Klemen ELER[1], Rok MIHELIČ, Anton GOVEDNIK, Sara PINTARIČ, David LENARČIČ in Marjetka SUHADOLC

Ocene emisij toplogrednih plinov ter z njimi povezana vezava in zaloge ogljika v agroekosistemih so postale eden ključnih segmentov pri vrednotenju različnih načinov kmetovanja. Pri tem lahko uporabljamo modelne ocene ali meritve emisij plinov. V naši študiji smo primerjali meritve kratkoročnih (nekajdnevnih) in srednjeročnih (sezonskih) emisij CO_2 iz tal (1) med konvencionalno in ohranitveno (zmanjšano) obdelavo tal v različnih pedoklimatskih in pridelovalnih danostih in (2) med različnimi načini gnojenja (mineralno gnojenje, kompost, brez gnojenja). Podatke smo pridobili iz dveh dolgoročnih poljskih poskusov (Rašica-Moškanjci in laboratorijsko polje Biotehniške fakultete (BF), oba zastavljena leta 1999) bodisi s periodičnimi bodisi kontinuiranimi (polurnimi) meritvami z uporabo zaprtih komor. Meritve so bile izvedene v letu 2021, ko je bila na obeh poskusih posejana koruza. Neposredno, t.j. prve pol ure po oranju v maju, smo v poskusu na BF polju zaznali v povprečju 6-kratno povečanje emisij CO_2 v primerjavi s tistimi pred oranjem; emisije so se s povprečja 0,35 ± 0,03 g CO_2 m^{-2} ura^{-1} povečale na 2,14 ± 1,1 g CO_2 m^{-2} ura^{-1}. Neobdelane parcele so vzdrževale stalne emisije v časovnem obdobju 5 dni, t.j. v povprečju 0,47 ± 0,03 g CO_2 m^{-2} ura^{-1}, brez razlik med načini gnojenja. Tako povečanje emisij ob oranju je v rangu drugih podobnih študij, v katerih dokazujejo, da so takojšnja povečanja emisij ob oranju niso le posledica mikrobne respiracije, pač gre tudi za sproščanje v talnih porah uskladiščenega CO_2. Na sezonski ravni se je dinamika emisij CO_2 med oranimi in neoranimi parcelami na BF polju prav tako razlikovala, pri čemer so emisije na oranih parcelah bolj sledile dinamiki talne temperature skozi sezono z največjimi emisijami (okrog 1,8 g CO_2 m^{-2} ura^{-1}) v višku poletja. Na neoranih parcelah smo, nekoliko nepričakovano, beležili visoke emisije konec pomladi, ko so bile le te na oranih parcelah še nizke, nato pa upad proti začetku poletja in vnovičen porast ob višku poletja. Skupne emisije za obdobje meritev so bile na oranih parcelah v primerjavi z neoranimi v povprečju večje za 6,7 %. Načini gnojenja so na letni potek emisij manj značilno vplivali, so pa bile razlike v skupnih vsotah emisij; le-te so bile najvišje pri gnojenju s kompostom. Na poskusu v Moškanjcih se emisije neposredno po oranju niso tako povečale kot na polju BF; v povprečju so bile le za 20 % večje, kar je lahko posledica manjše količine v tleh skladiščenega CO_2 zaradi bolj zračnih, peščenih tal v tem poskusu. Sezonske meritve v Moškanjcih so pokazale večje skupne emisije CO_2 na oranih parcelah v primerjavi z neoranimi (za 32 % večje) in tistimi pri zmanjšani obdelavi (za 23 % večje). Kljub temu da na oranih parcelah v Moškanjcih beležimo manj organske snovi v tleh in bi zato pričakovali manjše dihanje tal, pa očitno k večjim emisijam dovolj prispeva avtotrofna komponenta (rastlinske korenine), ki kompenzira dihanje mikrobov. Biomasa koruze je bila na oranih parcelah namreč bistveno večja kot na parcelah drugih dveh načinov obdelave tal. Rezultati v splošnem kažejo, da obdelava tal vpliva na kratkoročne in sezonske emisije CO_2, potrebne pa so dodatne raziskave, ki bodo pojasnile, koliko k izmerjenim emisijam prispevajo posamezne komponente talnega ekosistema in kolikšen je prispevek abiotskih procesov (ventilacija tal).

Ključne besede: dihanje tal, gnojenje, oranje, zmanjšana obdelava tal, Q10 vrednost dihanja tal

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CO_2 emissions and soil respiration as affected by different agrotechnical measures and environmental factors – some results of two long-term field experiments

Estimation of greenhouse gas emissions and related carbon sequestration and stocks in agroecosystems have become one of the key segments in the evaluation of different farming methods. In doing so, both model assessments and various tools as well as gas emission measurements can be used. In this study, we compared the measurements of short-term (a few days) and medium-term (seasonal) CO_2 emissions from soil (1) between conventional and reduced till/no-till tillage in different pedoclimatic and production conditions and (2) between different methods of fertilization (mineral fertilization, compost, no fertilization). We obtained data from two long-term field experiments (Rašica-Moškanjci and laboratory field of Biotechnical Faculty (BF), UL, both established in 1999) either by periodic or continuous (half-hourly) measurements using closed chambers. The measurements were carried out in 2021, when maize was sown in both experiments. Directly, i.e. in the first half hour after ploughing in May, in the BF experiment, we detected on average 6-fold increase in CO_2 emissions compared to those before ploughing; emissions increased from an average of 0.35 ± 0.03 g CO_2 m^{-2} $hour^{-1}$ to 2.14 ± 1.1 g CO_2 m^{-2} $hour^{-1}$. Untreated plots maintained constant emissions over a period of 5 days, i.e. on average 0.47 ± 0.03 g CO_2 m^{-2} $hour^{-1}$, with no differences between fertilization methods. Such an increase in emissions during ploughing is comparable with the results of other similar studies which show that these immediate emission increases during ploughing cannot only be the result of increased microbial respiration, but are predominantly due to the degassing of CO_2, stored in soil pores. At the seasonal level, the dynamics of CO_2 emissions between ploughed and non-ploughed plots in the BF experiment also differed, with the ploughed plots more tightly following the soil temperature course (highest emissions of around 1.8 g CO_2 m^{-2} $hour^{-1}$) in the height of summer). Unexpectedly, we recorded high emissions on no-till plots at the end of spring, when emissions on ploughed plots were still low, then a decline towards the beginning of summer and again increase at the height of summer. Total emissions for the measurement period were on average 6.7% higher on ploughed plots compared to non-ploughed ones. Fertilization methods had a less significant influence on the annual course of emissions, but there were differences in the cumulative emissions, which were the highest in compost fertilization. In Moškanjci experiment, the emission increases were considerably lower than in BF experiment. On average, only 20% increase has been observed which might be the result of a lower amount of CO_2 stored in the soil due to more ventilated, sandy soil in this experiment. Seasonal measurements also showed higher cumulative CO_2 emissions on ploughed plots compared to no-till plots (32% higher) and reduced-till plot (23% higher). Even though we record somewhat less soil organic matter in ploughed plots and therefore we would expect less soil respiration, the autotrophic component (plant roots) evidently compensates for the respiration of soil microbes. Maize biomass was significantly higher on the ploughed plots than on the plots of the other tillage methods. The results of both experiments generally show that tillage affects short-term and seasonal CO_2 emissions, but additional research is needed to clarify how much the individual components of the soil ecosystem contribute to the measured emissions and how important is the contribution of abiotic processes (soil ventilation) to soil CO_2 emissions.

Key words: soil respiration, fertilization, ploughing, reduced tillage, Q10 soil respiration value

Izboljšanje bilanc ogljika ekoloških kmetij brez živine za sekvestracijo atmosferskega ogljika

Simon OGRAJŠEK[1], Branko LUKAČ, Werner VOGT-KAUTE in Aleš KOLMANIČ

Z ustreznim gospodarjenjem so tla lahko vir ponora ogljikovega dioksida in s tem pomemben dejavnik pri blaženju klimatskih sprememb. Projekt z naslovom "Izboljšanje bilanc ogljika ekoloških kmetij brez živine za sekvestracijo atmosferskega ogljika" poteka v okviru Evropske podnebne pobude (EUKI) in je financiran s strani Zveznega ministrstva za okolje, varstvo narave, jedrsko varnost in varstvo potrošnikov Nemčije. Koordinator projekta je združenje za ekološko kmetijstvo Naturland iz Nemčije, partnerja sta Kmetijski inštitut Slovenije in Inštitut za poljedelstvo in zelenjadarstvo iz Srbije. Cilj projekta je prenos znanja v prakso s prikazom praks za izboljšanje bilance ogljika v tleh na kmetijah brez živine, s poudarkom na ekoloških. Z aktivnostmi želimo spodbujati uporabo praks, ki večajo zaloge organskega ogljika v tleh in s tem vplivajo ugodno na rodovitnost in odpornost tal na abiotske dejavnike, predvsem z vidika večje zadrževalne sposobnosti tal za vodo.
V Sloveniji smo v letu 2022 na treh ekoloških kmetijah z različnimi pedo-klimatskimi razmerami zasnovali demonstracijske poskuse, v katerih smo kot glavne in kot dosevke posejali različne vrste metuljnic in nekatere pri nas razširjene mešanice dosevkov (Bodenfit, Nitrofit in Boni). Od metuljnic smo sejali neprezimne detelje (aleksandijska, perzijska), prezimne detelje (bela detelja, črna detelja, inkarnatka, lucerna, ptičja noga, švedska detelja, medena detelja), grašice (jara grašica, panonska grašica, kuštrava grašica), ter grahor. Med rastno dobo spremljamo dinamiko razvoja posameznih vrst, z vzorčenji nadzemne in podzemne biomase pa vrednotimo tvorbo sušine, simbiotsko aktivnost in vezavo hranil. Skupaj z analizami tal bomo iz pridobljenih podatkov izdelali bilance ogljika in dušika. Prvi rezultati vzorčenj na kmetiji Pucihar kažejo, da so pri setvi kot glavni posevek v obdobju maj-november največ sušine z nadzemno biomaso ustvarile prezimna grašica (840 g/m^2), bela detelja (739 g/m^2), črna detelja (741 g/m^2), perzijska detelja (706 g/m^2) ter panonska grašica (699 g/m^2). Grahor ter ptičja noga sta tu propadla zaradi suše. Pri setvi kot strniščni dosevek sta v obdobju avgust-november največ sušine z nadzemno biomaso tvorila perzijska detelja (640 g/m^2) ter jara grašica (456 g/m^2), najmanj pa sta jo tvorili panonska grašica in črna detelja (198 g/m^2).
Pridobljeni rezultati bodo služili tudi za izdelavo priporočil za uporabo določenih vrst metuljnic za namene izboljšanja vsebnosti organskega ogljika v tleh. Pomemben sklop aktivnosti je priprava kratkih tehnoloških navodil s primeri izvajanja dobrih in pri nas manj razširjenih praks za povečanje vsebnosti organske snovi v tleh. Poudarek bo pri uveljavljanju pri nas manj znanih ali pozabljenih metuljnic (npr. ptičja noga (*Ornithopus sativus*) in grahor (*Lathyrus sativus*)) ter inovativne tehnologije z uporabo sistema »donor-akceptor« (ang. »Cut and Carry«). Na kmetijah, kjer se ne ukvarjajo z živinorejo, lahko kompostiranje predstavlja pomemben doprinos k izboljšani bilanci ogljika. Tej temi bodo več pozornosti namenili partnerji projekta iz Srbije, njihove zaključke in priporočila pa bomo predstavili in prenesli tudi k nam. Zbrani in pripravljeni material bo objavljen na spletni strani projekta https://www.kis.si/EUKI/.

Ključne besede: organski ogljik, metuljnice, mešanice, dušik

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Improving carbon balances of livestock-free organic farms for atmospheric carbon sequestration

With proper management, soil can be a sink for atmospheric carbon dioxide and thus an important factor in mitigating climate change. The project entitled "Improving C- balances on livestock-free organic farms for atmospheric carbon sequestration" takes place within the European Climate Initiative (EUKI) framework EUKI) and is financed by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection of Germany. The coordinator of the project is the association for organic agriculture Naturland from Germany, and the partners are the Agricultural Institute of Slovenia and the Institute of Field and Vegetable Crops Novi Sad from Serbia. The project aims to collect and transfer knowledge into practice with demonstration of best practices for improving carbon balance in the soils of farms without livestock, with a focus on organic farms. With different activities, we want to encourage the use of practices that increase organic carbon reserves in the soils and thereby have a beneficial effect on soil fertility and resistance to abiotic factors (mainly due to higher water retention capacity).

In Slovenia, demonstrational trials on three organic farms with different pedo-climatic conditions were established in 2022. Different species of legumes and some widespread cover crop mixtures (Bodenfit, Nitrofit, and Boni) were seeded as a main and as a cover crop. Legumes seeded were non-winter clovers (Alexandrian, Persian, and Alsike clover), winter clovers (white clover, red clover, Italian clover, alfalfa, serradella, and sweet clover), vetch (spring vetch, Pannonian vetch, and winter vetch) and grass pea. During the growing period, the growth dynamics were monitored, and by sampling the above-ground and underground biomass, the formation of dry matter, symbiotic activity, and nutrients in the biomass were evaluated. Together with soil analyses, this data will help to create carbon and nitrogen balances.

The first results of above-ground biomass samplings on the Pucihar farm shows, that when seeded as the main crop, winter vetch (840 g/m^2), white clover (739 g/m^2), black clover (741g/m^2), Persian clover (706 g/m^2) and Pannonian vetch (699 g/m^2) produced the highest amount of dry matter per area during the May-November period. The grass pea and the serradela have failed to establish due to the drought. When seeded after the harvest of winter wheat as a cover crop, Persian clover (640 g/m^2) and spring vetch (456 g/m^2) formed the highest amount of dry matter with above-ground biomass, while Pannonian vetch and red clover (198 g/m^2) formed the least amount during the August-November period.

Results from the trials will also serve as recommendations about the use of certain species of legumes regarding improved organic carbon content in the soil. An important set of activities is the preparation of short technical instructions with examples of the implementation of good and less-known practices that increase the content of organic carbon in the soil. The emphasis will be on the less-known or forgotten legumes (e.g., serradella - *Ornithopus sativus* and grass pea - *Lathyrus sativus*) and the innovative approach using the "Cut and Carry" system. On non-livestock farms, composting can significantly contribute to an improved carbon balance. Project partners from Serbia focus on this topic and will present their findings also in Slovenia. Collected and prepared materials will be published on the project website https://www.kis.si/EUKI/.

Key words: organic carbon, legumes, mixtures, nitrogen

Odziv tujih sort hmelja v slovenskih hmeljiščih

Barbara ČEH, Andreja ČERENAK in Monika OSET LUSKAR[1]

Zaradi povpraševanja trgovine s hmeljem po tujih sortah se slovenski hmeljarji občasno zanimajo za pridelovanje sort, ki se v izvornih pridelovalnih območjih izkazujejo z velikim pridelkom in dobro kakovostjo. Vendar se lahko pri prenašanju tujih sort hmelja v naše pridelovalne razmere zaradi odziva rastlin na mikroklimatske razmere pojavijo težave, saj se v razmerah, drugačnih od tistih, v katerih je bila sorta požlahtnjena, rastline drugače odzovejo; ne samo s količino in kakovostjo pridelka, ampak tudi z odpornostjo na bolezni. S preizkušanjem tujih sort v naših pridelovalnih razmerah želimo zaznati potencialne težave s sorto v praksi, jih strokovno ovrednotiti in s sprotnimi rezultati seznanjati hmeljarje. Pridobljene informacije so toliko bolj pomembne, saj je hmelj trajnica in slab odziv neke sorte v tekočem letu lahko pomeni velik gospodarski manko tudi v naslednjih letih.

Med letoma 2010 in 2013 je bila od tujih sort v slovenskih hmeljiščih prisotna le nemška sorta Hallertauer Magnum. V letu 2014 sta se ji pridružili ameriška sorta Cascade in angleška sorta Bramling Cross ter v letu 2015 ameriška sorta Chinook. Te tri so zanimive zlasti za novejše manjše pivovarne. V letu 2016 je bila uvedena še fino aromatična angleška sorta Fuggle in v letu 2021 nemška sorta Akoya. V letu 2022 so bile tuje sorte posajene na 32 ha (od tega H. Magnum na 19 ha), kar je le 2 % od skupne površine s hmeljem (1530 ha). H. Magnum je visoko grenčična sorta hmelja, med tem ko so slovenske sorte predvsem aromatične.

V slovenskih razmerah smo pri sorti Cascade opazili povečano enodomnost, torej pojavljanje moških cvetov na ženskih rastlinah. Glede na Reglitz in Steinhaus (2017) sorta v slovenskih rastnih razmerah pri nekaterih komponentah eteričnega olja ne dosega pričakovanih vrednosti. Vrednost komponente z vonjem črnega ribeza (4-metil-4-sulfanilpentan-2-on), na primer, ima po njuni raziskavi razpon 1,25–3,94 µg/kg (povp. 2,34 µg/kg) v evropskih vzorcih; vsebnost je nižja kot v vzorcih iz ZDA (2,29-6,74 µg/kg, povp. 4,02 µg/kg) in najnižja na lokaciji Slovenija. Vendar pa ta sorta kljub temu dosega na naših lokacijah za slovenske razmere relativno visok pridelek oziroma je le-ta vsaj primerljiv sortama Aurora in Celeia; v zadnjih štirih letih povprečno 2 t/ha. Po katalogu sorta v ZDA dosega 2017–2465 kg/ha.

Sorta Bramling Cross je imela v letu 2016 na preučevani lokaciji dvakrat večjo vsebnost eteričnega olja, kot je zapisana pri opisu sorte (YCH HOPS, 2016), a je imela manjšo relativno vsebnost humulena, kariofilena in mircena v eteričnem olju. Opazili smo neizenačenost rasti med posameznimi rastlinami znotraj istega hmeljišča (na težkih tleh). Poleg tega se je nasad slabo razvijal, zato so ga lastniki konec leta 2016 izorali.

Sorta Chinook ima zanimivo sadno aromo, precej velike in manj zbite, a lažje storžke. Medvrstna razdalja, ki je primerna za razširjene slovenske sorte (3.000–3.200 rastlin/ha), se je pri tej sorti pokazala kot neustrezna, saj so se storžki razvili le v zgornji tretjini rastlin. Vsebnost alfa-kislin je bila v letu 2016 kar za polovico nižja od pričakovane, ki je 11,5–15,0 %, vsebnost eteričnega olja pa je bila primerljiva. Pri posameznih rastlinah, predvsem šibkejših, so bila opazna zakrnela socvetja. Sorta je pokazala občutljivost na hmeljevo peronosporo, pridelek pa je v slovenskih razmerah variabilen (v zadnjih 4 letih od 1140 od 2653 kg/ha). Sorta Fuggle, ki je zgodnja sorta in jo primerjamo z našo zgodnjo sorto Savinjski golding, je v letih 2020 in 2021 dosegla primerljiv pridelek tej sorti (1.396 kg/ha).

Ključne besede: hmelj, pridelek, tuje sorte, *Humulus lupulus* L., odziv na rastne razmere
Zahvala. Rezultati so nastali v okviru SN Introdukcija novih in tujih sort hmelja.

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Response of foreign hop varieties in Slovenian hop gardens

From time to time, there is an interest among Slovenian hop growers for cultivation of foreign varieties as a response of hop merchant's interest. Those varieties have a large yield and good quality in growing areas where they were bred. However, problems may arise when transferring hop varieties to different growing conditions due to the susceptibility of the plant to microclimate conditions. In conditions, different from those to which the variety is accustomed or in which it has been selected, it can react unexpectedly, not only with the yield but also with regard to disease resistance. By monitoring the response of foreign varieties to our growing conditions, we want to detect potential problems in practice, evaluate them and inform the hop growers with the results. The information obtained is important, since hop is perennial, and a poor response in one year can reflect in the coming years as well.

Between 2010 and 2013, only foreign variety in Slovene hop farms was the German variety Hallertauer Magnum, in 2014 it was joined by the American variety Cascade and the English variety Bramling Cross, in 2015 by the American variety Chinook. All of them are interesting especially for newer craft breweries. In 2016, the English noble hop variety Fuggle and in 2021 German variety Akoya were planted. So, all together in 2022, foreign varieties were planted on 32 ha (of which Hallertauer Magnum on 19 ha), which is only 2 % of the total area with hops (1530 ha). Hallertauer Magnum is a high alpha acid hop variety, unlike Slovenian hop varieties which are aromatic.

In Slovenian conditions, we observed a significantly increased monoeciousness in the Cascade variety, i.e. the appearance of male flowers on female plants. According to Reglitz and Steinhaus (2017), the variety in Slovenian growing conditions does not reach the expected values for some components of essential oils. The value of the component with the blackcurrant smell (4-methyl-4-sulfanylpentan-2-one), for example, has a range of 1.25–3.94 µg/kg (average 2.34 µg/kg) in European samples; the content is lower than in the samples from the USA (2.29–6.74 µg/kg, avg. 4.02 µg/kg) and the lowest in Slovenia's samples. However, despite this, this variety achieves at our locations a relatively high yield, or at least comparable to the Aurora and Celeia varieties; in the last four years, an average of 2 t/ha. According to the catalogue, the variety in the USA reaches 2017–2465 kg/ha.

In 2016, the variety Bramling Cross had twice the essential oil content of the variety description (YCH HOPS, 2016) at the studied location, but it had a lower relative content of humulene, caryophyllene and myrcene in the essential oil. We noticed uneven growth between individual plants within the same plantation (on heavy soil), the hop plantation was developing poorly, so the owners ploughed it in at the end of 2016.

The Chinook variety has an interesting fruity aroma, rather large and less dense, lighter cones. The inter-row distance, which is suitable for widespread Slovenian varieties (3.000–3.200 plants/ha), was found to be inadequate for this variety, as the cones developed only in the upper third of the plants. The alpha-acid content was lower than expected, which is 11.5–15.0%; in 2016 by as much as half, while the essential oil content was comparable. Stunted inflorescences were noticeable in individual plants, especially weaker ones. The variety showed sensitivity to hop downy mildew, the yield is variable in Slovenian conditions (in the last 4 years from 1140 to 2653 kg/ha).

The Fuggle variety, which is an early variety, achieved in 2020 and 2021 a comparable yield (1396 kg/ha) to our early variety Savinjski golding.

Key words: hops, crop, foreign varieties, *Humulus lupulus* L., response to growing conditions

Vpliv različnih sistemov obdelave tal na populacijo deževnikov

Anže ROVANŠEK[1], Robert LESKOVŠEK, Mojca VEK in Irena BERTONCELJ[2]

Biotska raznovrstnost tal in s tem povezane ekosistemske storitve upadajo zaradi vse večje intenzifikacije kmetijske proizvodnje. Deževniki so bioindikatorji, saj nam njihova raznovrstnost in številčnost nudita pomembno informacijo o stanju tal. Na populacijo deževnikov vplivajo okoljski pogoji, kot so temperatura, razpoložljivost vode, tekstura tal, pH in drugi abiotski dejavniki. Na združbe deževnikov ima pomemben učinek tudi način obdelave tal, saj z njim spreminjamo fizikalne lastnosti tal, porazdelitev hranil, razgradnjo rastlinskih ostankov, zadrževanje vode in druge lastnosti tal.
V jeseni 2021 smo po žetvi koruze preizkusili dve metodi določanja številčnosti in biomase deževnikov. Prvi postopek je vključeval uporabo razredčenega alil izotiocianata (metoda AITC) na površini tal, po kateri deževniki sami prilezejo na površje. Drugi način nabiranja deževnikov je bilo ročno prebiranje zgornje plasti tal, dopolnjeno z aplikacijo AITC za globino pod 20 cm (metoda HS). Vzorčenje smo izvedli na trajnem poskusu v Infrastrukturnem centru Jablje, ki je bil vzpostavljen v letu 2018 in vključuje tri sisteme obdelave tal: konvencionalna obdelava (z oranjem), ohranitvena obdelava (s plitko obdelavo tal brez obračanja) in sistem brez obdelave tal (no-till). Ploskve trajnega poskusa obsegajo skupno 2,8 ha. Z vsako metodo smo vzorčili 5 ponovitev v vsakem sistemu obdelave in sicer na površini 30x30 cm, skupno 30 ponovitev.
Naši rezultati so pokazali, da je bila metoda zbiranja z ročnim iskanjem v kombinaciji z aplikacijo AITC za globino pod 20 cm bolj učinkovita v primerjavi z uporabo AITC na površini tal. Biomasa nabranih deževnikov je bila pri metodi HS večja v primerjavi z metodo AITC. Podobno smo ugotovili tudi pri številčnosti mladih in odraslih osebkov deževnikov pri vseh treh sistemih obdelave tal. Primerjava vpliva sistema obdelave tal na številčnost deževnikov je pokazala značilno večjo številčnost odraslih deževnikov pri ohranitvenem sistemu obdelave tal (povprečje 6,1±1,0), kakor pri sistemu brez obdelave tal (povprečje 4,0±1,0) in konvencionalni obdelavi tal (povprečje 3,7±0,7).
Iz naše raziskave lahko sklepamo, da je sistem ohranitvene obdelave tal pozitivno vplival na populacijo deževnikov. Najboljše in najbolj primerljive rezultate pa smo dosegli z ročnim iskanjem deževnikov v kombinaciji z aplikacijo AITC za globino pod 20 cm.

Ključne besede: biodiverziteta tal, kazalnik, konvencionalna obdelava, ohranitvena obdelava, sistem brez obdelave tal, populacija deževnikov

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Effects of different tillage systems on the earthworm population in a test site in Slovenia

Soil biodiversity and the associated ecosystem services are deteriorating due to increasing intensification of agricultural production. Earthworms are well recognised as soil ecosystem engineers and important indicators of soil health status. Earthworm populations are affected by environmental conditions such as temperature, water availability, soil texture, pH, and other abiotic factors. However, earthworm communities are also influenced by soil management practices which alter the physical soil properties, nutrient distribution, plant residue management, and other soil characteristics.
Two earthworm field collection methods were investigated in the autumn of 2021: application of diluted allyl isothiocyanate (AITC) at the soil surface level (AITC method), after which earthworms crawl to the soil surface; and hand searching of topsoil combined with the application of AITC for depth below 20 cm (HS method). Our aim was to determine abundance and biomass of earthworms in three different tillage systems (conventional, conservation and no-tillage). The sampling was conducted in the corn stubble at the long-term trial at the Infrastructure Center Jablje in Slovenia, established in 2018. The test fields covered 2.8 ha, where each method was used at five 30x30 cm large sampling sites in each of three tillage systems, together comprising 30 sampling sites.
Our results showed the hand searching technique combined with AITC application for depth below 20 cm was consistently more productive compared to AITC method, applied at the soil surface. Both biomass as well as abundance of juveniles and adult earthworms was significantly higher for HS method compared to AITC method. This result was consistent in all three tillage systems.
Comparison of tillage system effects on earthworms showed a significantly higher abundance of adult earthworms in the conservation tillage system (mean 6.1±1.1) compared to both no-till (mean 4.0±1.0) and conventional system (mean 3.7±0.7).
Results of our study indicate that the preferred method with consistently better results for earthworm sampling is hand searching combined with AITC application for depth below 20 cm. The effect of tillage on earthworms is evident with conservation tillage system supporting the highest numbers of adult earworms.

Key words: soil biodiversity, indicator, conventional tillage, conservation tillage, no-till system, earthworm population

Strategije za pridelavo ozimnega graha

Werner VOGT-KAUTE[1], Aleš KOLMANIČ, Simon OGRAJŠEK, Snežana JAKŠIĆ in Milorad ŽIVANOV

V začetku tega tisočletja je bil ozimni grah uveden kot popolnoma nova poljščina v ekološko pridelavo. V zadnjih 20 letih postaja ozimni grah pomembna zrnata stročnica na mnogih ekoloških kmetijah v številnih evropskih državah, predvsem tam, kjer kmetujejo na revnejših tleh s sušnimi vremenskimi razmerami. Uvedba ozimnega graha je pripomogla tudi k povečanju količine ekološko pridelanega graha.
Poznamo dva tipa ozimnega graha: prvi tip so nizke po zrelosti zgodnje debelozrnate sorte, pogosto francoskega izvora, z relativno slabo odpornostjo na nizke temperature, slabo tekmovalnostjo s pleveli in belimi cvetovi. Nove sorte z izboljšano odpornostjo na nizke temperature izvirajo v zadnjih letih iz ZDA in Srbije in kažejo izboljšani potencial za pridelavo. Drugi tip ozimnega graha so visoke, pogosto drobnozrnate sorte, z večinoma dobro odpornostjo na nizke temperature, dobro tekmovalnostjo s pleveli ter belimi ali pisanimi cvetovi. Ker naj bi sorte s tem tipom rasti nastale izvorno v jugovzhodni Evropi, nekje med češkimi Krkonoši in severno Grčijo, ta tip v Severni Ameriki imenujejo tudi avstrijski njivski grah. Konvencionalni kmetje za pridelavo graha uporabljajo večinoma nizke sorte francoskega porekla, ekološki kmetje pa imajo raje visoke sorte, predvsem zaradi dobre tekmovalnosti s pleveli. Za zmanjšanje poleganja visokih sort ozimnega graha ga pridelujejo v mešanicah z žiti (tritikala, rž, pšenica ali ječmen). Količina semena za setev je odvisna od regije in lokacije. V osrednji Nemčiji je količina semena za setev pri združeni setvi žit in ozimnega graha okrog 150 semen žit in 40 semen graha na m². V sušnih pridelovalnih razmerah zmanjšamo v mešanici delež žit in povečamo delež graha, v mokrih razmerah ali na dobrih tleh pa zmanjšamo delež graha.
Ozimni grah lahko pridelujemo tudi kot prezimni dosevek (zimska ozelenitev), za zeleno gnojenje ali za silažo (običajno mešanica z žiti). Ozimni grah je lahko tudi zanimiv predposevek poljščinam s poznejšimi roki setve, kot je npr. sirek. Ker ne prenaša fizikalnih poškodb, ga je mogoče enostavno uničiti s košnjo ali mulčenjem brez tveganja za regeneracijo. Tako je ozimni grah zanimiv tudi kot posevek v reduciranih sistemih obdelave tal.
Zrnate stročnice so pomemben del strategije za izboljšanje vsebnosti ogljika v tleh v kolobarju. V projektu »"Izboljšanje bilanc ogljika ekoloških kmetij brez živinoreje za sekvestracijo atmosferskega ogljika", ki ga financira Zvezno ministrstvo za okolje, ohranjanje narave, jedrsko varnost in varstvo potrošnikov Nemčije v okviru poskusov Evropske podnebne pobude (EUKI), izvajajo poskuse na ozimnem grahu na treh lokacijah v Srbiji in na eni v Sloveniji, da bi pokazali njihov vpliv na vsebnost ogljika in dušika v tleh ter s tem na kakovost tal.
Zbrana in pripravljena gradiva bodo objavljena na spletni strani projekta https://www.kis.si/EUKI/.

Ključne besede: ozimni grah, mešanice, organski ogljik

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Strategies for the cultivation of winter peas

At the beginning of the 2000s, winter peas were introduced into organic agriculture as a completely new crop. Meanwhile, winter peas are an important grain legume in organic agriculture on many farms in many European countries, especially on poorer soils and under dry weather conditions. The introduction of winter peas helped to increase the amount of organic pea production.

There are two types of winter peas available: The first types are short straw varieties, often of French origin, with relatively low winter hardiness, poor weed suppression, white flower, large seed size, and early maturity. New short straw varieties with better winter hardiness from the USA and Serbia have come on the market in the last few years and have shown their potential for cultivation. The second types are long straw forage type varieties with mostly good winter hardiness, good weed suppression, white or coloured flowers, and often small seed size. This type is called an Austrian field pea in North America. The origin of these types is in Southeast of Europe, between the Czech Giant Mountains and the North of Greece. Conventional farmers prefer to grow short straw types of French origin for seed production, while organic farmers prefer long straw types due to their good weed competitiveness. Long straw types are always mixed with a cereal partner to reduce lodging. Partners are triticale, rye, wheat, or barley. Sowing density depends on the region and location. In central Germany, the average seeding rate is 150 seeds per m² of cereals with 40 seeds per m² of peas. In dry regions, the share of cereals is reduced, and the share of peas is increased. In wet regions or on soils with good quality, the share of peas is reduced.

Winter peas can also be grown as a winter hard-cover crop, for green manure, or silage (usually mixed with grain). Winter peas can also be an interesting pre-crop for species with later sowing dates, such as e.g., sorghum. Winter peas do not tolerate physical damage and can be easily terminated by cutting or mulching without risk of regeneration. Thus, it is an interesting crop also for systems with reduced tillage intensity.

Grain legumes are an important part of a strategy to improve carbon content in soil in a farm's rotation. In the project "Improving carbon balances of livestock-free organic farms for atmospheric carbon sequestration" funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection of Germany within the framework of European Climate Initiative (EUKI) trials on winter peas are conducted at three locations in Serbia and at one location in Slovenia to show their impact on soil carbon, nitrogen and soil quality.

Collected and prepared materials of the project will be published on the project website https://www.kis.si/EUKI/.

Key words: winter peas, mixtures, organic carbon

Izkušnje in stroški pridelave solate in bučk ob uporabi različnih zastirnih folij

Barbara ZAGORC[1] in Kristina UGRINOVIĆ

Folije za zastiranje tal so v vrtnarstvu zelo razširjene, saj predstavljajo pomembno zamenjavo za uporabo herbicidov. Vendar predstavljajo folije iz nerazgradljivih materialov, izdelane večinoma iz polietilena (PE), veliko obremenitev za okolje. Različne biorazgradljive (bio) zastirke so predstavljene kot okolju prijaznejše in zato v zadnjih letih vse bolj razširjene, njihova ponudba in uporaba pa se tudi v Sloveniji povečuje. Cene bio zastirk so običajno višje od cen PE folij, stroški strojnega polaganja so podobni, pri bio zastirkah pa ni stroškov s pobiranjem in odlaganjem folije na komunalno deponijo. Če se namaka, je potrebno pobrati in ustrezno odstraniti namakalne cevi.
V letih 2019–2022 smo v okviru Javne službe v vrtnarstvu preizkušali uporabo različnih zastirnih folij, ki smo jih položili na različnih lokacijah in zasadili z različnimi vrstami zelenjadnic v tunelih in na prostem. Uporabo bio zastirk pri pridelavi različnih zelenjadnic smo primerjali z uveljavljenimi PE folijami. Preizkušali smo tri različne črne bio folije (debelina: 15 µm, širina: 1,4 m, navitje: 1.100 tekočih metrov (tm) ali 1.600 tm), izdelane iz dveh osnovnih termoplastičnih materialov (eden temelji na fosilnih virih, drugi na rastlinskem škrobu, dodani so jima različni dodatki) in eno zastirko iz papirja (širina: 1,4 m, navitje: 200 tm), katere sestava temelji na celulozi, hemicelulozi, ligninu ter vosku, kot prevleki z obeh strani. Za primerjavo je bila v poskuse kot standard vključena tudi črna PE folija (debelina: 40 µm, širina: 1,4 m, navitje: 1.000 tm ali 1.250 tm). Stroške uporabe različnih zastirnih folij smo ocenili pri pridelavi solate in bučk na podlagi cen materiala, storitev in dela na slovenskem trgu v letu 2022. Za izračune smo uporabili modelne kalkulacije Kmetijskega inštituta Slovenije (MK KIS) za zelenjadnice. MK KIS za pridelavo spomladanske solate in bučk smo ustrezno dopolnili z bio zastirkami in prilagodili delovne faze. Izkušnje pri uporabi različnih zastirk kažejo, da so preizkušene bio zastirke primerljive s PE folijami in večinoma ustrezno zadržijo rast plevela. Večjih težav pri strojnem polaganju bio folij, kljub temu da so nekajkrat tanjše, ni bilo. Zaradi večje debeline pa je bilo pri papirju potrebno večkrat zamenjati role na polagalniku folije (omejitev za namestitev je premer role). Opazili smo, da pri večini bio folij (razen pri papirju) ostane po koncu rastne sezone več manjših nerazgrajenih delov folije, zato bomo v prihodnje razgradnjo bio zastirk bolj podrobno spremljali. Pri oceni stroškov smo upoštevali povprečne cene folij brez DDV (PE folija: 0,110 EUR/tm, bio folija: 0,179 EUR/tm, papir: 0,260 EUR/tm). Opazili smo, da se pri različnih ponudnikih cene bio folije razlikujejo tudi za več kot polovico (med 0,132 in 0,219 EUR/tm), medtem ko so cene PE folije manj variabilne (razlika med njihovimi cenami je približno 5 %). Stroški uporabe folije, ki vključujejo stroške folije, strojnega polaganja, pobiranja folije (PE folija) in odlaganja na komunalno deponijo (PE folija), znašajo med 1.395 EUR/ha pri uporabi bio folije in 1.975 EUR ha pri uporabi papirja. Stroški uporabe PE folije pri pridelavi solate in bučk so ocenjeni na 1.405 EUR/ha, kar je približno toliko kot pri uporabi bio folij in 30 % manj kot pri uporabi papirja. Delež stroškov uporabe bio zastirk v skupnih stroških pridelave je ob uporabi bio folij pri solati 7 % in pri bučkah 5 %, ob uporabi papirja pa 9-odstoten pri solati in 7-odstoten pri bučkah.

Ključne besede: solata, bučka, zastirne folije, stroški zastiranja, stroški pridelave, MK KIS

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Experience and production costs of lettuce and summer squash using different mulch films

Soil mulch films are widely used in horticulture, as they represent an important alternative to the use of herbicides. Films made of non-degradable materials, mostly polyethylene (PE), on the other hand, represent a large burden on the environment. Various biodegradable (bio) mulches are considered more environmentally friendly and are therefore spreading more and more. Their offer and use are increasing in Slovenia too. The prices of bio mulches are generally higher than the prices of PE films, the costs of mechanical laying are similar, and with bio mulches there are no costs with collecting the films and depositing them at the landfills. When irrigated, the irrigation tapes need to be collected and properly deposited too.
In the years 2019-2022, as part of the Public Service in vegetables and herbs, different mulches were tested at different locations and planted with different vegetables in the open field and tunnels. Three different black bio mulch films (thickness: 15 µm, width: 1.4 m, windings: 1,100 rm and 1,600 rm), made of two different thermoplastic materials (one based on fossil resources and the other on plant starch, both with different additives) and one black paper mulch (width: 1.4 m, winding: 200 rm), made of cellulose, hemicellulose, lignin and wax, as a coating on both sides were compared to black PE films (thickness: 40 µm, width: 1.4 m, windings: 1,000 rm or 1,250 rm) as a standard. The costs of using different mulching films in the production of lettuce and summer squash was estimated, based on the prices of materials and services on the Slovenian market in 2022. The costs of production were calculated using model calculations of Agricultural Institute of Slovenia (MC AIS) for vegetables. The MC AIS for production of lettuce (spring production) and summer squash was appropriately supplemented with additional materials (bio mulch) and work phases were adjusted.
Experience with different mulches shows that the tested bio mulches are comparable to PE films and mostly adequately restrain the growth of weed vegetation. There were no major problems with the machine laying of bio films, even though they are several times thinner. Due to the greater thickness of the paper, it was necessary to change the rolls on the films tray several times (the installation is limited with the roll diameter). We noticed that with bio films (except for paper mulch), several small non-degradaded parts of the film remained after the end of the growing season. Therefore, the degradation of bio films will be monitored more carefully. When estimating the costs, the average prices of mulch films without VAT were considered (PE: 0.110 EUR/rm, bio film: 0.179 EUR/rm, paper: 0.260 EUR/rm). We noticed that the prices of bio mulch films of different providers differ by more than half (between 0.132 and 0.219 EUR/rm), while the prices of PE mulch films are less variable (the difference between their prices is about 5%). We estimate that the costs of using the mulch films, which include the costs of the film, machine laying, picking up the film (PE mulch film) and disposal at the landfill (PE mulch film) amount to between 1,395 EUR per ha when using bio mulch film and 1,975 EUR per ha when using paper. The cost of using PE mulch film in the production of lettuce and summer squash is approximately 1,405 EUR per ha, which is almost the same as using bio mulch film and 30% less than using paper. The share of the costs of using bio mulches in the total production costs when using bio films is 7% (lettuce) and 5% (summer squash), and when using paper, it is 9-percent for lettuce and 7-percent for summer squash.

Key words: lettuce, summer squash, mulch films, costs of mulching, production costs, model calculation AIS

Kompostiranje hmeljevine in karakteristike zrelega komposta

Barbara ČEH[1], Lucija LUSKAR, Julija POLANŠEK, Ana KARNIČNIK KLANČNIK in Žan TROŠT

Hmeljevi storžki se pridelujejo za proizvodnjo piva in predstavljajo 1/3 sveže biomase, odpeljane s hmeljišč med obiranjem hmelja. Preostale 2/3 biomase predstavlja hmeljevina (listi in stebla hmelja). Le-ta ostane na gospodarskih dvoriščih hmeljarskih obratov (povprečno 15 t/ha). Kompostiranje je učinkovita tehnika za zapiranje kroga hranil na kmetijah. Gre za tehnologijo z nizkimi naložbami za pretvorbo sveže biomase v stabiliziran končni proizvod. Da bi se izognili potencialnemu prenašanju škodljivih organizmov, mora biti kompost zrel in stabilen, preden ga uporabimo kot gnojilo. V termofilni fazi mikrobna aktivnost povzroči higienizacijo in razgradnjo vhodnega materiala. Enake razmere kot za higienizacijo so potrebne, da se razgradi vrvica BioTHOP, ki je narejena je iz polimlečne kisline (PLA – poly lactic acid); le-ta se pri pravilnem kompostiranju razgradi na CO_2, vodo in organsko maso.
Poskuse smo postavili v Spodnji Savinjski dolini v dveh zaporednih letih (2020/2021 in 2021/2022). Po spravilu hmelja v septembru smo iz hmeljevine zgradili tri kompostne kupe trapezoidne oblike z višino 2 m, vsakega iz okrog 15 ton sveže hmeljevine. Kupi so se med seboj razlikovali glede na velikost delcev, na katere je biomaso razrezal obiralni stroj (1–5 cm, 2–5 cm, 2–10 cm) in dodatke (biooglje, efektivni mikroorganizmi EM™ (mešanica otrobov, pomešanih z melaso z več kot 80 mikroorganizmi), brez dodatkov). Primerjali smo tudi kompostiranje samih stebel z mešanico stebel in listov. Prilagojeno termometrsko sondo TFA® smo uporabili za redno merjenje temperature na globinah 50 in 100 cm. Kupe smo premešali vsakič, ko je temperatura dosegla 65 °C. V prvi sezoni kupov nismo pokrivali, v drugem letu pa smo jih pokrili po končani termofilni fazi (po približno dveh mesecih) s polprepustno membrano in pustili pokrite do aprila, ko smo komposte vrednotili.
Standard za higienizacijo se je izpolnil pri vseh kupih, saj so bile v vseh treh kupih temperature nad 55 °C več kot 14 dni. Kup je treba pokriti s polprepustno membrano vsaj po končani termofilni fazi (po približno 2 mesecih) in ga pustiti pokritega do aprila, da je količina izcedne vode čim manjša. Minimalna količina hmeljevine za uspešno vzpostavitev razmer za kompostiranje je okoli 15 ton. Najboljša kombinacija je bila, da so se stebla hmelja narezala na čim krajše delce ter da smo liste in stebla zmešali skupaj, saj ima kup samo s stebli preveč praznega prostora, kar se odraža v prehitrem sušenju in s tem prekinitvi/upočasnitvi procesa kompostiranja. Hmeljevina, kateri ob začetku ni bilo dodanih nobenih pospeševalcev kompostiranja, se je ob pravilnem kompostiranju glede na strukturo, videz, kemijsko sestavo in vonj skompostirala enako dobro kot hmeljevina z dodatki.
Tona komposta iz hmeljevine s povprečno vsebnostjo vlage 70 % je vsebovala 8,1 kg dušika (N), 1,14 kg fosforja (P) oz. 2,6 kg P_2O_5 in 3,24 kg kalija (K) oz. 3,8 kg K_2O. Pri vseh obravnavanjih je bilo več kot 2 % N v suhi snovi, torej so bili vsi komposti primerni kot gnojilo. Glede na indeks kalivosti redkvice noben kompost ni imel fitotoksičnih lastnosti.
Ob upoštevanju testa kalivosti kreše bi vsi komposti zagotovili s hranili bogato in biostimulativno spremembo tal. Vsi trije komposti so bili glede na stopnjo respiracije, rastni test in test kalivosti stabilni. Hmeljevina je pokazala velik potencial za kompostiranje.

Ključne besede: hmeljevina, *Humulus lupulus* L., kompostiranje na kmetijah, kompost

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Composting of hop biomass after harvest and characteristics of mature compost

Massive amounts of hop biomass after harvest appear in a short period as a by-product of hop (*Humulus lupulus* L.) cones production. Dried hop cones are the main product for the brewing industry, whereas surplus of the aboveground biomass (hop leaves and stems) accounts for around 2/3 of all hop biomass, taken from the hop field to the harvest machines. Every harvest season on average 15 t of fresh waste biomass stays next to the harvest halls from each harvested hectare, resulting in 23,000 tonnes of green waste all together in Slovenia.
Composting is an efficient technique to close the nutrient cycle at the point of the origin. It is low-investment technology to transform biomass into a stabilized final product with degraded organic matter and without a phytotoxicity effect on plants. To avoid the phytotoxic impact, compost should be mature and stable before being used as a fertilizer. In the thermophilic phase, high microbial activity results in hygienisation of compost and degradation of input material. The same conditions as for the hygeinisation are needed for the BioTHOP twine, made from polylactic acid (PLA), to degrade to CO_2, water, and organic mass, so after 7 months we get mature compost with no artificial leftovers.
The on-site experiments were set on three hop farms in the Lower Savinja Valley, Slovenia, in two successive years (2020/2021 and 2021/2022), from September to April. After the hop cone harvest in September, three trapezoidal composting piles with the height of 2 m were built from hop stems and leaves from 1 ha of hop field (approx. 15 tonnes each). Piles varied in the size of the particles the biomass was cut to by the harvest machine (1–5 cm, 2–5 cm, 2–10 cm) and additives (biochar, effective microorganisms EM™ (a mixture of bran mixed with molasses with over 80 microorganisms), no additive). In the first season we did not cover the piles, in the second year after the thermophilic phase piles were covered with semipermeable membrane until April. A customized thermometer probe was used to measure the temperature at depths of 50 and 100 cm in all four cardinal directions on a regular basis. The piles were turned when the temperature reached 65 °C.
The results showed that the hygienisation standards were met by all piles, as temperatures in all of them were over 55 °C for more than 14 days. Piles should be covered with semipermeable membrane at least after the thermophilic phase (after 2 months) and stay covered until April, so the leachate amount is minimized. The minimum amount of hop biomass for successful establishment of composting conditions is around 15 tons. The best option is to cut hop stems as short as possible, mix together leaves and stems, because a pile with only stems has too much empty spaces which reflects in too fast drying and by this interrupting/slowing the composting process.
A ton of compost from hop biomass with an average moisture content of 70%, contained 8.1 kg of total nitrogen (N), 1.14 kg of total phosphorus (P) or 2.6 kg of P_2O_5 and 3.24 kg of total potassium (K) or 3.8 kg of K_2O. In all investigated treatments it contained more than 2% of total nitrogen in dry mass, so it could be used as a fertilizer. According to the radish germination index, all composts had no phytotoxic properties and were stable and ready to use in plant production. Taking the cress germination test into consideration, they provided a nutrient-rich and bio-stimulative soil amendment. They were stable in terms of respiration rate, growth, and germination tests.
Results have shown that hop biomass after harvest has great potential for composting.

Key words: hop biomass after harvest, *Humulus lupulus* L., on-site composting, compost

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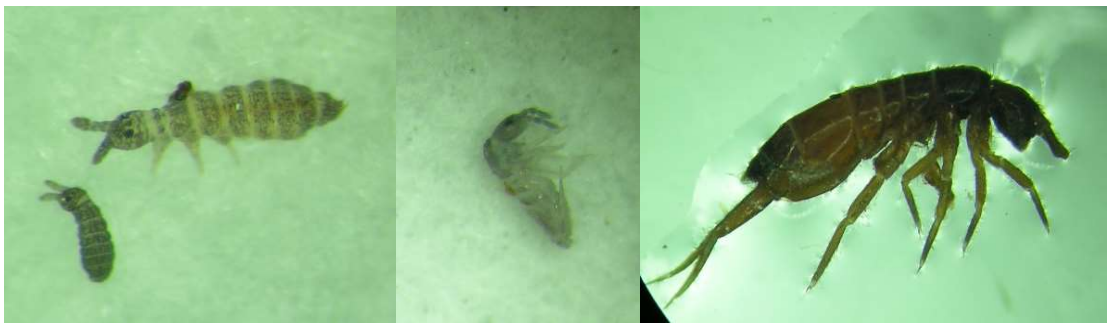
Favna v kompostirajoči hmeljevini in zrelem kompostu

Ana KARNIČNIK KLANČNIK[1], Magda RAK CIZEJ in Barbara ČEH

Kompostiranje je aerobni postopek, pri katerem mikrobi razkrajajo organsko snov. S tem dobimo stabilen material, ki se lahko uporablja kot organsko gnojilo. Da je kompostiranje učinkovito, moramo dobro poznati vključene materiale in fizikalne parametre, kot so vsebnost vlage, začetna količina materiala in njihove mehanske lastnosti. Cilj kompostiranja je zrel kompost, bogat s hranili in favno ter fitosanitarno varen (brez prisotnosti povzročiteljev rastlinskih bolezni, škodljivcev in kalivih semen plevelov). Prisotnost favne v kompostu je zaželena zato, ker le-ta s svojim mehanskim in kemičnim delovanjem sodeluje pri vzpostavitvi ustreznih fizikalnih in kemijskih lastnosti komposta. Favna obsega raznolike organizme, različnih življenjskih oblik in velikosti; med njimi so najpogostejši členonožci, od drobnih pršic do velikih žuželk. Njihova vloga je razgraditi organski material, ki po drugi strani zagotavlja hranila za celotno prehranjevalno verigo.
V raziskavi smo želeli oceniti, kako različni postopki kompostiranja hmeljevine (stebla in listi hmelja, ki ostanejo pri obiralnih halah po obiranju storžkov) vplivajo na številčnost, pestrost in vrstno sestavo favne. Pozimi (po petih mesecih kompostiranja na kmetiji) so prevladovali skakači, pršice, pajki, stonoge, različne ličinke ter žuželke (mrtvaška mušica …). Najštevilčnejši v vseh kompostnih kupih so bili skakači (vsaj deset v 2 g komposta) in pršice (vsaj deset v 2 g komposta). Najrazličnejše členonožce smo našli v kompostnem kupu, kjer smo ob začetku kompostiranja vmešali efektivne mikroorganizme EM.
Ob koncu kompostiranja (po sedmih mesecih kompostiranja; zrel kompost) so bili v kupih prav tako najštevilčnejši skakači (Springtails), ki so bili različnih velikosti in barv, ter pršice. Najdene so bile tudi amebe, deževniki, paščipalci, stonoge, pajki, ličinke, žuželke (različni hrošči, mušice …). Kup, kjer smo na začetku kompostiranja dodali biooglje in razrezali hmeljevino na zelo majhne delce (manjše od 5 cm), se je v termofilni fazi očitno premočno segreval (temperature so se večkrat povzpele nad 70 °C), saj je bila številnost in pestrost organizmov v končnem kompostu v tem kupu najmanjša.

Ključne besede: hmelj, kompostiranje, favna, členonožci, skakači, pršice



Detected Springtails (Collembola) in mature compost from hop waste biomass
Skakači (Collembola) v zrelem kompostu iz hmeljevine

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Fauna in composting hop biomass and mature compost

Composting is a process where organic matter is degraded by microbes under aerobic conditions to obtain a stable material that can be used as organic fertilizer. The trend towards more efficient methods of compost production and handling requires a complete understanding of the process, the materials involved, and the physical parameters of the materials such as moisture content, bulk density, and various mechanical properties. To obtain a high-quality compost on farms (on-site) it is necessary to understand the process involved as well as to evaluate the most suitable performance conditions. The goal of composting is mature compost, rich in nutrients, safe – without diseases and pests and weeds seed – and rich in microorganisms and fauna. Mesofauna and macrofauna comprise diverse organisms of various shapes and sizes right from tiny mites to large insects in the investigated composting biomass. Their role is to crush/break down organic material that than provide nutrients for the entire food web and thus restore natural balance in the compost. We want compost to contain fauna because it collaborates in maintaining the physical and chemical properties of compost through their mechanical and chemical activities. Therefore, it is essential to assess how different procedures affect the abundance, richness, and species composition of the retrieved arthropods.

The aim of this study was to take a snapshot of diversity of mesofauna and macrofauna (predators, scavengers, and decomposers) in composting hop biomass (stems and leaves of hop plants after hop cones harvest, no other biomass added) on the basis of different protocols in winter - after five months of on-site composting - and at the end of composting, in mature hop biomass compost (after 7 months of composting). The fauna abundance in piles after five months of the composting process start (in winter) was dominated by Springtails, Mites, Spider, Centipeds, Soldier flies, different Larves. Numerically the most abundant in all composting piles were Springatils (at least ten in 2 g of compost) and Mites (at least ten in 2 g of compost. There was the most diverse presence of Springtails, Mites, Spiders, Centipeds, Soldier flies, Rove Beetle, Larvae in the composting pile, in which we mixed effective microorganisms EM at the start of composting. In April, in mature compost, the most abundant were Collembola (Springtails) different sizes and color and Mites-Mesostigmata. There were also Amoeba, Earthworm, Pseudoscorpions, Millipedes, Spiders, Larvae, Beetles, and Insects. The pile, where we added biochar at the beginning of composting and cut the hop stems into very small pieces (smaller than 5 cm), temperatures rose several times above 70°C in the thermophilic phase, which obviously reflected in the smallest number and variety of organisms in the final compost of that pile.

Ključne besede: hmeljevina, kompostiranje, fauna, Arthropods, Springtails, Mites

Some in mature hop biomass compost detected organisms; from left to right: Spider, Pseudoscoripon and Earthworm
Nekaj v zrelem kompostu iz hmeljevine detektiranih organizmov; od leve proti desni: pajek, paščipalec in deževnik

Kompost – izboljšanje rodovitnosti tal in zalog organskega ogljika v tleh

Werner VOGT-KAUTE[1], Aleš KOLMANIČ, Simon OGRAJŠEK, Snežana JAKŠIĆ in Milorad ŽIVANOV

Uporaba komposta lahko izboljša rodovitnost tal in zaloge ogljika v tleh na kmetijah brez živine, kjer ni zlahka dostopnih organskih gnojil. Kompost pridobivamo s postopki mikrobne razgradnje odmrle organske snovi ob prisotnosti kisika (aerobno). Postopek termofilnega kompostiranja je zaželen način kompostiranja, saj lahko temperature 65 °C ali več med kompostiranjem uničijo patogene in zmanjšajo odstotek kalivih semen plevela. Za termofilno kompostiranje je treba kompost občasno prezračevati (običajno s strojem za obračanje komposta), kar otežuje izvedbo tega načina kompostiranja. Za kompostiranje morata biti ogljik (C) in dušik (N) v primernem razmerju. Razmerje C/N 25:1 - 35:1 je dober začetek za kompostiranje. Vire, bogate z dušikom (kot je travna ali deteljna biomasa), je treba pred kompostiranjem zmešati z viri, bogatimi z ogljikom (kot so npr. lesni sekanci), saj lahko ožje razmerje C/N povzroči anaerobne razmere med kompostiranjem. Komposta s širokim razmerjem C/N (25:1 - 35:1) ne moremo obravnavati kot gnojilo, ampak kot sredstvo za izboljšanje tal.
Obstajata dve strategiji za proizvodnjo komposta: i) kompostiranje gnoja, rastlinskega materiala ali bioloških odpadkov na kmetijah in ii) kompostiranje rastlinske biomase in bioloških odpadkov gospodinjstev v skupnosti.
Kompostiranje na kmetijah. Lokacije za kompostiranje na kmetijah morajo v nekaterih državah izpolnjevati predpise o varstvu okolja. Zaradi zahtevnosti termofilnega kompostiranja se kmetje običajno poslužujejo postopka mikrobno karboniziranega kompostiranja. Prednost tega postopka je, da materiala za kompostiranje ni treba obračati. Ker pa ta postopek ni popolnoma aeroben in doseže temperature le do okoli 45 °C, ostane več plevelnih semen kalivih. Izgube ogljika med karboniziranem kompostiranjem so manjše kot pri termofilnem kompostu, vendar je tak kompost zaradi slabše stabilnosti hitreje razgrajen na polju in s tem podvržen večjim izgubam C kot pri uporabi termofilnega komposta.
Kompostiranje v skupnosti. Skupnosti ali podjetja kompostirajo čiste zelene odpadke biomase iz skupnosti ali vrtov ali pa jih mešajo z biološkimi odpadki iz gospodinjstva. Pri tem je potrebno izvajati ukrepe in selekcionirati material za zmanjšanje onesnaženosti komposta s plastiko in drugimi nezaželenimi snovmi. Poleg tega mora biti vsebnost težkih kovin v skladu predpisi. Da bi izboljšali sprejemljivost tega komposta za kmete, bi lahko bili razviti zasebni standardi s strožjimi kriteriji glede vsebnosti mikro-plastike, težkih kovin, itd. Mešanice z biološkimi odpadki iz gospodinjstev pogosto dosežejo nižje razmerje C/N med 15:1 in 18:1.
V projektu "Izboljšanje bilanc ogljika ekoloških kmetij brez živinoreje za sekvestracijo atmosferskega ogljika", ki ga financira Zvezno ministrstvo za okolje, ohranjanje narave, jedrsko varnost in varstvo potrošnikov Nemčije v okviru poskusov Evropske podnebne pobude (EUKI) izvajamo poskuse z uporabo komposta in izdelujemo informativno gradivo. Zbrano gradivo bo objavljeno na spletni strani projekta https://www.kis.si/EUKI/.

Ključne besede: organski ogljik, kompost

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Compost – improving soil fertility and soil carbon

The use of compost can improve soil fertility and soil carbon content in farms without livestock, where no organic fertilizers are easily available. Compost is the result of microbial decomposition of dead organic matter in the presence of oxygen (aerobic). Thermophilic composting is preferred, as temperatures of 65 °C or more during composting can eliminate pathogens and reduce the viability of weed seeds. For thermophilic composting, compost has to be aerated, usually done with a compost-turning machine.
Carbon (C) and nitrogen (N) must be at the proper ratio for composting. A C/N ratio of 25:1–35:1 is a good start for composting. Sources rich in N (e.g., grass or clover biomass) have to be mixed with sources rich in C (e.g., wood chips) before composting, as a narrower C/N ratio can cause anaerobic conditions during composting. Compost with a wide C/N ratio cannot be regarded as a direct fertilizer but as a soil improver.
There are two strategies for compost production: on–farm composting of manure or plant residues or composting of green waste and bio-waste of households in a community.
On-farm composting: In some country's locations for on-farm composting must fulfil regulations on environmental protection. Due to difficulties with thermophilic composting aeration, farmers commonly use microbial carbonizing composting where composting material does not have to be turned. However, as the process is not completely aerobic and reaches temperatures of about 45 °C, more weed seeds remain viable. Carbon losses during carbonizing composting are lower than in thermophilic compost; however, due to its lower stability, compost is decomposed faster in the field and is thus subject to greater C losses compared to thermophilic compost.
Composting in the community: Communities or companies compost either pure green waste from the community or gardens or mix it with bio-waste from a household. Measures and material selection must be implemented to reduce the pollution of compost with plastic and other unwanted substances. In addition, the contents of heavy metals must be in accordance with the legislative values. Private standards could have stricter thresholds (e.g., amount of plastic) to improve the acceptance of farmers. Mixes with bio-waste from households often reach a lower C/N ratio between 15:1 and 18:1.
In the project "Improving carbon balances of livestock-free organic farms for atmospheric carbon sequestration" funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection of Germany within the framework of the European Climate Initiative (EUKI) trials are conducted and information material is produced.
Materials of the project will be published on the project website https://www.kis.si/EUKI/.

Key words: organic carbon, compost

Metode, postopki in rezultati preverjanja sortne pristnosti žit in križnic

Barbara PIPAN[1], Teja KRPAN, Romana RUTAR, Uroš BENEC, Darja VOUK, Lovro SINKOVIČ, Peter DOLNIČAR in Vladimir MEGLIČ

V postopku uradnega potrjevanja sadilnega materiala in semenskih posevkov se vse pogosteje pojavlja problem identifikacije sorte, vrste ali celo rodu prisotnih netipičnih rastlin, predvsem med žiti in križnicami. Nove sorte so si namreč morfološko vedno bolj podobne, zato je njihova identifikacija na osnovi vidnih/fenotipsko izraženih znakov vedno težja. Skupno smo v projekt vključili 54 sort (vsaka sorta samoprašne vrste zastopana s 4 individualnimi rastlinami/genotipi *oz* z 8 za tujeprašne vrste), izbranih na podlagi podatkov o semenski pridelavi ter pregleda veljavne Slovenske sortne liste, katerih seme smo pridobili iz uradnih standardnih vzorcev. Skupno smo analizirali 403 genotipe s 46 različnimi DNA markerji (Simple Seguence Repeat-SSR, Cleaved Amplified Polymorphic Sequences-CAPS, Sequence Characterizied Amplified Region-SCAR) za genomsko specifično in sortno ločevanje znotraj/med žiti in križnicami. Za razločevanje znotraj kompleksa vrst pšenica/rž/tritikala/pira smo uporabili 13 DNA markerjev z visoko stopnjo polimorfnosti (He=0,599; I=1,108; Nm=1,251); za razločevanje znotraj rodu *Avena* 7 DNA markerjev (najbolj polimorfen lokus AM4); za razločevanje znotraj rodu *Hordeum* 6 DNA markerjev (v analizi glavnih koordinat prve tri pojasnijo skupaj 69,1 % molekulske variabilnosti); za raznolikost in razločevanje znotraj in med navadno in tatarsko ajdo 11 visoko informativnih DNA markerjev (UHe=0,777; I=1,399; Ne=4,079; Np=0,6); za raznolikost in razločevanje znotraj in med vrstami družine Brassicaceae pa 9 DNA markerjev (najbolj informativen lokus BN83B1). Za vsak marker posebej smo optimizirali reakcijske mešanice in pogoje namnoževanja v verižni reakciji s polimerazo ter v fragmenti analizi za pridobitev kvalitativnega/binarnega (prisotnost/odsotnost namnožka na posameznem lokusu) in alelnega profila sorte. Nadalje smo z uporabo statističnih programov in orodij populacijske genetike pridobili informacije o frekvencah alelov na posameznem lokusu ter ovrednotili intra-specifično raznolikost znotraj posamezne sorte. V projektu smo tako na nacionalni ravni vzpostavili bazo podatkov z genetskimi profili sort in prvič validirali vzpostavljen sistem za zanesljivo identifikacijo žit in križnic z DNA markerji, ki sedaj omogoča hitro, učinkovito in finančno sprejemljivo preverjanje sortne pristnosti in čistosti v okviru postopka uradnega potrjevanja za službo za uradno potrjevanje semenskega in sadilnega materiala kmetijskih rastlin, inšpekcijske službe, ministrstva, pridelovalce, uvoznike semen in žlahtnitelje same.

Ključne besede: sortna pristnost, DNA markerji, genetska identifikacija, križnice, žita

Zahvala. Raziskava je nastala v okviru projekta CRP V4-1806, sofinanciranega s strani Javne agencije za raziskovalno dejavnost RS in Ministrstva za kmetijstvo, gozdarstvo in prehrano.

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Methods, procedures and results of seed authenticity of cereals and brassicas

In the certification of seeding materials, the problem of identifying the variety, species, or even genus of atypical plants, especially in cereals and crucifers, is appearing with increasing frequency. New varieties are becoming more and more similar morphologically, making their identification based on visible/phenotypically distinct characteristics increasingly difficult. In total, we included 54 varieties in the project (self-pollinated with 4 and cross-pollinated species with 8 individual genotypes), selected based on seed production data and a review of the valid Slovenian List of Varieties, and whose seeds were obtained from official standard samples. We analyzed a total of 403 genotypes with 46 different DNA markers (Simple Sequence Repeat-SSR, Cleaved Amplified Polymorphic Sequences- CAPS, Sequence Characterized Amplified Region- SCAR) for genome-specific and varietal distinguishing within/between cereals and brassicas. We used 13 highly polymorphic DNA markers (He=0.599; I=1.108; Nm=1.251) to discriminate within the wheat/rye/triticale/spelt species complex; to distinguish within the genus Avena, 7 DNA markers (the most polymorphic locus AM4); to differentiate within the genus Hordeum, 6 DNA markers (in the principal coordinate analysis, the first three axes explained a total of 69.1% of molecular variability); 11 highly informative DNA markers for diversity and differentiation within and between common and tartary buckwheat (UHe=0.777; I=1.399; Ne=4.079; Np=0.6); for diversity and differentiation within and between species of the family Brassicaceae 9 DNA markers (the most informative locus BN83B1). For each marker, we individually optimized reaction mixtures and amplification conditions in polymerase chain reaction and fragment analysis to obtain a qualitative/binary (presence/absence of amplification at a single locus) and allelic profiles of the variety. In addition, we used statistical programs and population genetics tools to obtain information on the frequency of alleles at each locus and to assess intra-specific diversity within each variety. As part of the project, we have created a database of genetic profiles of varieties at the national level and validated for the first time the established system for reliable identification of cereals and brassicas with DNA markers, which now allows fast, efficient and financially acceptable verification of the authenticity and purity of the varieties in the certification process for the official certification body, control services, ministries, producers, seed importers and breeders themselves.

Key words: varietal authenticity, DNA markers, genetic identification, cereals, brassicas

Acknowledgement. The research was carried out within the framework of the CRP V4-1806 project, co-financed by the Slovenian Research Agency and the Ministry of Agriculture, Forestry and Food.

Optimizacija semenarjenja hibridnih sort zelja (*Brassica oleracea* var. *Capitata* L.)

Katarina RUDOLF PILIH[1], Adriana PODRŽAJ, Kristina UGRINOVIĆ in Barbara ZAGORC

Semenarstvo je kmetijska panoga, ki je temelj za uspešno in gospodarno tržno pridelavo hrane. V Sloveniji semenarstvo že vrsto let stagnira, pri zelenjadnicah pa zadnja leta beležimo celo upad. Povečanje deleža domačega semenarstva je nujno, tako zaradi prispevka k prehranski varnosti, kot tudi zaradi ohranjanja biodiverzitete v kmetijski pridelavi. Z letom 2014 je Ministrstvo za kmetijstvo, gozdarstvo in prehrano pričelo s sistematičnim financiranjem žlahtnjenja slovenskih sort zelenjadnic, v okviru katerega smo na Biotehniški fakulteti uspeli požlahtniti več hibridnih sort zelja. Postopki za pridobivanje hibridnih sort so optimizirani in na letni ravni lahko pridobimo 5–10 novih potencialnih hibridov zelja. Zaključna faza žlahtnjenja rastlin je zagotavljanje dovolj velike količine semena za oskrbo, v prvi vrsti slovenskega trga. Hibridne sorte so pri pridelovalcih in potrošnikih zaželene, vendar v Sloveniji semena hibridnih sort zelenjadnic do sedaj nismo pridelovali. Z namenom vzpostavitve pridobivanja lastnega hibridnega semena, smo na podlagi predhodnih raziskav uporabili dva pristopa, in sicer na osnovi samoinkompatibilnosti ter s pomočjo vnosa citoplazmatske moške sterilnosti v materino linijo. Uspešnost križanja starševskih linij smo nato določili s pomočjo molekularnih markerjev. Ti omogočajo hitro in zanesljivo določanje heterozigotnosti potomcev in s tem čistosti semena. V poskuse smo vključili 10 hibridnih sort, ki smo jih semenili na različnih lokacijah po Sloveniji. Na ta način smo dobili informacijo o primernosti lokacij, o ustreznosti linij in postopkih, ki so najprimernejši za pridobivanje semena hibrida. Vsakoletno množenje linij smo izvedli *in vitro* s tehnikami mikropropagacije. Za uspešnost pridelave zdravega semena z visokim rastnim potencialom so vsekakor potrebni tudi ustrezni agrotehnični postopki, ki bodo predstavljeni v tehnoloških listih. Pridobljeni rezultati lahko vodijo do vzpostavitve partnerstva za semenarstvo hibridnih in populacijskih sort, vključujoč koncept prenosa znanja med raziskovalnimi institucijami, semenarskimi podjetji in kmetijskimi gospodarstvi. Z zeljem kot modelno rastlino želimo vzbuditi zanimanje za semenarjenje, doseči večji obseg semenarjenja na slovenskih tleh in s tem tudi večjo ponudbo semena slovenskih sort na prodajnih policah.

Ključne besede: semenarjenje, hibridi, čiste linije, moška sterilnost, mikropropagacija

Mikropropagirane starševske linije za pridobivanje hibridnega semena
Micropropagated parental lines for hybrid seed production

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Optimisation of hybrid seed production of cabbage (*Brassica oleracea* var. *Capitata* L.)

Seed production is an agricultural sector that forms the basis for successful and market-oriented economic food production. In Slovenia, seed production has been stagnating for many years, and in the case of vegetables, it has even been declining. There is a need to increase the share of domestic seed production, both in terms of food security and preservation of biodiversity in agricultural production. In 2014, the Ministry of Agriculture, Forestry and Food started systematic funding of breeding of Slovenian vegetable varieties, within which we successfully bred several cabbage hybrid varieties at the Biotechnical Faculty. The procedures for obtaining hybrid varieties have been optimized and we can obtain 5-10 new potential cabbage hybrids every year. The final phase of plant breeding is to provide a sufficient amount of seed for supply, especially for the Slovenian market. Hybrid varieties are desirable for breeders and consumers, but in Slovenia we do not produce hybrid seed of vegetable. To establish the production of our own hybrid seed, we have taken two approaches based on previous research, namely based on self-incompatibility and by introducing cytoplasmic male sterility into the seed line. The success of crossing the parental lines was determined using molecular markers. These allow a rapid and reliable determination of the heterozygosity of the progeny and thus the purity of the seed. In the experiment ten hybrid varieties grown at different locations in Slovenia were included. In this way we obtained information about the suitability of the locations, the suitability of the lines and the methods best suited to obtain the hybrids. The annual propagation of the lines is carried out *in vitro* using micropropagation techniques. Effective cultivation practices are critical to the successful production of healthy seed with high growth potential. Therefore, agronomy fact sheets will be provided. The expected results will help to establish a partnership for seed production of hybrid and population varieties of cabbage, including the concept of knowledge transfer between research institutions, seed companies and farms. Using cabbage as a model crop, we aim to stimulate interest in seed production, achieve a higher volume of seed production and thus a greater supply of seed of Slovenian varieties on market shelves, which will lead to a higher level of self-sufficiency and thus greater food security.

Key words: seed production, hybrids, inbred lines, men sterility, micropropagation

Semenarjenje hibrida v rastlinjaku in na prostem
Hybrid seed production in greenhouse and in open field

Uporaba plinske plazme za obdelavo semen

Pia STARIČ, Katarina VOGEL-MIKUŠ, Aleš KOLMANIČ, Kristina UGRINOVIĆ in Ita JUNKAR[1]

Tehnologija hladne plazme je razmeroma nova metoda, ki se vse bolj uveljavlja tudi na področju agronomije. Njena uporaba je dvostranska: uporabljamo jo lahko tako za dekontaminacijo semen in svežih rastlinskih pridelkov (sadje, zelenjava), kot tudi za vzpodbujanje kalitve semen in rasti kalic. Nekateri avtorji poročajo celo o večjem pridelku ter boljši odpornosti rastlin na nekatere abiotske dejavnike stresa.
Semena različnih sort pšenice smo obdelali z direktno (G) ali indirektno (AG) nizkotlačno kisikovo plazmo pri različnih časih obdelave (30 in 90 s) ter pri konstantni moči (200 W) in tlaku (50 Pa) plazme. Fiziološke lastnosti semen in kalic smo ocenili s testi kalivosti, študijami rasti kalic ter meritvami aktivnosti encima α-amilaze. Preučili smo tudi spremembe omočljivosti semen v povezavi z oksidacijo lipidov s strani plazemskih komponent med obdelavo. Le daljša izpostavitev plazmi je povzročila spremembe v parametrih kalitve semen, tako da je upočasnila njihovo kalitev ter znižala končno kalivost. Hladno-plazemska obdelava je povzročila tudi znižanje aktivnosti encima α-amilaze ter vplivala na razvoj koreninskega sistema kalic. Na Sliki 1 je prikazana razlika v kalitvi semen pri različnih pogojih obdelave, na sliki 1a je prikazana končna kalivost (G (%)) v odvisnosti od vrste obdelave, na sliki 2a pa hitrost kalitve (MR (1/dan)) v odvisnosti od vrste obdelave.

Ključne besede: plazma, pšenica, kalitev, α-amilaza, omočljivost

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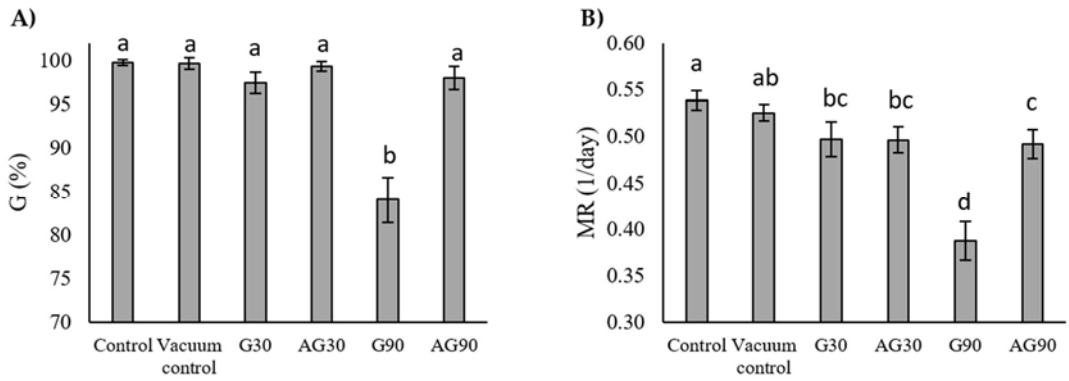
Gaseous plasma treatment of seeds

The nonthermal or cold plasma technology is a relatively new technology being introduced into agriculture. The research is focused on two kinds of uses of this technology: Firstly, it could be used as a new decontamination method of seed material and fresh food products, such as berries. Secondly, cold plasma technology could be used as a tool for seed priming; improving seed germination, seedling growth and potentially even improve crop yield and alleviate abiotic stress from the environment.
Wheat seeds were treated with glow (G) or afterglow (AG) low-pressure radio-frequency oxygen plasma at different treatment times and constant power input (200 W) and pressure (50 Pa) The physiological characteristics of the germinating seeds and seedlings after plasma treatment were determined by germination tests, growth studies, and measurements of α-amylase activity. The changes of seed wettability after plasma treatment were also studied, mainly in correlation with functionalization of the seed surface and oxidation of lipid molecules by plasma components. Only longer direct plasma treatment resulted in changed germination parameter of seeds. The cold plasma treatment slowed the germination of seedlings, decreased the activity of α-amylase in seeds after imbibition, and affected the root system of seedlings. In Figure presents the difference in germination, where Figure A presents final germination (G (%)) in relation to different treatment conditions, and in Figure B the germination rate (MR (1/dan)) is presented in relation to different treatment conditions.



Difference in germination in relation to different treatment conditions; control, vacuum control, glow 30 s (G30), afterglow 30 s (AG30), glow 90 s (G90) and afterglow 90 s (AG90), for final germination (G (%)) in Figure A and for rate of germination (MR (1/day)) in Figure B.
Kalitev v odvisnosti od vrste obdelave; kontrola, vakuumska kontrola, direktna obdelava 30 s (G30), indirektna obdelava 30 s (AG30), direktna obdelava 90 s (G90) ter indirektna obdelava 90 s (AG90), za končno kalitev (G (%)) na sliki A ter za hitrost kalitve (MR (1/dan) na sliki B.

Key words: plasma, wheat, germination, α-amylase, wettability

Povezanost barve semenske ovojnice z barvo cvetov pri kompozitnih genskih virih navadnega fižola (*Phaseolus vulgaris* L.)

Eva PLESTENJAK[1], Vladimir MEGLIČ in Barbara PIPAN

Navadni fižol (*Phaseolus vulgaris* L.) je glede na letno pridelavo in pomembnost v prehrani ljudi v svetovnem merilu najpomembnejši med stročnicami. Danes ga pridelujemo po vsem svetu, njegova sposobnost prilagajanja na različne okoljske dejavnike in različne metode pridelovanja, pa sta razlog za veliko genetsko raznolikost, tako med različnimi populacijami kot tudi znotraj populacij. Semena predstavljajo bogat vir rastlinskih beljakovin, kompleksnih ogljikovih hidratov, prehranskih vlaknin, vitaminov in mineralov ter imajo nizek delež maščob. Barva semenske ovojnice je pri pridelovalcih in potrošnikih pomemben dejavnik izbire in je glede na podatke v literaturi povezana z barvo cvetov. V naravi so cvetovi navadnega fižola obarvani v svetlo do temno rožnatih odtenkih, gojeni pa imajo lahko tudi belo obarvane cvetove. Genetsko ozadje barve in vzorca semenske ovojnice vključuje 22 genov, od tega je sedem genov povezanih tudi z barvo cvetov. Glavni in najpomembnejši gen, ki je odgovoren za nastanek pigmentov tako v semenski ovojnici kot tudi v cvetovih, je gen *P*. Njegova recesivna oblika, *pp,* preprečuje sintezo transkripcijskega faktorja, s tem pa je onemogočena biosintetska pot nastanka pigmentov. Fenotipsko se genotip *pp* izrazi kot belo obarvana semenska ovojnica in belo obarvani cvetovi, ne glede na prisotnost drugih genov, ki nosijo zapis za barvo. V naši raziskavi smo želeli preveriti, ali obstaja povezava med belo barvo semenske ovojnice in belo barvo cvetov pri 50 kompozitnih genskih virih navadnega fižola. Posamezen genski vir je imel od dve do pet komponent; skupno smo obravnavali 130 komponent, ki so se razlikovale v barvi oziroma vzorcu semenske ovojnice. Pred setvijo so bila semena ovrednotena na podlagi barve in vzorca na površini semena z uporabo znakov oziroma deskriptorjev UPOV (International Union for the protection of new varieties of plants). Med rastno dobo smo rastline fižola vizualno vrednotili glede na barvo kril ter barvo jadra na cvetovih z deskriptorji Phaselieu (Improvement of sustainable Phaselous production in Europe for human consumption). Statistične obdelave podatkov in preverjanje povezave med barvo semena in barvo cveta smo izvedli z uporabo R programa in paketa *Rcmdr*. Rezultati raziskave so potrdili povezavo med belo barvo semenske ovojnice in belo barvo cvetov tako kril kot tudi jadra ($p < 0{,}0001$). Vsa semena z belo obarvano semensko ovojnico so imela belo obarvana krila in jadro, semena s kombinacijo primarne in sekundarne barve semenske ovojnice pa so imela poleg rožnatih in vijoličnih odtenkov tudi od 17,9 do 46,7 % belo obarvanih kril ter od 17,9 do 39,4 % belo obarvanih jader. Poleg razlik v barvi semen pri kompozitnih genskih virih smo v raziskavi opazili razlike tudi v kombinacijah barv cvetov, zato bomo raziskavo nadaljevali na genetskem in genomskem nivoju.

Ključne besede: fižol, seme, barva kril, barva jadra

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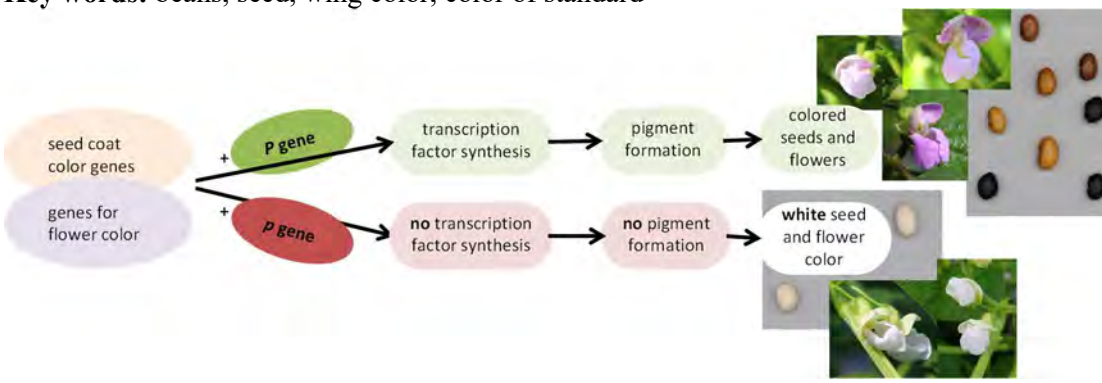
Association of seed coat color with flower color in common bean (*Phaseolus vulgaris* L.) composite genetic resources.

Common bean (*Phaseolus vulgaris* L.) is the most important among legumes in terms of annual production and importance for human nutrition. Nowadays it is cultivated all over the world, and the ability to adapt to different environmental factors and different cultivation methods has led to a great genetic diversity, both between different populations and within a population. The seeds are a rich source of vegetable protein, complex carbohydrates, dietary fiber, vitamins, and minerals, and contain low amounts of fats. The color of the seed coat is an important factor of acceptance for growers and consumers, and according to information in the literature, it is related to the color of flowers. In the wild, common bean flowers are colored in light to dark pink shades but cultivated beans may also have white-colored flowers. The genetic background of seed coat color and pattern includes 22 genes, seven of which are also linked to flower color. The most important gene responsible for pigment formation in both seed coat and flowers is the *P* gene. Its recessive form, *pp*, prevents the synthesis of the transcription factor that overrides the biosynthetic pathway of pigment formation. Phenotypically, the *pp* genotype is expressed as a white-colored seed coat and white-colored flowers, independent of the presence of other color-coding genes. In our research, we investigated the association between the white color of the seed coat and the white color of the flowers in 50 composite genetic resources of common bean. A single gene source had two to five components; we considered a total of 130 components that differed in seed coat color or pattern. Prior to sowing, seeds were evaluated for seed coat color and pattern according to UPOV (International Union for the protection of new varieties of plants). During the growing season, plants were visually evaluated on wing color and color of standard using descriptors Phaselieu (Improvement of sustainable Phaselous production in Europe for human consumption). Statistical data processing and verification of the correlation between seed coat color and flower color were performed using the R program under the *Rcmdr* package. The results of the study confirmed the association between the white color of the seed coat and the white color of the flowers for both, wings and standard ($p < 0.0001$). All seeds with a white-colored seed coat had white-colored wings and standards, and seeds with a combination of primary and secondary seed coat colors, besides to pink and purple hues, also had between 17.9 and 46.7% white-colored wings and between 17.9 and 39.4% white-colored standards. In addition to the differences in seed coat color between the composite genetic resources, differences in flower color were also noted, so we will continue research at the genetic and genomic levels.

Key words: beans, seed, wing color, color of standard



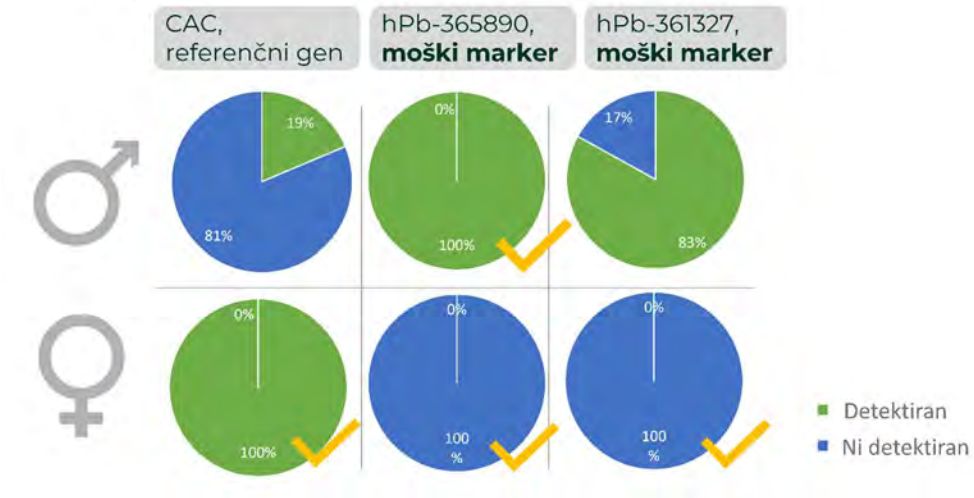
Shema nastanka barve cvetov in barve semenske ovojnice
Scheme of the formation of the flower and seed coat color

Nova in hitrejša molekularne metoda za določanje spola pri hmelju

Lucija LUSKAR[1], Jernej JAKŠE in Andreja ČERENAK

Hmelj (*Humulus lupulus L.*) je dvodomna vetrocvetna trajnica. V pivovarstvu se uporabljajo le zrela neoplojena ženska socvetja in tudi trgovska vrednost osemenjenih ženskih storžkov je manjša, zato je potrebno določanje spola v zgodnji fazi žlahtniteljskega postopka. Rastline hmelja spolno dozorijo po dveh letih, zato je za hitro določanje spola zaželena uporaba molekulskih markerjev. Leta 2016 smo v žlahtniteljskem programu Inštituta za hmeljarstvo in pivovarstvo Slovenije vzpostavili metodo določanja spola s PCR s hkratnim pomnoževanjem moških markerjev, določenih na podlagi DArT tehnologije. Z namenom časovne optimizacije detekcije spola brez koraka post PCR analize pomnožkov z agarozno gelsko elektroforezo smo v predstavljeni študiji vzpostavili novo, qPCR metodo z dvojno označenimi hidrolizirajočimi sondami (TaqMan qPCR sonde). Z napravo QuantStudio 3 lahko zaznamo štiri različne fluorofore, zato smo načrtovali qPCR test za tri moške markerje in en referenčen hmeljev gen. V prvem koraku optimizacije smo na novo načrtovane začetne oligonukleotide testirali s klasično metodo PCR in agarozno gelsko elektoroforezo. Pari začetnih oligonukleotidov, ki so uspešno ločili moške in ženske genotipe, so bili izbrani za TaqMan pristop. Z validacijskim postopkom sta bila za qPCR izbrana dva markerja; enega za moški spol in drugega za referenčni gen, ki pomnoži hmeljno DNA neodvisno od spola. Najprej smo naredili posamične reakcije za izbrane markerje, nato pa s pristopom hkratnega pomnoževanja preverili 108 genotipov z raznolikim pedigrejem. Z izbranimi markerji smo ustrezno določili spol. Eden od markerjev (hPb-365890) je imel 100% učinkovitost za določanje spola in ga lahko uporabljamo kot samostojni marker za moški spol.

Ključne besede: molekularni markerji, žlahtnjenje, spol, hmelj, metode, hkratno pomnoževanje, qPCR



Določanje spola z multiplex qPCR na 108 genotipih (59 moških, 48 žensk), z mejo detekcije na 30. ciklu

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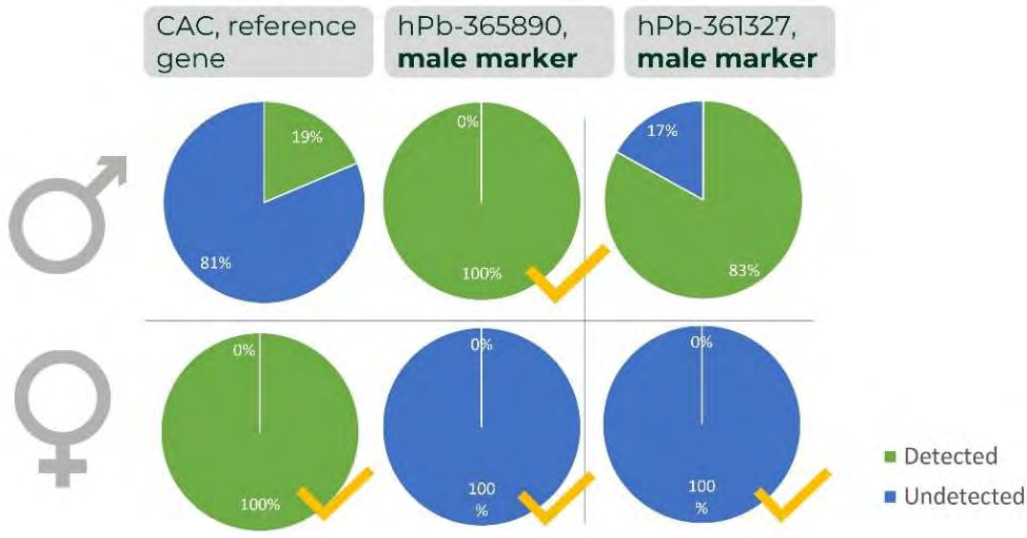
New and faster molecular method for sex determination in hop

Hop (*Humulus lupulus* L.) is a dioecious perennial wind-pollinated plant. Sex selection is required in the early stages of the breeding program because only ripe female inflorescences are used in the brewing process and because seeded female cones have lower market value. Hop plants reach reproductive phase in two years, therefore use of sex molecular markers is desired for early detection of sex. In breeding program of Slovenian Institute of Hop Research and Brewing, in 2016, we have introduced multiplex PCR method for detection of male markers, discovered by DArT genotyping method. With tension for time optimisation without post PCR analysis, which includes tedious gel electrophoresis we developed qPCR method with dual-labelled hydrolysis probes (TaqMan qPCR probes). Since four different fluorescent colours can be used on QuantStudio 3 the qPCR test was prepared for three male specific markers and one reference hop gene. Newly designed primer pairs were tested in PCR coupled with agarose gel electrophoresis in the first step of optimisation, and pairs with distinguishing properties were selected for TaqMan approach. The qPCR test was designed for three hop male specific markers and one reference gene. Based on 108 tested genotypes differing in pedigree, we can conclude that developed primers and probes for markers hPb-356890 and hPb-361327 can be used as male markers for determination of hop sex. Moreover, one marker (hPb-365890) was 100% efficient to determine sex, therefore it is used as single male marker.

Key words: molecular markers; breeding, sex; hop; methods; multiplex, qPCR



Sex determination with multiplex qPCR of 108 genotypes (59 male, 48 female) with "cut off" on 30th cycle

Uporaba različnih biotehnoloških pristopov v žlahtnjenju hmelja (*Humulus lupulus* L.)

Andreja ČERENAK[1], Sebastjan RADIŠEK, Lucija LUSKAR, Nataša ŠTAJNER in Jernej JAKŠE

Storžki hmelja so ena glavnih sestavin, ki se uporablja v pivovarski industriji. Slovenija zaseda 3. mesto v EU in 5. mesto v svetu po površini hmeljišč. Danes je 98 % slovenskih hmeljišč zasajenih s sortami hmelja iz nacionalnega žlahtniteljskega programa. V žlahtniteljskem programu imajo poleg agronomsko pomembnih lastnosti, vključenih v razvoj novih sort hmelja, pomembno vlogo tudi pivovarske lastnosti. Inštitut za hmeljarstvo in pivovarstvo Slovenije (IHPS) je požlahtnil nove sorte s tradicionalno aromo, visoko vsebnostjo alfa kislin, z različnimi dišavnimi aromami ter različnim razponom odpornosti na bolezni. Pri žlahtnjenju odpornosti na bolezni se osredotočamo predvsem na hmeljevo peronosporo (*Pseudoperonospora humuli*), hmeljevo pepelovko (*Podosphaera macularis*), verticilijsko uvelost hmelja (*Verticillium nonalfalfae*) in zadnja leta tudi na hudo viroidno zakrnelost hmelja (CBCVd). Uspešno sodelovanje med inštitutom, industrijo in univerzo je omogočilo napredek v raziskavah, ki so vpete v razvoj novih selekcijski metod. V programu žlahtnjenja se uporablja hkratni qPCR test za razlikovanje ženskih od moških rastlin v zgodnji fazi razvoja križancev, da se prepreči kasnejše navzkrižno opraševanje v hmeljiščih in odstrani moške rastline iz selekcijskega polja. Poleg tega se mikrosatelitni (SSR) markerji uporabljajo za genotipizacijo sort hmelja za določanje sortne čistosti. Z uporabo biotehnoloških orodij razvijamo izvorne rastline brez virusov in viroidov, ki se uporabljajo kot matične rastline pri razmnoževanju certificiranega sadilnega materiala. Nedavno je bila iz prepisanega dela genoma implementirana možnost uporabe novih generacij molekularnih markerjev, ki temeljijo na podatkih visoko zmogljivega sekvenciranja. V raziskavi, ki je vključevala 8 različnih sort, so bili prepoznani številni pogosti in heterozigotni polimorfizmi (SNP), ki jih bomo lahko uporabili za nadaljnje raziskave vrednotenja genetske variabilnosti ali kartiranja. Izmed 191 236 določenih polimorfizmov pri sorti Wye Target je bilo 90 503 homozigotnih in 92 724 heterozigotnih. Za določanje odpornosti na bolezni je potrebno nadaljnje iskanje molekulskih markerjev, kar je ena od naših prihodnjih usmeritev.

Ključne besede: hmelj, *Humulus lupulus*, žlahtnjenje, biotehnološki pristopi

Zahvala. Rezultati so nastali v okviru programske skupine P4-0077 in SN Žlahtnjenje hmelja.

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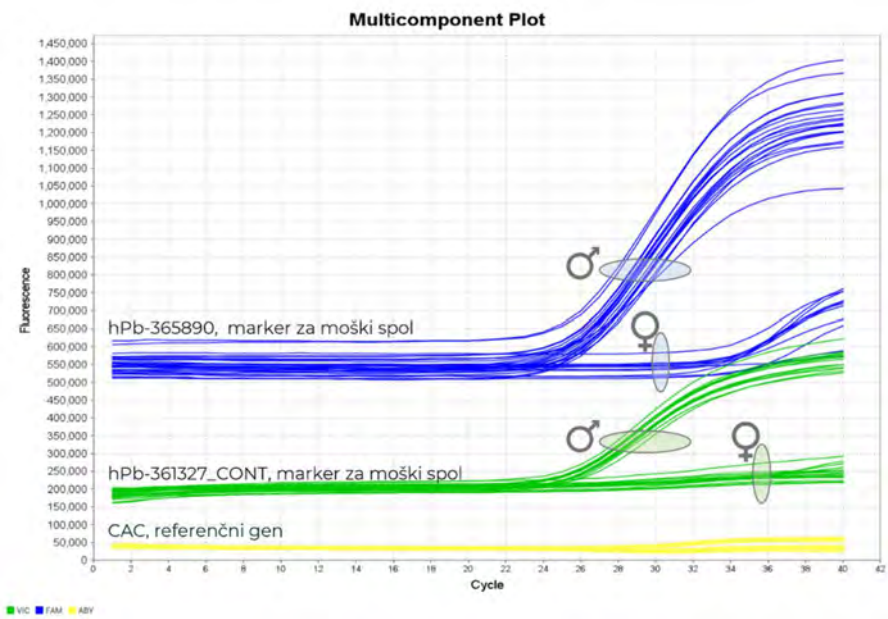
Use of different biotechnological approaches in hop (*Humulus lupulus* L.) breeding program

Hop cones are one of the main ingredients used in the brewing industry. Slovenia is presenting the 3rd place in EU and 5th worldwide in acreage of hop fields. Nowadays, 98% of Slovenian hop fields are planted with hop varieties originating from national breeding program. In breeding program, besides agronomically important traits included in the development of hop varieties, brewing goals play a major role. Consequently, IHPS has developed new varieties with traditional aroma, high alpha-acid content, different flavour aromas and different range of resistance to diseases. In the disease resistance breeding, the main focus is on downy mildew (*Pseudoperonospora humuli*), powdery mildew (*Podosphaera macularis*), verticillium wilt (*Verticillium nonalfalfae*) and to citrus bark cracking viroid (CBCVd) in last years. Successful institute, industry and university collaboration has enabled progress in research of new selection methods. In breeding program multiplex qPCR is applied to differ female from male plants at the early seedling stage to prevent crosspollination in the fields. Furthermore, SSR markers are used for genotyping hop varieties for determination of varietal purity. By using biotechnological tools, we are developing virus and viroid free stock plants used as mother plants in cloning certified planting material. In recent years the possibility of using new generations of molecular markers based on high throughput sequencing was implemented from transcribed part of the genome. In the study including 8 different varieties numerous common and heterozygous polymorphisms (SNPs) were recognized which could be used for further association or mapping studies. Among the 191 236 identified polymorphisms in the Wye Target variety, 90 503 were homozygous and 92 724 were heterozygous. Furthermore, searching for molecular markers necessary for resistance breeding is one of our future perspectives.

Key words: hop, *Humulus lupulus*, breeding, biotechnological approaches



S pristopom hkratnega pomnoževanja s kvantitativnim PCR uspešno določamo spol križancem hmelja z raznolikim pedigrejem.

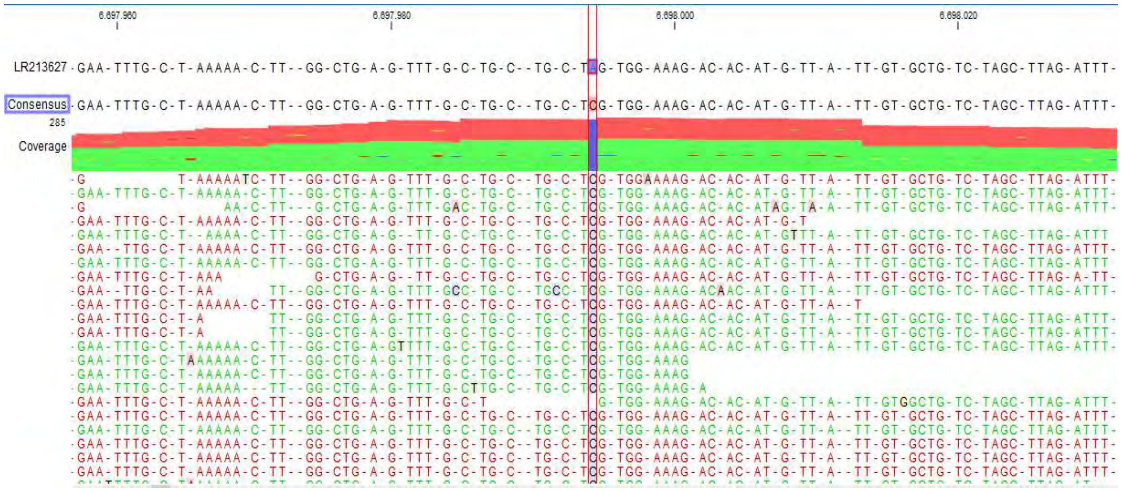
With multiplex qPCR approach we successfully determining sex in hop breeding lines differing in pedigree.

Genetska raznolikost različnih fenotipov konoplje (*Cannabis sativa* L.)

Marjeta ERŽEN[1], Andreja ČERENAK, Tjaša CESAR, Lucija LUSKAR in Jernej JAKŠE

Konoplja (*Cannabis sativa* L.) je dvodomna diploidna (*2n*=20) rastlina, katere genom je sestavljen iz devetih parov avtosomnih kromosomov in enega para spolnih kromosomov. Njen genom meri okrog 830 mega baznih parov (Kovalchuk et al. 2020). Zaradi heterozigotnosti populacijskih sort prihaja do pojava številnih fenotipov znotraj sorte (Barcaccia et al. 2020). Namen naše raziskave je bil ugotoviti variabilnost in populacijsko strukturo različnih fenotipov konoplje znotraj treh različnih sort ('Carmagnola selected', 'Tiborszallasi' in selekcija 'Finole') z metodo lovljenja izbranih predelov DNA in visokozmogljivim sekvenciranjem. Za ta namen smo določili 4631 SNP pozicij v genomu s pomočjo transkriptomskih podatkov in od tega uspešno izdelali 4086 sond za lovljenje. Iz listov konoplje smo izolirali genomsko DNA in izdelali 188 NGS knjižnic. Vsaka knjižnica je bila označena s svojo črtno kodo za prepoznavanje po skupnem sekvenciranju. Pomnožene knjižnice smo združili do skupne koncentracije 2000 ng (skupaj 4 reakcije) in obogatili po postopku hibridizacije lovljenja s sondami. NGS knjižnice smo kvantitativno ovrednotili z metodo qPCR. Knjižnice smo sekvencirali z dvema Proton PII čipoma, na enem čipu lahko sekvenciramo do 96 različnih NGS knjižnic. Dobljene sekvence smo uvozili v program CLC Genomic Workbench (CLC), jih ovrednotili, očistili regije slabe kvalitete in odstranili prekratka zaporedja. Odčitke smo nato poravnali na referenčni genom konoplje CBDRx in določili SNP variante na predvidenih polimorfnih mestih.

Ključne besede: *Cannabis sativa* L., konoplja, NGS knjižnice, sekvenciranje, SNP



Sekvenca poravnana na referenčni genom s potrjenim homozigotnim SNP v izbranem vzorcu konoplje
Sequence aligned to a reference genome with a confirmed homozygous SNP in a selected hemp sample

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Genetic diversity in different hemp (*Cannabis sativa* L.) phenotypes

Hemp (*Cannabis sativa* L.) is a dioecious, diploid (2n=20) plant whose genome has nine pairs of autosomal chromosomes and one pair of sex chromosomes. The genome size is approximately 830 megabase pairs (Kovalchuk et al. 2020). Due to heterozygosity and thus population varieties different phenotypes occur within varieties (Barcaccia et al. 2020). The aim of our study was to determine the variability and population structure of the different phenotypes within three different varieties ('Carmagnola selected', 'Tiborszallasi' and 'Finola' selection) using the DNA target capture method and high-throughput sequencing. From the transcriptome data, 4631 SNP positions in the genome were determined and 4061 capture probes were successfully developed from them. Genomic DNA was isolated from the hemp leaves, from which 188 NGS libraries were designed. Each library had its own barcode for identification after co-sequencing of the pooled NGS libraries. Amplified libraries were pooled to a total of 2000 ng (4 reactions), enriched by hybridization of capture-based probes, and quantified by qPCR. Libraries were sequenced using two Proton PII chips, with one chip capable of sequencing up to 96 different NGS libraries. Final sequences were imported into the CLC Genomic Workbench (CLC) program and analyzed. Regions of poor quality were cleaned up and sequences that were too short were removed. Reads were mapped to the CBDRx reference genome and SNP variants were determined at the predicted polymorphic sites. Further detailed results will be presented at the symposium.

Key words: *Cannabis sativa* L., hemp, NGS libraries, sequencing, SNP

Tvorba cvetnega prahu pri superiornih R linijah navadne pšenice (*Triticum aestivum* L.)

Primož TITAN[1]

Uporaba heterozisa je pogost pristop pri razvoju visokoproduktivnih kultivarjev. Genetski fenomen heterozisa se najpogosteje povezuje z razvojem F_1 hibridov in sintetikov. Danes so F_1 hibridi pri poljščinah razširjeni predvsem v pridelavi koruze in oljne ogrščice. Kljub številnim naporom, ki so bili vloženi v razvoj hibridnih sort navadne pšenice (*Triticum aestivum* L.), se le te nikoli niso razširile v široki proizvodnji. Danes v splošni kmetijski praksi še vedno prevladujejo tako imenovane linijske sorte navadne pšenice.
Kot glavni dejavniki, ki omejujejo razvoj in uporabo hibridnih sort navadne pšenice, so se izkazali nezadovoljiva raven heterozisa, ki jo je mogoče eksploatirati v dednini navadne pšenice, velika poraba semena na enoto površine in dvospolni (hermafroditni) cvetovi, ki zahtevajo indukcijo moške sterilnosti. Danes razvoj hibridnih sort navadne pšenice še vedno temelji na citoplazemsko-genetski moški sterilnosti, ki predvideva tri komponente (moško sterilna ženska komponenta, fertilni analog moško sterilne komponente, R linija oziroma opraševalec (moška komponenta), ki je hkrati nosilec genov za obnovo fertilnosti v F_1 generaciji).
V 70. in 80. letih je bil pri razvoju hibridnih sort navadne pšenice poudarek predvsem na obnovi fertilnosti v F_1 generaciji. Citoplazma timofejeve pšenice (*Triticum timopheevii* Zhuk.) je bila zaradi težav, ki jih povzroča pri obnovi fertilnosti v prvi filialni generaciji, predmet številnih raziskav. Še danes se številne študije ukvarjajo s tako imenovanimi *Rf* geni (Restorer fertility genes), ki prekrivajo delovanje timofejeve citoplazme. Kljub odkritju učinkovitih genov za obnovo fertilnosti v F_1 generaciji (predvsem geni *Rf1*, *Rf3* in *Rf9*) pa se je v praksi kot ključen problem izkazala nezadostna velikost pridelka hibridnega semena pšenice. Nizek izplen uporabnega hibridnega semena je posledično vodil v opustitev marsikaterega žlahtniteljskega programa »hibridne pšenice«.
Danes se pri razvoju R linij poleg genetskega ozadja kot pomembna lastnost pojavljajo tudi parametri, ki določajo kvantiteto in kvaliteto cvetnega prahu. V naši študiji smo preučili lastnosti cvetenja desetih R linij navadne pšenice, ki temeljijo na znanem donorju *Rf3* gena, sorti Primepi. Pri tem smo določili parametre, kot je število prašnic na klas, trajanje ekstruzije prašnic in koncentracijo pelodnih zrn (z napravo Ampha P20). Rezultati so pokazali na statistično značilne razlike med obravnavanimi linijami. Kot najbolj perspektivna R linija se je izkazal žlahtniteljski material, ki izhaja iz križanja sort Ludwig × Primepi. Navedeni material je v primerjavi z drugimi R linijami izstopal po številu prašnic na klas (≥ 250) in koncentraciji pelodnih zrn (med 4,5 in 5,5 x 10^3 celic mL^{-1}). Izvedena študija predstavlja nadgradnjo obstoječega dela na razvoju F_1 hibridov navadne pšenice, predvsem v smislu iskanja rešitev za pridelavo hibridnega semena na komercialni ravni.

Ključne besede: cvetni prah, CMS, F_1 hibridi, heterozis, R linije

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Pollen production in superior R lines of common wheat (*Triticum aestivum* L.)

The use of heterosis is a common approach in the development of high-yielding cultivars. The genetic phenomenon of heterosis is most often associated with the development of F1 hybrids and synthetics. Today, F1 hybrids are widespread in crops, mainly in the production of corn and oilseed rape. Despite the many efforts that have been invested in the development of hybrid varieties of common wheat (Triticum aestivum L.), these have never been used in wide agricultural production. Today, so-called line varieties of common wheat still dominate general agricultural production.

The main factors limiting the development and use of common wheat hybrids are the unsatisfactory level of heterosis that can be exploited in common wheat germplasm, high seed consumption per unit area and bisexual (hermaphrodite) flowers that require the induction of male sterility. Today, the development of common wheat hybrids is still based on cytoplasmic-genetic male sterility, which assumes three components, male sterile female component, a fertile analogue of a male sterile component and the R line (known also as male component or the carrier of *Rf* genes).

In the 1970s and 1980s, the emphasis by the development of hybrid wheat varieties was mainly on the fertility restoration in the F1 generation. Cytoplasm of *Triticum timopheevii* Zhuk. has been the subject of many studies due to the problems it causes in the fertility restoration. Even today, many studies deal with the so-called *Rf* genes (Restorer fertility genes), which overlap the function of the *T. timopheevii* cytoplasm. Despite the discovery of effective genes for the fertility restoration in the F1 generation (mainly genes *Rf1*, *Rf3* and *Rf9*), in practice, the insufficient production of hybrid wheat seed per unit area proved to be a key problem. The low yield of useful hybrid seed consequently led to the abandonment of many "hybrid wheat" breeding programs.

Today, in the development of R lines, in addition to the genetic background, parameters that determine the quantity and quality of pollen also appear as an important variable. In our study, we examined the floral characteristics of ten R lines of common wheat based on the known donor of the *Rf3* gene, the variety Primepi. We determined parameters such as the number of anthers per spike, the duration of anther extrusion and the concentration of pollen grains (with the Ampha P20 device). The results showed statistically significant differences between the considered lines. The breeding material derived from the Ludwig × Primepi cross proved to be the most promising R line. Compared to other R lines, this material stood out in terms of the number of anthers per spike (≥ 250) and the concentration of pollen grains (between 4.5 and 5.5 x 103 cells ml^{-1}). Our study represents an upgrade of the existing hybrid wheat breeding work, mainly in terms of finding the solutions to produce hybrid wheat seed material on a commercial scale.

Key words: CMS, F_1 hybrids, heterosis, pollen, R lines

KIS Blegoš, KIS Mangart in KIS Tamar – nove slovenske sorte krompirja

Peter DOLNIČAR[1], Irena MAVRIČ PLEŠKO, Aleš KOLMANIČ, Saša ŠIRCA in Andrej SIMONČIČ

Program žlahtnjenja krompirja na Kmetijskem inštitutu Slovenije poteka že 30. leto. V tem času je bilo potrjenih 15 novih sort krompirja. Glavni cilji programa so vzgoja rodovitnih zelo kakovostnih sort za svežo uporabo, tolerantnih na sušne in vročinske razmere ter odpornih proti virusu Y krompirja in krompirjevi plesni. Gre za klasičen program žlahtnjenja, ki se prične z odbiro staršev, nadaljuje s križanji, setvijo sejancev v prvem letu v rastlinjaku, ter sajenjem na polje, kjer poteka odbira na izbrane lastnosti. V prvem letu sejance inokuliramo z virusom Y in opravimo množično odbiro na odpornost proti virusu Y krompirja. V naslednjih 5 do 6 letih sledi množična odbira na kvalitativne in kvantitativne lastnosti na polju. Najboljše križance uvrstimo v dvoletne poskuse v predizbiri. Tem poskusom sledi postopek registracije sorte, ki vključuje VPU in RIN preskušanje. Postopek vzgoje nove sorte od križanja do potrditve sorte traja vsaj 12 let, če je potrebno križanca očistiti virusov ali namnožiti zdravo seme in vitro pa tudi do 15 let. Program žlahtnjenja je uspešen še naprej, saj smo v letu 2021 vzgojili novo zgodnjo sorto krompirja KIS Blegoš, v letu 2022 pa dve novi sorti krompirja za ozimnico - KIS Mangart in KIS Tamar.

KIS Blegoš je zgodnja sorta s srednje velikim pridelkom gomoljev, ki se lahko skladiščijo do pozne pomladi. Okroglo-ovalni gomolji so drobnejši, zraste jih 10 do 12 na grm, očesa so srednje plitva, meso in kožica sta rumena. Sorta razvije grm z veliko stebli in manjšimi listi. Številni cvetovi so belo vijolični. KIS Blegoš je zgodnja večnamenska sorta odlične kakovosti kuhanega krompirja (tip B), za pečenje ter pražen krompir, prav tako je odlična tudi za pripravo ocvrtega krompirja, saj ima nizko vsebnost reduciranih sladkorjev ter povprečno vsebnost sušine 21 %. Odporna je proti virusu Y krompirja in je primerna za pridelovanje pod prekrivno tkanino. Povprečni triletni pridelek sorte KIS Blegoš v Lahovčah je bil s 47,4 t/ha na ravni standarda Adora, po kakovosti je bila sorta najboljša za kuhanje (skupni vtis – SV 2) in pomfrit (SV 1,7). KIS Mangart je srednje pozna sorta z zelo velikim pridelkom, ki se zelo dobro skladišči do pozne pomladi. Gomolji so okrogli, srednje debeli, s srednje plitvimi očesi, z rumenim mesom in kožico. Povprečno jih je 10 do 12 na grm. Sorta razvije srednji grm z malo stebli in srednje velikimi listi in številni cvetovi so belo vijolični. KIS Mangart je odlične kakovosti kuhanega krompirja (tip B), za pečenje ter pražen krompir s povprečno vsebnostjo sušine 21 %. Odporna je proti virusu Y in tolerantna na sušo. KIS Mangart je imel najvišji pridelek leta 2020 v Lahovčah (63,6 t/ha), v sušnem letu 2021 pa je v Jabljah (39,2 t/ha) značilno presegal standardno sorto Sante (26,8 t/ha). Povprečna kakovost kuhanega krompirja KIS Mangart (SV 3,3) je bila boljša kot pri standardu (SV 4,7). KIS Tamar je pozna sorta z zelo velikim pridelkom, ki se zelo dobro skladišči do pozne pomladi. Gomolji so ovalni, srednje debeli, zraste jih 10 do 12 na grm, imajo plitva očesa, meso je krem belo in kožica je svetla. Razvije majhen grm s pokončnimi stebli in manjšimi temno zelenimi listi. Cvetovi so beli. Zanjo je značilna počasnejša začetna rast. Je zelo primerna za kuhanje, za pečenje in pražen krompir. Povprečna vsebnost sušine gomoljev je 19 %: Gomolji so po tipu kuhanja B, in po kuhanju ne potemnijo. Odporna je proti virusu Y in tolerantna na sušo. KIS Tamar je imel najvišji pridelek leta 2018 v Lahovčah (64,7 t/ha), leta 2020 pa v Rakičanu (64,0 t/ha).

Ključne besede: *Solanum tuberosum,* krompir, sorte, agronomske lastnosti, jedilna kakovost

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KIS Blegoš, KIS Mangart and KIS Tamar - new Slovenian potato varieties

The potato breeding program at the Agricultural Institute of Slovenia has been running for the 30th year. During this time, 15 new potato varieties have been released. The main objectives of the program are the breeding of yield, high-quality varieties for fresh use, tolerance to drought and heat conditions, and resistance to potato virus Y and potato late blight. It is a classical breeding program that begins with the selection of parents, continues with crossings, sowing seedlings in the first year in the greenhouse, and planting them in the field, where selection for selected traits takes place. In the first year, the seedlings are inoculated with virus Y and mass selection for resistance to potato virus Y is carried out. In the next 5 to 6 years, mass selection for qualitative and quantitative traits in the field follows. The best clones are placed in two-year pre-selection trials, followed by the variety registration process, which includes VCU and DUS testing. The process of growing a new variety from crossing to registration of the variety takes at least 12 years, if it is necessary to clean the clone of viruses or multiply healthy seeds in vitro, up to 15 years. The breeding program continues to be successful, as in 2021 a new early potato variety KIS Blegoš was released, and two new potato varieties for the winter season, KIS Mangart and KIS Tamar in 2022.

KIS Blegoš is an early variety with a medium yield that can be stored until late spring. The round oval tubers are smaller, 10 to 12 per bush, the eyes are medium shallow, the flesh and skin are yellow. It develops into a bush with many stems and smaller leaves. Many flowers are white-purple. KIS Blegoš is an early multi-purpose variety of excellent quality for canning (type B), for baking and roasted potatoes, it is also excellent for preparing fried potatoes, as it has a low content of reduced sugars and a dry matter content of 21%. It is resistant to potato virus Y and is suitable for cultivation under cover. With 47.4 t/ha, the average three-year yield of the KIS Blegoš variety in Lahovče was at the level of the Adora standard, and in terms of quality, it was the best for canning (overall impression – OI 2) and french fries (OI 1.7).

KIS Mangart is a medium-late variety with a very large yield that can be stored until late spring. The tubers are round, of a medium size, 10 to 12 per bush, the eyes are medium shallow, tuber flesh and skin are yellow. It develops a medium sized plant with a few stems with medium sized leaves, many flowers are white-purple. KIS Mangart is an excellent quality potato for canning (type B), for baking and roasted potatoes with a dry matter content of 21%. It is resistant to Y virus and drought tolerant. KIS Mangart had the highest yield in Lahovče in 2020 (63.6 t/ha), and it significantly exceeded (39.2 t/ha) the standard variety Sante (26.8 t/ha) in Jablje in the dry year 2021. The average quality of KIS Mangart canned potatoes (OI 3.3) was better than that of the standard (OI 4.7).

KIS Tamar is a late variety with a very large yield, which is well stored until late spring. Tubers are oval, medium sized, 10 to 12 per bush, they have shallow eyes, the flesh is creamy white, the skin is light. It develops a small bush with upright stems and small dark green leaves, the flowers are white. It has slower initial growth. It is suitable for canned potatoes, for baking and roast potatoes. Dry matter content is 19%, cooking type B, does not darken after cooking. It is resistant to potato Y virus and drought tolerant. The highest yields of KIS Tamar were achieved in Lahovče in 2018 (64.7 t/ha), and in Rakičan in 2020 (64.0 t/ha).

Key words: *Solanum tuberosum,* potato, varieties, agronomy traits, consumption quality

Spremljanje koruzne vešče (*Ostrinia nubilalis* Hübner) z avtomatsko vabo Trapview CONE-NET

Magda RAK CIZEJ[1] in Franček POLIČNIK

Koruzna vešča (*Ostrinia nubilalis* Hübner) [Lepidoptera, Crambidae] je v Sloveniji gospodarsko pomemben škodljivec, ki povzroča škodo predvsem na koruzi (*Zea mays* L.) in hmelju (*Humulus lupulus* L.). Škodljivec, ki ima dve generaciji letno, pogosto najdemo tudi na številnih vrtninah in okrasnih rastlinah. V zadnjih 20 letih se je populacija koruzne vešče v Sloveniji močno povečala, saj opažamo veliko gospodarsko škodo predvsem na hmelju in koruzi. V osrednjem delu Slovenije imamo E-sev koruzne vešče (Z11-14Ac: E11-14Ac = 1:99). Na Inštitutu za hmeljarstvo in pivovarstvo Slovenije že več kot 45 let spremljamo koruzno veščo s klasično svetlobno vabo v hmeljiščih v okolici Žalca. Ta metoda spremljanja se je v praksi izkazala za zelo učinkovito, saj se na svetlobno vabo ulovijo metulji tudi takrat, ko je populacija vešče zelo majhna, še posebej pri prvi generaciji. Svetlobna vaba ima veliko omejitev, ker za delovanje potrebuje električno energijo, ki ni vedno dostopna na posameznih mikrolokacijah spremljanja. To je bil razlog za začetek uporabe avtomatske vabe Trapview CONE-NET (Efos, Slovenija), ki je avtomatizirana past, energijsko popolnoma neodvisna, ima možnost samodejnega čiščenja, dnevno slika ulove in slike pošilja na strežnik, kjer se podatki obdelajo in preverijo. Sistem na sliki avtomatsko označi škodljivce in jih prešteje. V izogib napakam, ki jih sistem lahko naredi pri označevanju je pomemben pregled tudi s strani skrbnika sistema oziroma prognostika. Na dnu Trapview CONE-NET smo dodali feromon za koruzno veščo E-seva, podjetja Bioprox iz Francije. Po naših dosedanjih rezultatih spremljanje koruzne vešče s Trapview CONE-NET skupaj s feromonom trenutno za prvo generacijo koruzne vešče ni zadovoljivo, ker s pomočjo vabe nismo ulovili nobenega samca koruzne vešče, na rastlinah pa je bila povzročena škoda. Zato bomo z raziskavo nadaljevali v smeri potencialne nadgradnje za uspešno spremljanje pojava koruzne vešče prve generacije in ovrednotili sistem za napoved pojava koruzne vešče druge generacije.

Vaba Trapview CONE NET v koruzi za spremljanje koruzne vešče (Ostrinia nubilalis)
Trapview CONE NET trap in maize field for monitoring of ECB (Ostrinia nubilalis)

Ključne besede: feromoni, koruzna vešča, *Ostrinia nubilalis*, spremljanje, Trapview

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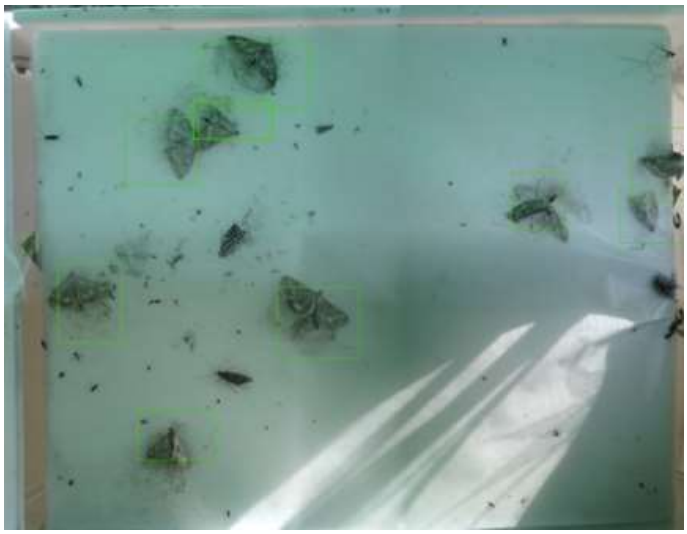
Using automatic Trapview CONE-NET for monitoring European Corn Borer (*Ostrinia nubilalis* Hübner)

European corn borer, *Ostrinia nubilalis* (Hübner) [Lepidoptera, Crambidae] - ECB is a important economical pest in Slovenia which causes damage on corn (*Zea mays* L.) and hop (*Humulus lupulus* L.) and has two generations per year. It's often found also on many vegetables and ornamentals plants. In the last 20 years, the presence of ECB in Slovenia increased significantly. We also observed increases population and economic damage on hop and corn plants. The central part of Slovenia has ECB on the hop and corn E strain (Z11-14Ac: E11-14Ac = 1:99) is present. Slovenian Institute of Hop Research and Brewing monitored ECB in the hop gardens in location Žalec with a classical light trap for over 45 years, which has proven to be a very effective method of monitoring the population of ECB. The light trap has a big limit because we do not have electric resources in each microclimate condition. This was the reason to use automatically trap Trapview CONE-NET (Efos, Slovenia) for monitoring ECB. The system pictures ECB and counts them. To avoid mistakes that the system can make it, when marking, it is also important to review it on the part of the administrator of the system or prognostics. At bottom of Trapview CONE-NET trap, we put the pheromone E strain from the company Bioprox (France.) Trapview is an automated trap, which is completely energy independent, has auto-cleaning capability, takes daily pictures of caught insects, and sends these pictures to the cloud where they are processed and verified. According to our preliminary results, monitoring of ECB with the Trapview CONE-NET and with pheromone currently is not successful for the first-generation because we didn't catch any males of ECB. In future we will continue with research to upgrade the trap so that it could be successfully used to monitoring the appearance of the first-generation ECB. We must validate the system for predicting the appearance of the second generation of the ECB.

Key words: European corn borer, monitoring, *Ostrinia nubilalis*, pheromones, Trapview

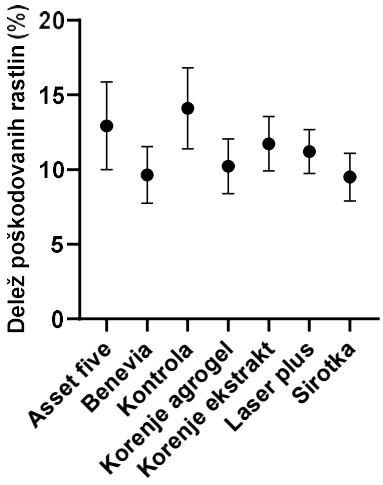


Ulov samcev koruzne vešče (Ostrinia nubilalis) v past Trapview CONE NET
Catch of males ECB (Ostrinia nubilalis) in the Trapview CONE NET trap

Preučevanje uporabe izvlečka korenjeve cime za zatiranje čebulne muhe *Delia antiqua* (Meigen) in porove zavrtalke *Phytomyza gymnostoma* Loew v čebuli

Špela MODIC[1], Jaka RAZINGER, Eva PRAPROTNIK, Igor NEKREP, Darko VERNIK, Anže PRAŠNIKAR in Primož ŽIGON

Čebulna muha (*Delia antiqua* [Meigen], Anthomyiidae) in porova zavrtalka (*Phytomyza gymnostoma* Loew, Agromyzidae) sta pomembna škodljivca čebule v Sloveniji. Zadnja leta pri nas vse pogosteje opažamo predvsem poškodbe zaradi porove zavrtalke. Ker je na razpolago vse manj učinkovitih insekticidov za njuno zatiranje, je bil namen naše naloge v poljskem poskusu preučiti predvsem okoljsko sprejemljive načine zatiranja obeh škodljivcev čebule ter ustreznost njihove uporabe. Poskus je potekal v letu 2022 na območju Selekcijsko-poskusnega centra Ptuj. Znano je, da mešani posevki s korenjem odvračalno vplivajo na oba škodljivca, zato smo odvračalni učinek rastlinskega izvlečka korenjeve cime preučevali na dva načina: v obliki raztopine in kroglic agrogela, namočenih v izvleček korenjeve cime. V tretji dekadi aprila, ko smo opazili prve simptome dopolnilnega hranjenja porove zavrtalke na listih čebule, smo opravili prvi nanos šestih preizkušanih pripravkov: Asset five (a. s. piretrin), Benevia (a. s. ciantraniliprol), izvleček korenjeve cime-agrogel, izvleček korenjeve cime-raztopina, Laser plus (a.s. spinosad) in sirotka,. Na kontrolnem obravnavanju rastlin nismo škropili. V začetku maja smo nanos pripravkov ponovili, razen v obravnavanju Benevia, kjer smo opravili le eno škropljenje. Učinkovitost posameznega obravnavanja smo ocenjevali na podlagi spremljanja značilnih poškodb na rastlinah, premera čebulic in tržne mase pridelka. Med obravnavanji in kontrolo pri oceni poškodb ni bilo značilnih razlik, kljub temu da je bilo v kontroli v povprečju poškodovanih več rastlin. Povprečen delež poškodovanih rastlin je bil največji v kontroli (14,1 ± 2,7 %), najmanjši pa v obravnavanju sirotka (9,5 ± 1,5 %). Pri škropljenju z insekticidom Benevia je bilo v povprečju poškodovanih 9,6 ± 1,9 % rastlin, glede na delež poškodovanih rastlin so sledila obravnavanja: korenjeva cima-agrogel (10,2 ± 1,8 %), Laser plus (11,2 ± 1,5 %), korenjeva cima-raztopina (11,7 ± 1,8 %) in Asset five (12,9 ± 2,9 %). Razlik v pridelku prav tako nismo zaznali, saj v masi pridelka in premeru čebulic med obravnavanji ni bilo statistično značilnih razlik. Povprečna masa suhih rastlin na parcelico je v znašala od 4,6 kg v kontroli do 5,8 kg v obravnavanju sirotka, povprečen premer čebulic pa je bil 6,4 cm in se je med posameznimi obravnavanju v povprečju razlikoval za največ 6 % (0,4 cm). Delež poškodovanih rastlin je bil do 15 %, kar nakazuje manjši napad škodljivcev oziroma da zgodnje poškodbe nimajo velikega vpliva na pridelek.



Delež poškodovanih rastlin čebule (% ± SN) zaradi čebulne muhe in porove zavrtalke v različnih obravnavanjih
Percentage of onion plants damaged (% ± SN) due to the onion fly and the allium leaf miner in different treatments

Ključne besede: okoljsko sprejemljivi načini zatiranja, čebula, *Allium cepa*, porova zavrtalka, *Phytomyza gymnostoma*, čebulna muha, *Delia antiqua*, izvleček korenjeve cime, odvračalni učinek

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Testing the use of root greens extract against the onion fly *Delia antiqua* (Meigen) and allium leaf miner *Phytomyza gymnostoma* Loew in onoion

The onion fly (*Delia antiqua* [Meigen], Anthomyiidae) and the allium leaf miner (*Phytomyza gymnostoma* Loew, Agromyzidae) are important pests of onion in Slovenia. In recent years, increased damage to the latter has been observed. Since less effective insecticides are available for their control, the aim of our research was to investigate environmentally sound strategies against both onion pests and the appropriateness of their use. The field trial was conducted in 2022 on the premises of the Ptuj Selection and Experimental Center. Mixed crops with carrots are known to have a deterrent effect on both pests. Therefore, the deterrent effect of the plant extract of carrot greens was studied in two ways: in the form of a solution and agrogel pellets soaked with carrot greens extract. In the third decade of April, when the first feeding symptoms of *Phytomyza gymnostoma* larvae were observed on onion leaves, the first application of six tested preparations was carried out: Asset five (a.i. pyrethrin), Benevia (a.i. cyantraniliprole), carrot greens extract agrogel, carrot greens extract solution, laser plus (a.i. spinosad), and whey. Plants were not treated in the control treatment. In early May, the application was repeated, except for the treatment with Benevia. The effectiveness of each treatment was evaluated by monitoring typical damage to plants, bulb diameter, and marketable weight of the crop. There were no significant differences in damage ratings between the treatments and the control, although on average more plants were damaged in the control. The average percentage of damaged plants was the highest in the control (14.1 ± 2.7%) and the lowest in the whey treatment (9.5 ± 1.5%). When spraying with the Benevia insecticide, on average 9.6 ± 1.9% of the plants were damaged. According to the percentage of damaged plants, the following treatments followed: carrot greens extract-agrogel (10.2 ± 1.8%), Laser plus (11.2 ± 1.5%), carrot greens extract solution (11.7 ± 1.8%) and Asset five (12.9 ± 2.9%). No difference was found in yield either, as there were no significant differences in crop weight and bulb diameter between treatments. The average weight of dry plants per plot ranged from 4.6 kg in the control to 5.8 kg in the whey treatment. The average diameter of the bulbs was 6,4 cm which on average differed no more than 6% (0.4 cm) among individual treatments. The percentage of damaged plants was up to 15%, indicating low pest infestation or that early damage does not have a large impact on yield.

Key words: environmentally acceptable control methods, onion, *Allium cepa*, onion fly, *Delia antiqua*, allium leaf miner, *Phytomyza gymnostoma,* carrot greens extract, deterrent effect

Poškodbe na čebuli zaradi čebulne muhe in/ali porove zavrtalke (Foto: Š. Modic)
Damage to an onion plant by onion fly and/or allium leaf miner (Photo: Š. Modic)

Preživetje virusa rjave grbančavosti plodov paradižnika in njegov prenos z vodo

Ana VUČUROVIĆ[1], Katarina BAČNIK[2], Irena BAJDE[3], Jakob BRODARIČ[4], Adrian FOX[5], Ion GUTIÉRREZ-AGUIRRE[6], Miha KITEK[7], Denis KUTNJAK[8], Yue LIN LOH[9], Olivera MAKSIMOVIĆ CARVALHO FERREIRA[10], Maja RAVNIKAR[11], Elise VOGEL[12], Christine VOS[13] in Nataša MEHLE[14]

Virus rjave grbančavosti plodov paradižnika (tomato brown rugose fruit virus; ToBRFV) so odkrili leta 2014 v Izraelu, kmalu za tem so o izbruhih okužbe s tem virusom poročali iz vsega sveta. Danes ToBRFV resno ogroža pridelavo paradižnika in paprike. Domneva se, da so razlog naglega širjenja ToBRFV po svetu okužena semena in sadike. Po vnosu virusa na novo lokacijo, se ta zlahka razširi na druge rastline mehansko s sokom okuženih rastlin. Ugotovili so, da je ToBRFV izredno stabilen virus, ki lahko dolgo preživi na različnih površinah. Zato ga je, če se zanese v rastlinjake, težko izkoreniniti z obstoječimi metodami dezinfekcije. Genetski material ToBRFV smo zaznali tudi v nekaterih vzorcih vode, tudi v vzorcih vod, ki se uporabljajo za namakanje rastlin. To nas je spodbudilo k izvedbi eksperimentov, s katerimi smo želeli odgovoriti na vprašanje o pomenu prisotnosti tega virusa v vodi. Dokazali smo, da se lahko v vodo za namakanje infektivni delci ToBRFV sproščajo iz korenin okuženih rastlin ter da lahko virus pri sobni temperaturi preživi v vodi do štiri tedne. Dokazali smo tudi, da je voda onesnažena s ToBRFV lahko vir inokuluma za rastline tako v primeru uporabe za namakanje v hidroponskih sistemih gojenja rastlin kakor tudi v primeru namakanja tal, v katerih vzgajamo rastline. S poskusi smo potrdili, da lahko ToBRFV iz vode okuži zdrave rastline preko korenin in se nato razširi v zelene dele, kjer pa ga lahko zaznamo šele po več mesecih. Poleg tega naši podatki kažejo, da je smiselno spremljati morebitno prisotnost virusa ToBRFV v vodi, saj s tem lahko predvidimo prisotnost virusa na kritičnih lokacijah pred izbruhom bolezni. Rezultati naših študij zapolnjujejo vrzeli v znanju o epidemiologiji ToBRFV s preučevanjem vloge prenosa tega virusa z vodo, kar je ključno za pripravo zanesljive ocene tveganja ter za prepoznavanje kritičnih točk pomembnih za spremljanje in nadzor bolezni.

Ključne besede: virus rjave grbančavosti plodov paradižnika, voda, širjenje, preživetje, paradižnik

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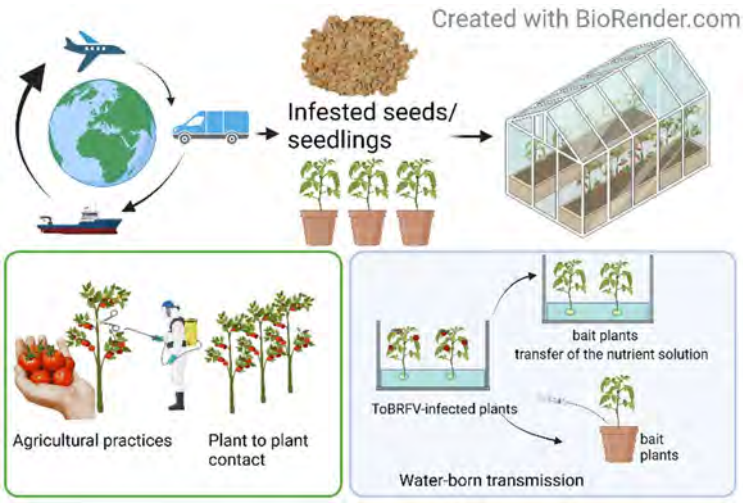
Survival in and transmission by water of tomato brown rugose fruit virus

Tomato brown rugose fruit virus (ToBRFV), which emerged in Israel around 2014 and subsequently caused outbreaks worldwide, seriously threatens tomato and pepper production. ToBRFV is thought to be introduced into new countries and regions mainly via infested seeds and infected planting material. After introduction to a new location, it can be easily spread to other plants by mechanical transmission. It has been confirmed that ToBRFV can survive on various surfaces for a long time and is environmentally stable. Therefore, once ToBRFV enters the greenhouse, it is difficult to eradicate it with existing disinfection methods. In addition, ToBRFV RNA has been detected in some water samples, including samples of water used to irrigate plants. This prompted us to conduct experimental studies to address the question of the significance of detecting ToBRFV in water samples. We have shown that infectious ToBRFV particles can be released from the roots of infected plants into irrigation water and that the virus can survive in water stored at room temperature for up to four weeks. Our data also suggest that water contaminated with ToBRFV can be a source of inoculum to plants through irrigation in hydroponic and soil-based cropping systems. We have shown that ToBRFV from water can infect healthy plants through their roots and eventually spread to the green parts, where it can be detected after several months. Furthermore, our data show that it is worthwhile to monitor water for ToBRFV to predict critical locations and moments for viral disease outbreaks. The results of our studies fill the knowledge gaps in the epidemiology of ToBRFV by examining the role of water-mediated transmission, and provide a reliable risk assessment to identify critical points for surveillance and control.



Key words: tomato brown rugose fruit virus, water, spread, suvival, tomato

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Glivične bolezni na sadikah in v nasadih šparglja

Urša PRISLAN[1], Janja ZAJC, Hans-Josef SCHROERS in Neja MAROLT

Špargelj (*Asparagus officinalis* L.) je zelenjadnica, ki v zadnjih letih v Sloveniji pridobiva na pomenu, saj se pridelovalne površine povečujejo. Pridelovalci se srečujejo z vse večjimi izzivi pri pridelavi zaradi talnih glivičnih bolezni, ki povzročajo propad večletnih nasadov. Glive rodu *Fusarium* so najpogostejši vzrok gnitja koreninskega sistema ter propada celotnih rastlin. Rod *Fusarium* je uvrščen med nadzorovane nekarantenske škodljive organizme (NNŠO) na razmnoževalnem in sadilnem materialu špargljev. V iskanju rešitev za obvladovanje glivičnih bolezni na špargljih smo v letu 2022 zasnovali večletni poljski poskus na Primorskem (Orehovlje), kjer bomo v naslednjih letih ocenjevali zmanjšanje škode, ki jih povzročajo talne glive, s tretiranjem sadilnega materiala in tal s pripravki na osnovi koristnih mikroorganizmov. V letu 2021 smo na sadikah špargljev, namenjenih tržni pridelavi, odkrili različne fitopatogene glive glede na sorto in izvor sadik. Pri sorti `Atos´ iz Italije je bilo 50 % analiziranih sadik okuženih z glivami iz kompleksa vrst *Fusarium oxysporum* (FOSC). Pri sorti `Dariana´ (izvor Španija) je prevladovala vrsta *Fusarium proliferatum*, potrdili smo jo na 80 % testiranih sadikah. Pri isti sorti `Dariana´, ki je izvirala iz Nemčije, pa vrsta *F. proliferatum* ni bila prisotna, raznolikost izolatov FOSC je bila precejšnja in potrjena na vseh testiranih sadikah.
Pred sajenjem smo naključno izbrali 10 sadik špargljev sorte `Dariana´(izvor Španija), ki smo jo izbrali za poskus, in jih analizirali. Analiza je pokazala prisotnost gliv rodu *Fusarium* že na sadilnem materialu, prevladovala je vrsta *F. proliferatum*. V manjših deležih so bile prisotne glive drugih rodov (*Alternaria, Botrytis*, *Stemphylium* …). Sadike smo šest dni pred sajenjem tretirali z biotičnimi pripravki. Sadike smo pokrili s substratom in jih zalili z raztopino pripravka. V poskus smo vključili 5 različnih obravnavanj. Prvo obravnavanje je kontrola, kjer sadike pred sajenjem niso bile tretirane z nobenih pripravkom, tudi tla tekom rastne dobe nismo tretirali. Pri drugem obravnavanju smo sadike pred sajenjem tretirali s pripravkom Micotric L. (aktivna snov Glomus spp, Trichoderma spp, rizosferne bakterije, organska snov). Pri drugem obravnavanju smo pri tretiranju tal, ki smo ga v letošnjem letu izvedli trikrat, pripravku Micotric L. dodali še kombinacijo dveh pripravkov Amminostim bio (organski dušik, aminokisline, naravni pospeševalci rasti) in Euroradix (celuloza, hemicelulaza, alfa-amilaza ...). Tretje obravnavanje vključuje sadike, tretirane s pripravkom Polyversum z aktivno snovjo *Pythium oligandrum*. V četrto obravnavanje smo uvrstili sadike tretirane s pripravkom Prestop (aktivna snov *Clonostachys rosea*). Pri obravnavanju 5 pa smo sadike pred sajenjem tretirali s kemičnim pripravkom Switch 62,5 WG (aktivni snovi ciprodinil in fludiokosnil), ki je pri nas registrirano fitofarmacevtsko sredstvo za uporabo tudi na špargljih. To obravnavanje bo služilo kot kontrola oziroma primerjava učinkovitosti med biotičnimi in kemičnimi pripravki. Ker gre pri špargljih za trajne nasade in šparglji vstopijo v rodnost po dveh ali treh letih bomo nasade ocenjevali vsaj tri leta zaporedoma. Učinkovitost pripravkov na osnovi koristnih mikroorganizmov za obvladovanje bolezni se bo pokazala v naslednjih letih.

Ključne besede: špargelj, glivične bolezni, *Fusarium*, biotični pripravki

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Fungal diseases on seedlings and in asparagus plantations

Asparagus (*Asparagus officinalis* L.) is a vegetable that has been gaining importance in Slovenia in recent years, as the cultivation areas have been increasing. Farmers face challenges in production due to soil fungal diseases that cause the collapse of perrennial crops. Fungi from the genus *Fusarium* are the most common cause of root rot system and the collapse of entire plants. The genus *Fusarium* is defined as a regulated non-quarantine pest on planting material of asparagus. For fungal diseases management study, we designed field experiment in Primorska (Orehovlje) in 2022. In the next years we will evaluate the reduction of damage caused by soil fungi by treating planting material and soil with biotic preparations. Last year, different pathogenic fungi were discovered on asparagus seedlings, depending on the variety and origin of the seedlings. On the variety `Atos´ from Italy, 50% of the analyzed seedlings were infected with fungi from *Fusarium oxysporum* species complex (FOSC). *Fusarium proliferatum* was dominant on the variety `Dariana´ (from Spain), we confirmed it on 80% of the tested seedlings. *F. proliferatum* was not present on the same variety `Dariana´ from Germany where the diversity of FOSC isolates was high and FOSC was confirmed on all tested seedlings.
We randomly selected 10 asparagus seedlings before planting of the variety `Dariana´(from Spain), which we chose for field experiment and analyzed them. The analysis showed the presence of fungi from genus *Fusarium* on planting material. Species *F.proliferatum* was dominantly present. Wherease fungi of other genera (*Alternaria, Botrytis, Stemphylium* …) were present in smaller proportions. Seedlings were treated with biotic preparations six days before planting. They were covered with substrate and watered with solution of biotic preparation. We included 5 different treatments in the experiment. The first treatment is control, seedlings were not treated with any preparation before planting, neither was the soil during growing season. In the second treatment seedlings were treated with preparation Micotric L. (active substance Glomus spp, Trichoderma, rhizosphere bacteria, organic matter) before planting. We treated the soil three times this year and we added a combination of two preparations Amminostim bio (organic nitrogen, amino acids, natural biopromoters) and Euroradix (cellulose, hemicellulase, alpha-amylase …). Third treatment includes seedlings treated with Polyversum with active substance *Pythium oligandrum.* Fourth treatment includes seedlings treated with Prestop (active substance *Clonostachys rosea*). In treatment five, seedlings were treated with chemical preparation Switch 62,5 WG (active substances cyprodinil and fludiocosnil), which is registered for use also on asparagus. This treatment will serve us as a control and comparison of the effectiveness betwen biotic and chemical preparations. Since asparagus becomes fertile after two or three years after planting, we will evaluate plantations for at least three years. The effectiveness of biotic preparations for disease control will be demonstrated in the next years.

Key words: asparagus, fungal diseases, *Fusarium*, biotic preparations

Možnosti biotičnega zatiranja topolistne kislice (*Rumex obtusifolius* L.) na travinju z vnosom naravnega sovražnika *Pyropteron chrysidiformis* (Esper, 1782)

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Steklokrilka *Pyropteron chrysidiformis* (Esper, 1782) (Lepidoptera, Sesiidae) je naravni sovražnik topolistne kislice (*Rumex obtusifolius* L.) in zato dober potencialni kandidat za biotično zatiranje te trdovratne trajne plevelne vrste na travnikih in pašnikih. V okviru evropskega projekta IWMPRAISE smo z namenom preučevanja učinkovitosti preplavnega biotičnega varstva v letih 2019–2021 izvajali poljski poskus na dveh lokacijah z različnimi pedoklimatskimi razmerami v Sloveniji (Ajdovščina in Murski Črnci). Vnos naravnega sovražnika je temeljil na inokulaciji jajčec *P. chrysidiformis* na posamezne rastline topolistne kislice, ki smo ga v različnih obravnavanjih izvedli od enkrat (vnos le v eni sezoni) do trikrat (vnos na isto rastlino v treh zaporednih letih). V posamezno obravnavanje je bilo vključenih 25 rastlin, na katera smo jajčeca nanesli enkrat, dvakrat ali trikrat v obdobju treh let. V poskusu smo ocenjevali vpliv različnega števila vnosov na zmanjšanje števila rastlin topolistne kislice in beležili vremenske razmere na obeh lokacijah kot potencialni dejavnik, ki vpliva na učinkovitost zatiranja topolistne kislice. Izkop rastlin smo glede na obravnavanje opravili v istem letu oz. eno/dve ali tri leta po prvi inokulaciji jajčec. Poškodovanost rastlin, ki smo jo ovrednotili na podlagi ocene deleža poškodovanih korenin, in zmanjšanje števila rastlin zaradi ličink steklokrilke je bilo večje na lokaciji Ajdovščina, kjer je že po enkratnem vnosu odmrlo 78 % inokuliranih rastlin (po trikratnem vnosu organizma odmrlo več kot 96 % rastlin). V Ajdovščini smo ob izkopu inokuliranih rastlin potrdili tudi večje število prisotnih ličink *P. chrysidiformis* v koreninah, večje je bilo tudi število odmrlih kontrolnih rastlin, kot posledica napada *P. chrysidiformis*. Na večjo učinkovitost zatiranja v Ajdovščini je vplivala manjša starost gostiteljskih rastlin topolistne kislice, ki so imele manj razvit koreninski sistem in so bile zato bistveno bolj občutljive na objedanje ličink. Domnevamo, da so na večjo učinkovitost zatiranja vplivale tudi vremenske razmere na lokaciji Ajdovščina. Milejše zime in toplejša, suha poletja, so v primerjavi s celinskim podnebjem v Murskih Črncih ugodno vplivale na razvoj in preživetje ličink *P. chrysidiformis* v koreninah rastlin.

Ključne besede: biotično zatiranje plevelov, *Rumex obtusifolius*, ščavje, *Pyropteron chrysidiformis,* steklokrilka

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Possibilities of biological control of broad-leaved dock (*Rumex obtusifolius* L.) in grassland by introducing the natural enemy *Pyropteron chrysidiformis* (Esper, 1782)

Pyropteron chrysidiformis (Esper, 1782), (Lepidoptera, Sesiidae) is a natural enemy of broad-leaved dock (*Rumex obtusifolius* L.) and therefore a good potential candidate for the biological control of this persistent weed in meadows and pastures. Within the European project IWMPRAISE, a three-year field experiment at two sites with contrasting pedoclimatic conditions in Slovenia (Ajdovščina and Murski Črnci) was performed to study the effectiveness of inundative biological control of *Rumex obtusifolius* using *P. chrysidiformis*. The introduction of the natural enemy was based on the inoculation of *R. obtusifolius* plants with *P. chrysidiformis* eggs, which was carried out – depending on the treatment – one (a single season inoculation) to three times (the same plant was inoculated in three consecutive seasons). Each treatment consisted of 25 plants on which eggs were applied once, twice or three times over a three-year period. Mortality of *R. obtusifolius* plants, dependent on the number of different inoculations, was evaluated and different weather conditions at the two locations measured in order to assess their potential effect on the efficacy of *P. chrysidiformis* inundative biocontrol. Depending on the treatment, the excavation of the plants was carried out in the same year or one/two or three years after the first egg inoculation. Root damage which was evaluated as a proportion of damaged roots and plant mortality due to *P. chrysidiformis* larvae feeding in the rootstocks was greater at location Ajdovščina, where 78% of inoculated plants died after a single inoculation (more than 96% of the plants died after three inoculations with *P. chrysidiformis* eggs). When the inoculated plants were dug up, a higher number of *P. chrysidiformis* larvae were present in the roots in Ajdovščina, and the number of dead control plants was also higher. In general, the increased efficacy at Ajdovščina site was largely influenced by the development stage of Rumex plants, where younger plants with less developed root system were more sensitive to larvae feeding. Weather conditions at location Ajdovščina, characterized by milder winters and warmer, drier summers than in Murski Črnci, probably had a favourable effect on the development and survival of *P. chrysidiformis* larvae in plant rootstocks.

Key words: biological weed control, *Rumex obtusifolius*, broad-leaved dock, *Pyropteron chrysidiformis*, clearwing moth

Pyropteron chrysidiformis (Esper, 1782) – odrasel osebek, samica
Pyropteron chrysidiformis (Esper, 1782) – adult female

Uporaba daljinskega zaznavanja za zgodnje odkrivanje strun (Coleoptera: Elateridae) in suše v koruzi

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Povečanje pogostosti in jakosti abiotskega stresa, kot je na primer suša, ima velik vpliv na rast in razvoj koruze, hkrati pa lahko vpliva tudi na interakcije med koruzo in talnimi škodljivci. Z metodami daljinskega zaznavanja lahko zaznamo te spremembe preden postanejo vidne človeškemu očesu. Namen naše raziskave je bil s tri-faktorskim lončnim poskusom (vodni režim x talni škodljivec x hibrid) preučiti vpliv abiotskega (suša) in biotskega (strune) stresa ter vzajemnega vpliva obeh stresorjev (suša+strune) na hiperspektralni podpis koruze ter na njene fiziološke in morfološke značilnosti. V poskusu smo uporabili dva hibrida z različno stopnjo občutljivosti na sušni stres, in sicer na sušo toleranten hibrid Futurixx (RAGT Semences SAS, Francija) in na sušo manj toleranten hibrid ZP341 (Institut za kukuruz "Zemun polje", Srbija). Fiziološki parametri koruze so bili merjeni 14., 21. in 28. dan po dodajanju strun vrste *Agriotes lineatus* L. in pričetku sušnega stresa. Štirim naključno izbranim rastlinam iz vsakega obravnavanja smo izmerili neto fotosintezo (P_n), prevodnost listnih rež (g_s), transpiracijo (E), dejansko fotokemično učinkovitost (Fv'/Fm'), relativno vsebnost klorofila (SPAD) in vode (RWC) v listih, ter potencialno fotokemično učinkovitost fotosistema II (Fv/Fm). Hiperspektralno slikanje lončnega poskusa smo izvajali 14., 21. in 28. dan po dodajanju strun in pričetku sušnega stresa. Štiri naključno izbrane rastline iz vsakega obravnavanja smo slikali z dvema senzorjema, ki zajemata spekter od vidne in bližnje infrardeče svetlobe (400–950 nm) do kratkovalovne infrardeče svetlobe (950–2500 nm). Podatke o morfologiji rastlin (dolžina nadzemnega dela rastlin, suha masa nadzemnega dela rastlin, suha masa korenin, premer stebla) in poškodbe škodljivcev (število lukenj v koreninah in steblu zaradi prehranjevanja strun) smo pridobili ob koncu poskusa. Najvidnejše razlike v fizioloških parametrih rastlin med obravnavanji so bile izmerjene 21. dan, ko je imela suša značilen negativen vpliv na relativno vsebnost vode v listih, prevodnost listnih rež, neto fotosintezo, transpiracijo in fotokemično učinkovitost. Prisotnost strun je vplivala na večjo fotokemično učinkovitost in višjo relativno vsebnost vode v listih, a hkrati znižala relativno vsebnost klorofila v listih. Prav tako so imele rastline s strunami značilno manjšo dolžino in suho maso nadzemnega dela rastlin. Hibrid Futurixx je imel značilno višjo relativno vsebnost vode v listih in mejno značilno večjo fotokemično učinkovitost v primerjavi z ZP341, vendar pa so imele rastline hibrida ZP341 s strunami ob koncu poskusa značilno večji premer stebla, a hkrati tudi večje število lukenj v primerjavi z rastlinami hibrida Futurixx s strunami. Naši rezultati so pokazali, da vzajemni vpliv obeh stresorjev (suša+strune) ne deluje vedno sinergistično. Rezultati hiperspektralnega slikanja so omogočili identifikacijo spektralnih podpisov za razlikovanje med obravnavanji v bližnje infrardečem (NIR) in kratkovalovnem infrardečem (SWIR) območju. Z uporabo hiperspektralnega slikanja smo lahko že 14. dan zaznali in s 84.7 % natančnostjo razlikovali med abiotskim in biotskim stresom, zaradi česar je metoda zanesljiva za hitro in natančno zaznavanje sušnega stresa in napada strun v koruzi.

Ključne besede: daljinsko zaznavanje, sušni stres, strune, koruza, zgodnje zaznavanje, natančno kmetijstvo

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Early detection of wireworms (Coleoptera: Elateridae) and drought in maize using hyperspectral imaging

Increasing frequency and severity of abiotic stress has significant impact on maize growth and development, but may also affect interactions between maize and soil herbivores, including wireworms. Remote sensing methods allow us to detect these changes before they become visible to the naked eye. The purpose of our research was to study the effects of abiotic (drought) and biotic (wireworm) stress as well as the combined effect of both stressors (drought+wireworm) on the hyperspectral signature of maize and on its physiological and morphological characteristics. Two hybrids with different drought stress (in)tolerance were used, namely the drought tolerant hybrid Futurixx (RAGT Semences SAS, France) and the drought intolerant hybrid ZP341 (Zemun Polje Maize Institute, Serbia). Maize physiological parameters were obtained on the 14th, 21st and 28th day after adding *Agriotes lineatus* wireworms and changing watering regime. Net photosynthesis (Pn), leaf stomatal conductivity (gs), transpiration rate (E), effective quantum yield of PSII (Fv'/Fm'), relative chlorophyll (SPAD) and water (RWC) content in leaves, and maximum quantum efficiency of PSII (Fv/Fm) were measured on four randomly selected plants from each treatment. Hyperspectral imaging of the pot experiment was performed on the 14th, 21st and 28th day after adding *A. lineatus* and changing watering regime. Four randomly selected plants from each treatment were imaged using two sensors covering visible and near-infrared light range (400-950 nm) and short-wave infrared light range (950-2500 nm). At the end of the experiment, data were collected on plant morphology (shoot length, shoot dry weight, root dry weight, stem diameter) and herbivory damage (number of tunnels in roots and stem caused by wireworm feeding). The greatest differences in plant physiology between treatments were detected on day 21, when drought had a significant negative effect on relative leaf water content, leaf stomatal conductivity, net photosynthesis, transpiration rate, and effective quantum yield of PSII. The presence of wireworms resulted in higher effective quantum yield of PSII and higher relative water content in leaves, but at the same time lower relative chlorophyll content in leaves. In addition, plants with wireworms had significantly lower shoot length and dry shoot mass. The Futurixx hybrid had significantly higher relative water content and borderline significant effective quantum yield of PSII compared to ZP341. At the end of the experiment ZP341 plants with wireworms had significantly larger stem diameter, but in contrast, also had a higher number of tunnels compared to the Futurixx plants with wireworms. Our results indicate that the combined effect of both stressors (drought+wireworms) does not always have a synergistic effect. Hyperspectral imaging results allowed to identify spectral signatures to distinguish between treatments in near-infrared (NIR) and short-wave infrared (SWIR) regions. Using hyperspectral imaging, we were able to detect abiotic and biotic stress and distinguish between them as early as day 14 with 84.7% accuracy, making it a reliable method for rapid and accurate prediction of drought and wireworm infestation in maize.

Key words: hyperspectral imaging, drought stress, wireworms, maize, early detection, precision agriculture

Določanje napada koruznega hrošča iz zraka

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Koruzni hrošč (*Diabrotica v. virgifera*) je eden najpomembnejših škodljivcev koruze. Ličinke hrošča objedajo koreninski sistem rastlin, kar privede do splošnega slabljenja rastlin in zmanjšanje pridelka. V prizadevanju, da bi preprečili izgube pridelka, evropski kmetje za zatiranje odraslih hroščev in ličink uporabljajo sintetične insekticide. Slednji, zlasti teflutrin, spadajo med najbolj toksične piretroide na trgu in negativno vplivajo na neciljne in koristne talne organizme. Metode daljinskega zaznavanja omogočajo pristope natančnega kmetijstva (angl. precision agriculture) k integriranemu varstvu rastlin. Multispektralni senzorji omogočajo preučevanje velikih površin, kjer lahko pri določenih posevkih določimo posamezne rastline in ocenimo spremembe njihove fiziologije in zdravstvenega stanja, preden lahko odkrijemo te spremembe z drugimi metodami.
Z multispektralnim sistemom, vgrajenim na brezpilotnem letalniku, smo večkrat posneli parcelice poskusa z dvema hibridoma koruze v faktorski postavitvi. V poskusu je bilo 8 obravnavanj (sorta 2x, komercialno seme 2x, Force 2x, *Trichoderma* 2x, nerazkuženo seme 2x). Izbrali smo 35 spektralnih indeksov v vidnem in bližnje infrardečem delu spektra, skupaj s spektralnimi pasovi smo tako pridobili 41 spremenljivk. Te podatke smo nato uporabili za razvoj klasifikacijskih modelov z metodo podpornih vektorjev. Ker sta pri uporabi spektralnih indeksov v podatkih prisotni visoka kolinearnost in reduncanca, smo zmanjšali dimenzionalnost podatkov z metodama analize glavnih komponent in metodo delnih najmanjših kvadratov. Na združenih podatkih brez ločitve med hibridoma koruze je bila največja dosežena zanesljivost prepoznavanja obravnavanj približno 65 %. Model za ločevanje med sortama hibridov je s 94 % pravilnih uvrstitev dosegel visoko zanesljivost. S tako pridobljenimi podatki smo zanesljivost določanja napada koruznega hrošča v odvisno od hibrida povišali na od 70 do 85 %. Z uporabo multispektralnega slikanja lahko torej zanesljivo določimo napad koruznega hrošča pred pojavom vidnih znakov. Ker je senzor nameščen na brezpilotnem letalniku, lahko v razmeroma kratkem času določimo napad ličink za vse rastline na polju.

Ključne besede: daljinsko zaznavanje, multispektralno slikanje, koruzni hrošč, *Diabrotica virgifera,* brezpilotni letalnik, strojno učenje

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Detecting western corn rootworm infestations from the air

The western corn rootworm (*Diabrotica v. virgifera*) is one of the most important pests of maize. Larvae of the beetle feed on the root system of the plants, which leads to a general weakening of the plants and a decrease in yield. To prevent yield losses, European farmers use synthetic insecticides to control both adult beetles and their larvae. Among these insecticides is tefluthrin, one of the most toxic pyrethroids on the market, which negatively affects non-target and beneficial soil organisms. Remote sensing methods enable precision agriculture approaches to integrated plant protection. Multispectral sensors make it possible to study large areas, in some crops identifying individual plants in these areas and assessing changes in their physiology before they can be detected by other methods. We used a drone-mounted multispectral system to image a microplot experiment of two hybrids of corn in a factorial layout. The experiment contained 8 treatments (variety 2x, commercial seeds 2x, Force 2x, *Trichoderma* 2x, untreated seeds 2x). We selected 35 spectral indices in the visible and near-infrared part of the spectrum; together with the spectral bands we thus obtained 40 variables. These data were then used to develop classification models using support vector machines. Since high collinearity and redundancy are present in the data when using spectral indices, we reduced the dimensionality of the data using principal component analysis and partial least squares. On pooled data, i.e. without separation to maize hybrid, the highest achieved reliability of treatment identification was app. 65%. The model for hybrid separation achieved a high accuracy, with 94% correctly classified instances. The highest achieved reliability of classifications without separation by maize variety was 65%. Hybrid separation was highly reliable, with 94% correct classifications. With the data divided by maize hybrid, we increased the reliability of western corn rootworm infestation to between 70% and 85%, depending on the variety. By using multispectral imaging, we can therefore reliably determine western corn rootworm infestations before the appearance of visible symptoms. Since the sensor is mounted on a drone, we can determine infestations for all plants in a field, in a relatively short time.

Keywords: remote sensing, multispectral imaging, western corn rootworm, *Diabrotica virgifera*, drone, machine learning.

Uporaba multispektralnega slikanja za identifikacijo različnih sort krompirja (*Solanum tuberosum* L.)

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V programu ekološkega žlahtnjenja krompirja za ekološko pridelavo na Kmetijskem inštitutu Slovenije zelo pomembna odbira genotipov z ustreznim razvojem listne mase na polju. Hiter razvoj močneje olistanih rastlin, ki dobro pokrijejo tla, omogoča večjo konkurenčnost s pleveli, zmanjšuje izgubo vode in na koncu zagotavlja visok pridelek. Hitra identifikacija ustreznih genotipov lahko pomembno prispeva k hitrejši odbiri na polju. Metode daljinskega zaznavanja lahko olajšajo identifikacijo sort in omogočajo visokozmogljivo fenotipizacijo na poljih. Preizkusili smo uporabnost multispektralnega sistema, nameščenega na brezpilotnem letalniku, za identifikacijo 68 sort krompirja (*Solanum tuberosum* L.). V poskusu z bločno zasnovo smo za posamezno sorto krompirja na manjše parcele sadili po 30 rastlin v 3 ponovitvah. Multispektralne slike smo pridobili opoldne s 5-kanalno multispektralno kamero z višine 50 m. Iz slik smo izolirali rastrske celice z informacijami o rastlinah za vsako rastlino, ter podatke združili z oznakami sort. Za vsako rastrsko celico smo izračunali 40 spektralnih indeksov. Drug nabor podatkov smo ustvarili z izračunom povprečnih vrednosti indeksov za vsako rastlino. Oba nabora podatkov smo nato razdelili na nabora podatkov za učenje algoritmov ter za testiranje, v razmerju 70:30. Prvi nabor podatkov smo uporabili za učenje modela ekstremnega gradientnega spodbujanja, ki smo ga ovrednotili s 5-krat ponovljeno 5-kratno navzkrižno validacijo. Za vsako posamezno rastrsko celico smo izvedli klasifikacijo in na podlagi vseh napovedi rastrskih celic izvedli večinsko glasovanje za določitev uspešnosti klasifikacije za posamezne rastline napoved razreda rastline. Testni nabor podatkov smo nato uporabili za ustvarjanje tako imenovanih matrik zmede in končno oceno razvitih modelov. Pri klasifikaciji povprečnih vrednosti smo dosegli 97,1 % natančnost, pri klasifikaciji na rastrskih celicah 88,5 % natančnost, pred večinskih glasovanjem. Slednje je povišalo natančnost na 98,4 %. Ti rezultati kažejo, da je multispektralno slikanje z brezpilotnimi letalniki mogoče uporabiti za natančno identifikacijo sort krompirja, kar lahko olajša karakterizacijo sort v žlahtniteljskih programih in pospeši celoten proces žlahtnjenja.

Ključne besede: identifikacija sort, daljinsko zaznavanje, multispektralno slikanje, žlahtnjenje, dron

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Identification of different potato (*Solanum tuberosum* L.) cultivars using multispectral imaging

The selection of genotypes with appropriate development of leaf mass in the field is very important in the organic potato breeding program for organic production at Agriculture Institute of Slovenia. The rapid development of stronger leafy plants that cover the ground well enables greater competition against weeds, reduces water loss and ultimately ensures a high yield. Rapid identification of suitable genotypes could significantly contribute to faster and more efficient selection in the field. Remote sensing methods have the potential to facilitate cultivar identification and enable high-throughput phenotyping in fields. We tested the applicability of a multispectral system mounted on an unmanned aerial vehicle (UAV) to identify 68 potato (*Solanum tuberosum* L.) cultivars. The potato cultivars were planted in microplots in a randomised design with 30 plants per microplot and three replicates per cultivar. Multispectral images were obtained using a 5-band multispectral an altitude of 50 m at midday. The reflectance images were segmented, leaf area pixels extracted for each plant and labelled for each cultivar. For each pixel we calculated 40 spectral indices. Another dataset was created by calculating mean values for each plant. Both datasets were then split into training and test datasets in a 70:30 ratio. The first dataset was used to train an Extreme Gradient Boosting model, which was evaluated using 5-times repeated 5-fold cross validation. For the per-pixel dataset, majority voting was implemented to determine classification success for individual plants. The test dataset was then used to create confusion matrices and perform the final evaluation of the developed models. Classification of mean values achieved 97.1% accuracy, while per-pixel classification achieved 88.5% accuracy. Majority voting increased the overall accuracy to 98.4%. These results show that UAV-based multispectral imaging can be used to accurately identify potato cultivars, which can facilitate cultivar characterisation in breeding programmes and accelerate the selection process in potato breeding program.

Key words: cultivar discrimination; remote sensing, multispectral imaging, potato, organic breeding, unmanned aerial vehicle

Zgodnje določanje sušnega stresa vinske trte z brezpilotnimi letalniki in letalom

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Smotrna raba vode je ključnega pomena za gospodarjenje z vinogradi v kraški pokrajini. Vinogradniki se zavedajo pomembnosti primernega upravljanja namakanja za zmanjšanje vodnega stresa vinske trte ter zagotavljanje zadostnih količin in visoke kakovosti pridelka. Na voljo so različne metode za določanje sušnega stresa rastlin, vendar so večinoma omejene na posamezne rastline, torej so zamudne in ne omogočajo nadzora nad celotnim vinogradom. Večspektralni senzorji, nameščeni na brezpilotnem letalniku ali letalu, omogočajo ocenjevanje zdravstvenega stanja posameznih rastlin v celotnem vinogradu. V vinogradih na Komnu in Preceniccu (Videm, Italija) smo v letu 2021 izvedli namakalni poskus. Vinograda smo slikali z multispektralno kamero na brezpilotnem letalniku ter hiperspetkralnim sistemom na ultralahkem letalu, oboje v časovni vrsti. Iz multispektralnih podatkov smo izračunali 35 spektralnih indeksov. Dimenzionalnost podatkov za oba sistema smo zmanjšali z metodo delnih najmanjših kvadratov (PLS), klasifikacije pa izvedli z metodo podpornih vektorjev (SVM). Kombinacijo metod PLS in SVM smo uporabili tudi za izračun regresijskih modelov za določanje vodnega potenciala rastlin z uporabo daljinskega zaznavanja. Določanje sušnega stresa vinske trte je bilo najbolj uspešno s hiperspektralnim slikanjem, kjer je bilo pravilno uvrščenih 93 % primerov, z multispektralnim slikanjem pa 89 %. Razvili smo tudi regresijske modele za določanje vodnega potenciala rastlin. Z uporabo hiperspektralnega slikanja smo lahko zanesljivo določili vodni potencial (R^2 med 0,87 in 0,96; RMSE med 0,09 in 0,18). Oba sistema daljinskega zaznavanja sta se izkazala za primerna za hitro, zanesljivo in prostorsko natančno določanje sušnega stresa vinske trte.

Ključne besede: daljinsko zaznavanje, multispektralno slikanje, hiperspektralno slikanje, sušni stres, vinska trta, strojno učenje.

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Early detection of grapevine drought stress using drones and airborne imaging

Prudent water use is crucial for vineyard management in karst regions. Winegrowers are aware of the importance of proper irrigation management to optimize water stress of grapevines, to ensure enough and high quality of the crop. Various methods are available for determining drought stress of plants, but they are mostly limited to individual plants, i.e., they are time-consuming and do not allow control over the entire vineyard. Multi- and hyperspectral sensors mounted on a drone or aircraft can enable health status assessment of individual plants in the entire vineyard. In 2021, we conducted an irrigation experiment in the vineyards near Komen and Precenicco (Videm, Italy). We imaged the vineyards with a multispectral camera on an unmanned aerial vehicle and a hyperspectral system on an ultralight aircraft, both in a time series. We calculated 35 spectral indices from the multispectral data. The dimensionality of the data for both systems was reduced using partial least squares (PLS), and the classifications were performed using support vector machines (SVM). The combination of PLS and SVM was also used to calculate regression models of plant water potential, using remote sensing data. Determining grapevine drought stress was most successful with hyperspectral imaging, where 93% of cases were correctly classified, while multispectral imaging achieved an 89% success rate. We also developed regression models for determining the water potential of plants. Using hyperspectral imaging, we were able to reliably determine the water potential (R^2 between 0.87 and 0.96; RMSE between 0.09 and 0.18). Both remote sensing systems proved to be suitable for fast, reliable, and spatially accurate determination of grapevine drought stress.

Keywords: remote sensing, multispectral imaging, hyperspectral imaging, drought stress, grapevine, machine learning.


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