

**DRUŠTVO GENETIČARA SRBIJE
SEKCIJA ZA OPLEMENJIVANJE ORGANIZAMA**

SERBIAN GENETIC SOCIETY
SECTION OF THE BREEDING OF ORGANISMS

**DRUŠTVO SELEKCIONERA I
SEMENARA REPUBLIKE SRBIJE**

SERBIAN ASSOCIATION OF PLANT
BREEDERS AND SEED PRODUCERS

ZBORNIK APSTRAKATA

**XI SIMPOZIJUM DRUŠTVA SELEKCIONERA I SEMENARA RS
VIII SIMPOZIJUM SEKCIJE ZA OPLEMENJIVANJE ORGANIZAMA DRUŠTVA
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PRODUCERS VIII SYMPOSIUM OF THE SECTION OF BREEDING OF ORGANISMS
SERBIAN GENETIC SOCIETY**

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PLENARNA PREDAVANJA
PLENARY LECTURES

ČETVRTA ERA OPLEMENJIVANJA – KOLIKO DALEKO SMO STIGLI?

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Globalna proizvodnja kukuruza suočava se sa brojnim izazovima, a jedan od najznačajnijih je promena uslova gajenja. Usled sve izraženijih negativnih klimatskih scenarija, posebno u regionima koji su tradicionalno smatrani povoljnim za gajenje kukuruza, postavlja se pitanje da li genetička dobit ostvarena isključivo konvencionalnim oplemenjivanjem može pružiti adekvatan odgovor na predstojeće izazove. U ovom radu posmatrana je evolucija oplemenjivačkih programa kukuruza kroz osvrt na uvođenje novih tehnologija i ostvarivanje veće genetičke dobiti u jedinici vremena. U protekle dve decenije, oplemenjivanje kukuruza pretrpelo je značajne transformacije. Smatra se da je danas u toku 4. era oplemenjivanja kukuruza, takozvano inteligentno oplemenjivanje. Pored genomske selekcije, u moderne programe se sve više integrišu sofisticirani alati za predviđanje, donošenje odluka, integraciju i interpretaciju podataka. Međutim, dinamika usvajanja ovih tehnologija u naučno-istraživačkom i privatnom sektoru nije jednaka i zahteva detaljniju analizu, kako na globalnom nivou, tako i u domaćim okvirima. Jedna od najefikasnijih metoda za praćenje razvoja određene naučne oblasti je bibliometrijska analiza. U tu svrhu analizirano je preko 500 naučnih radova iz baze *Web of Science* (WoS). Korišćenjem tehnike LDA (*Latent Dirichlet Allocation*), identifikovano je 15 ključnih tema raspoređenih u tri glavna domena koji oblikuju savremeno oplemenjivanje kukuruza: i) genetika i genomika, ii) računarske nauke i mašinsko učenje, i iii) fenotipizacija i senzori. Dobijeni rezultati ukazuju na sve veće prisustvo savremenih alata u komercijalnim oplemenjivačkim programima, ali i na činjenicu da još uvek postoji prostor za njihovu punu implementaciju, posebno u malim i finansijski ograničenim oplemenjivačkim programima. Takođe, ključni korak predstavlja premošćavanje jaza između teorijskih mogućnosti i njihove praktične primene.

Ključne reči: kukuruz, genetička dobit, bibliometrijska analiza

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THE FOURTH ERA OF PLANT BREEDING – WHERE DO WE STAND?

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Global maize production faces numerous challenges, among which altered agro-ecological conditions are one of the most significant. Due to increasingly pronounced adverse climate scenarios, particularly in regions traditionally considered favorable for maize cultivation, the question arises whether genetic gain achieved solely through conventional breeding can adequately address upcoming challenges. This paper examines the evolution of maize breeding programs, highlighting the integration of novel technologies to achieve higher genetic gains per unit of time. Over the past two decades, maize breeding has undergone significant transformations. It is considered that the fourth era of maize breeding, so-called intelligent breeding, is currently underway. Alongside genomic selection, modern breeding programs increasingly integrate sophisticated tools for prediction, decision-making, data integration, and interpretation. However, the dynamics of technology adoption across the research and private sectors are uneven, requiring a more detailed analysis both globally and nationally. One of the most effective methods for tracking the development of a specific scientific field is bibliometric analysis. For this purpose, over 500 scientific papers retrieved from the Web of Science (WoS) database were analyzed. Using Latent Dirichlet Allocation (LDA), 15 key topics were identified across three main domains shaping modern maize breeding: i) genetics and genomics, ii) computer science and machine learning, and iii) phenotyping and sensors. The obtained results indicate a growing presence of modern tools in commercial breeding programs, while also highlighting the fact that there is still room for their full implementation, particularly in small and resource-limited breeding programs. Furthermore, bridging the gap between theoretical capabilities and their practical application represents a critical next step.

Keywords: maize, genetic gain, bibliometric analysis

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MULTI-OMIKS ALATI ZA RAZUMEVANJE I PREDVIĐANJE PRINOSA GAJENIH BILJAKA

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Genetička dobit kod soje zaostaje za kukuruzom i strnim žitima, dok fenotip na osnovu kojeg oplemenjivač bira najperspektivniji materijal predstavlja rezultat zajedničkog delovanja genotipa, spoljašnje sredine i njihove interakcije ($P = G + E + G \times E$). U ovom radu razmatra se kako različiti predikcioni i asocijativni pristupi doprinose razumevanju i predviđanju ovih komponenti, uz polazište da izbor metode treba da bude usmeren genetičkom arhitekturom osobine i ciljem selekcije, a ne dostupnošću tehnologije. Analiza je zasnovana na rezultatima oplemenjivačkog programa soje Instituta za ratarstvo i povrtarstvo. Modeli genomske predikcije razvijeni su na raznorodnim panelima genotipizovanim sekvenciranjem (GBS) i vrednovani unakrsnom i spoljašnjom validacijom na istorijskim podacima. Asocijativno mapiranje u više sredina sprovedeno je na 182 linije iz Srbije i Austrije primenom metode 3VmrMLM, dok su UAV multispektralna fenotipizacija i NIRS integrisani sa genomskim podacima na 206 genotipova u četiri sredine. Sposobnost genomske predikcije prinosa dostigla je 0,60, pri čemu je unakrsna validacija precenjivala performanse u odnosu na spoljašnju validaciju. Modeli mašinskog učenja nisu nadmašili GBLUP, a model sa 50 informativnih markera ostvario je performanse uporedive sa modelom sa svim markerima. UAV-izvedeni indeksi predviđali su prinos sa $R^2 = 0,79$, dok je duže trajanje maksimalne pokrovnosti useva bilo pozitivno povezano sa prinosom. Identifikovano je 178 QTN, 95 QTN $\times$ sredina i 142 epistatičke interakcije. Integracija multi-modalnih podataka omogućila je razlikovanje genotipova sličnog prinosa prema različitim strategijama formiranja prinosa. Rezultati ukazuju da kombinovanje genomskih i dinamičkih fenotipskih podataka pruža osnovu za preciznije i biološki informisanije predviđanje prinosa i donošenje selekcionih odluka.

Ključne reči: soja, genomska selekcija, fenotipiziranje visoke propusnosti, interakcija genotip $\times$ sredina, pangenom

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MULTI-OMICS TOOLS FOR UNDERSTANDING AND PREDICTING CROP YIELD

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Genetic gain in soybean lags behind maize and cereals, while the phenotype used by breeders to select promising material reflects the combined effects of genotype, environment, and their interaction ($P = G + E + G \times E$). This study examines how predictive and association-based approaches address these components, assuming that method selection should reflect the genetic architecture of the trait and breeding objective rather than technology availability. The analysis uses results from the soybean breeding programme of the Institute of Field and Vegetable Crops. Genomic prediction models were developed using diverse panels genotyped by sequencing (GBS) and evaluated through cross-validation and external validation on historical data. Multi-environment association mapping was performed on 182 lines from Serbia and Austria using 3VmrMLM, while UAV multispectral phenotyping and NIRS were integrated with genomic data for 206 genotypes across four environments. Genomic prediction ability for yield reached 0.60, while cross-validation overestimated performance relative to external validation. Machine-learning models did not outperform GBLUP, and a model using 50 informative markers achieved performance comparable to the full marker set. UAV-derived indices predicted yield with $R^2 = 0.79$, while longer duration of maximum canopy cover was positively associated with yield. In total, 178 QTN, 95 QTN $\times$ environment interactions, and 142 epistatic interactions were identified. Integration of multi-modal data enabled differentiation of genotypes with similar yield according to distinct yield-forming strategies. The results indicate that combining genomic and dynamic phenotypic data provides a basis for more accurate and biologically informed yield prediction and breeding decisions.

Keywords: soybean, genomic selection, high-throughput phenotyping, genotype $\times$ environment interaction, pan-genome

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USKLAĐIVANJE CILJEVA OPLEMENJIVANJA HORTIKULTURNOG BILJA SA KONCEPTOM „OD PARKA DO TRPEZE“

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Savremeni ekološki, društveni i ekonomski izazovi diktiraju suštinsku transformaciju uloge hortikulture u postizanju održivog razvoja. Tradicionalni pristup, primarno usmeren na dekorativne funkcije hortikulturnih vrsta, u tekućem veku ustupa mesto multifunkcionalnim modelima koji spajaju urbane pejzaže, proizvodnju hrane i principe cirkularne ekonomije. Iz tog razloga, ovaj rad analizira trenutno stanje i predlaže savremene pravce u oplemenjivanju hortikulturnog bilja kroz prizmu koncepta „Od parka do trpeze“ (eng. „Park-to-Fork“), ističući potrebu za preispitivanjem klasičnih selekcionih kriterijuma. U fokusu savremenih oplemenjivačkih programa više ne smeju biti isključivo habitus, boja i trajnost cveta, nego unapređenje kvaliteta ploda, nutritivne vrednosti i otpornosti na stresne uslove spoljašnje sredine, što omogućava integraciju jestivih vrsta u javne i privatne zelene površine. Pored toga, značajan selekциони pomak ogleda se u usmeravanju ka proizvodnji biomase kao sirovine za različite grane cirkularne ekonomije. Savremeni oplemenjivački ciljevi sve češće obuhvataju odabir genotipova pogodnih za ekstrakciju bioaktivnih jedinjenja u svrhu proizvodnje biopesticida, kao i sintezu sekundarnih metabolita i biomase iskoristive za proizvodnju biodizela, bioplastike, biohrane i farmaceutskih sirovina. Integracijom klasičnih i molekularnih metoda oplemenjivanja omogućava se stvaranje genotipova koji istovremeno zadovoljavaju estetske, nutritivne i industrijske zahteve. Ovakav multidisciplinarni pristup u oplemenjivanju hortikulturnog bilja vodi ka održivim, zelenim gradovima i resursno-efikasnoj proizvodnji, kao i inoviranju rasadničke ponude.

Ključne reči: Biocirkularnost, Multifunkcionalni pejzaži, Održivo oplemenjivanje, Unapređenje hortikulturnog bilja, Urbana hortikultura

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ALIGNING HORTICULTURAL CROP BREEDING GOALS WITH THE “PARK-TO-FORK” CONCEPT

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Contemporary ecological, social, and economic challenges advocate for a fundamental transformation of the role of horticulture in achieving sustainable development. The traditional approach, primarily focused on the decorative functions of horticultural species, is giving way to multifunctional models that combine urban landscapes, food production, and circular economy principles. For this reason, this paper analyzes the current situation and proposes novel directions in horticultural plant breeding through the lens of the “Park-to-Fork” concept, emphasizing the need to revise classic selection criteria. The focus of modern breeding programs should no longer be exclusively on habit, color, or flowering features, but on the improvement of fruit quality, nutritional value, and resistance to stressful environmental conditions, thereby enabling the integration of edible species into public and private green areas. In addition, a significant selection shift is reflected in the production of biomass as a raw material for various circular economy branches. Modern breeding goals nowadays include the selection of genotypes suitable for the extraction of bioactive compounds for the production of biopesticides, as well as the synthesis of secondary metabolites and the formation of biomass usable for the production of biodiesel, bioplastics, biofood, and pharmaceutical raw materials. The integration of classical and molecular breeding methods enables the selection of genotypes that simultaneously satisfy aesthetic, nutritional, and industrial requirements. This multidisciplinary approach in breeding horticultural plants leads to sustainable, green cities and resource-efficient production, as well as nursery marketing innovation.

Keywords: Biocircularity, Horticultural plant improvement, Multifunctional landscapes, Sustainable breeding, Urban horticulture

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UVODNA PREDAVANJA

INTRODUCTORY PRESENTATIONS

ŠUMSKO SEMENARSTVO I RASADNIČKA PROIZVODNJA U SRBIJI - STANJE, IZAZOVI I PRAVCI RAZVOJA

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Šumsko semenarstvo i rasadnička proizvodnja predstavljaju osnovu obnove šuma, očuvanja šumskih genetičkih resursa i prilagođavanja šumskih ekosistema klimatskim promenama. U radu je analizirano stanje ove oblasti u Srbiji na osnovu registara semenskih objekata i rasadnika, kao i podataka o proizvodnji semena, sadnica i reznica. Registrovano je 480 semenskih objekata poznatog porekla, površine 26.632,7 ha, i 174 selekcionisana objekta, ukupne površine 2.174,6 ha. Kvalifikovani polazni materijal obuhvata 23 registrovane jedinice, od kojih pet semenskih plantaža i 18 grupa roditeljskih stabala. U Srbiji su registrovana 83 šumska rasadnika. U periodu 2012-2025. sakupljeno je 2.151,4 t semena. Materijalu poznatog porekla pripadalo je 85,2%, selekcionisanom 14,6%, a kvalifikovanom svega 0,2%. Godišnja proizvodnja varirala je od 7,7 do 571,3 t, što odražava izraženu periodičnost uroda. Od 2015. do 2025. proizvedeno je 111,1 milion sadnica, prosečno 10,1 milion godišnje. Četinari su činili 56,1%, a lišćari 43,9% proizvodnje. U periodu 2017-2025. proizvedeno je i 13,54 miliona topolovih reznica, pri čemu su dva klona činila 85,3% ukupne količine. Rezultati pokazuju da Srbija raspolaže značajnom proizvodnom osnovom, ali da njeno korišćenje obeležavaju velike godišnje oscilacije, malo učešće materijala viših kategorija i koncentracija proizvodnje na ograničen broj vrsta i klonova. Unapređenje sistema zahteva obnovu i proširenje mreže semenskih objekata, modernizaciju rasadnika, jačanje kontrole kvaliteta i sledljivosti i dugoročno usklađivanje proizvodnje sa potrebama obnove i sanacije šuma.

Ključne reči: šumsko semenarstvo, šumski rasadnici, reproduktivni materijal, semenski objekti, genetički resursi, klimatske promene.

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FOREST SEED AND NURSERY PRODUCTION IN SERBIA - CURRENT STATUS, CHALLENGES AND PROSPECTS FOR DEVELOPMENT

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Forest seed and nursery production form the basis for forest regeneration, the conservation of forest genetic resources, and the adaptation of forest ecosystems to climate change. This paper analyses the current state of this sector in Serbia using registers of seed sources and forest nurseries, as well as data on the production of seeds, seedlings, and cuttings. A total of 480 seed sources of known origin, covering 26,632.7 ha, and 174 selected seed sources, covering 2,174.6 ha, have been registered. Qualified basic material comprises 23 registered units, including five seed orchards and 18 groups of parent trees. Serbia has 83 registered forest nurseries. Between 2012 and 2025, the country collected 2,151.4 tons of seed. Material of known origin accounted for 85.2%, selected material for 14.6%, and qualified material for only 0.2%. Annual seed production ranged from 7.7 to 571.3 tons, reflecting pronounced periodicity in seed crops. Between 2015 and 2025, 111.1 million seedlings were produced, averaging 10.1 million seedlings per year. Conifers accounted for 56.1% and broadleaved species for 43.9% of total production. In addition, 13.54 million poplar cuttings were produced between 2017 and 2025, with two clones accounting for 85.3% of the total quantity. The results show that Serbia has a substantial production base. Still, its utilization is characterized by considerable annual fluctuations, a low share of higher-category reproductive material, and production concentrated in a limited number of species and clones. Improving the system requires renewing and expanding the seed-source network, modernizing forest nurseries, strengthening quality control and traceability, and aligning production over the long term with the requirements of forest regeneration and rehabilitation.

Keywords: forest seed production, forest nurseries, reproductive material, seed sources, genetic resources, climate change.

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FENOTIPSKA VARIJABILNOST OSOBINA ŠIŠARICA I SEMENA PANČIĆEVE OMORIKE (*PICEA OMORIKA* (PANČ.) PURK.) I NJEN ZNAČAJ ZA KONZERVACIJU I OPLEMENJIVANJE

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Pančićeva omorika (*Picea omorika* (Panč.) Purk.) je tercijarni relik i balkanski endem čiji ograničeni areal i fragmentisane populacije ukazuju na potrebu očuvanja genetičke raznovrsnosti i identifikacije perspektivnog reproduktivnog materijala. Cilj ovog istraživanja bio je da se utvrdi nivo i struktura fenotipske varijabilnosti osobina šišarica i semena prirodnih populacija Pančićeve omorike i proceni njihov značaj za konzervaciju i oplemenjivanje. Istraživanjem su obuhvaćene četiri prirodne populacije Pančićeve omorike (Vranjak, Trenice, Zmajevački potok i Kremići). Analizirano je 50 materinskih stabala, pri čemu je po svakom stablu mereno po 30 šišarica i semena. Određivane su dimenzije šišarica i semena, kao i klijavost semena. Prosečna dužina i širina šišarica iznosile su 41,39 mm i 16,25 mm, dok je prosečna klijavost semena bila 82,5%. Najveća varijabilnost utvrđena je kod debljine semena (CV = 20,18 %). Rezultati su pokazali postojanje značajne fenotipske varijabilnosti ispitivanih osobina, pri čemu je varijabilnost između materinskih stabala bila izraženija od varijabilnosti između populacija. Dobijeni rezultati ukazuju da se najveći deo fenotipske raznovrsnosti Pančićeve omorike nalazi unutar populacija, odnosno na nivou pojedinačnih genotipova. Utvrđena visoka unutarpopulaciona varijabilnost ukazuje na značajan potencijal za selekciju superiornih genotipova i naglašava potrebu uključivanja većeg broja materinskih stabala u programe *in situ* i *ex situ* konzervacije, kao i u buduće programe oplemenjivanja i proizvodnje šumskog reproduktivnog materijala Pančićeve omorike.

Ključne reči: Pančićeva omorika, fenotipska varijabilnost, genetički resursi, konzervacija, oplemenjivanje

Zahvalnica: Rad je realizovan uz finansijsku podršku kompanije PS Fashion.

PHENOTYPIC VARIABILITY OF CONE AND SEED TRAITS IN SERBIAN SPRUCE (*PICEA OMORIKA* (PANČ.) PURK.) AND ITS SIGNIFICANCE FOR CONSERVATION AND BREEDING

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Serbian spruce (*Picea omorika* (Panč.) Purk.) is a Tertiary relict and a Balkan endemic species whose restricted distribution range and fragmented populations highlight the need to preserve its genetic diversity and identify promising reproductive material. The aim of this study was to determine the level and structure of phenotypic variability in cone and seed traits of natural populations of Serbian spruce and to assess their significance for conservation and breeding. The study included four natural populations of Serbian spruce (Vranjak, Trenice, Zmajevački Potok, and Kremići). A total of 50 mother trees were analysed, with 30 cones and seeds measured per tree. Cone and seed dimensions, as well as seed germination, were determined. The average cone length and width were 41.39 mm and 16.25 mm, respectively, while the average seed germination rate was 82.5%. The highest variability was recorded for seed thickness (CV = 20.18%). The results revealed significant phenotypic variability in the studied traits, with variability among mother trees being more pronounced than variability among populations. These findings indicate that most of the phenotypic diversity in Serbian spruce occurs within populations, reflecting substantial variation among individual genotypes. The high level of within-population variability highlights the considerable potential for the superior genotypes selection and underscores the importance of sampling a larger number of mother trees for *in situ* and *ex situ* conservation, future breeding programmes and the production of forest reproductive material of Serbian spruce.

Keywords: Serbian spruce, phenotypic variability, genetic resources, conservation, breeding

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OD GENETIČKOG MAPIRANJA DO PANGENOMOM POTPOMOŽNUTE IZOLACIJE GENA *Rph30* ZA OTPORNOST JEČMA PREMA LISNOJ RĐI

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Lisna rđa ječma, koju prouzrokuje *Puccinia hordei*, predstavlja značajnu bolest ječma. Gen otpornosti *RphMBR1012*, identifikovan u akcesiji ječma poreklom iz bivše Jugoslavije, i *Rph4* prethodno su mapirani u distalnom regionu hromozoma 1HS, ali njihov genetički odnos nije bio razjašnjen. Fenotipizacija diferencijalnim izolatima i genetičko mapiranje potomstva ukrštanja *MBR1012* × Gold (*Rph4*) identifikovali su dva različita, ali blisko vezana lokusa otpornosti. Mapiranjem 90 F3:4 familija sa 5.702 markera pozicionirani su QTL pikovi za *RphMBR1012* i *Rph4* na 1,92 odnosno 2,71 cM. Osam kosegregirajućih markera testirano je na 143 genetički različita genotipa ječma, pri čemu je KASP marker QBS217 pokazao najveću prediktivnu tačnost (96,48%). Visokorezoluciono mapiranje i komparativna genomika zasnovana na pangenomu korišćeni su za dalje sužavanje strukturno kompleksnog regiona *RphMBR1012*. Poređenjem genoma Morex, Maximus i rezistentnog donora ciljni interval je sužen na približno 318–513 kb i identifikovana su dva NLR kandidat-gena. Za funkcionalnu validaciju, 5.000 semena rezistentnog donora tretirano je EMS-om, a 2.309 M2 familija testirano je izolatom I-80. Identifikovano je deset mutanata sa gubitkom funkcije, od kojih je pet odabrano za sekvenciranje celog genoma. Fenotipska promena iz otpornosti u osetljivost, zajedno sa resekvenciranjem mutanata, pruža direktan pristup identifikaciji odgovornog gena. Rezultati genetičkog mapiranja, pangenomske analize i mutageneze podržavaju *RphMBR1012* kao lokus različit od *Rph4*, označen kao *Rph30*, i omogućavaju njegovu molekularnu izolaciju.

Ključne reči: ječam, *Puccinia hordei*, *Rph30*, pangenom, EMS mutageneza, NLR, gene isolation

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FROM GENETIC MAPPING TO PANGENOME-ASSISTED ISOLATION OF THE BARLEY LEAF RUST RESISTANCE GENE RPH30

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Barley leaf rust, caused by *Puccinia hordei*, is an important foliar disease of barley. The resistance gene *RphMBR1012*, identified in a barley accession originating from the former Yugoslavia, and *Rph4* were previously mapped to the distal region of chromosome 1HS, but their genetic relationship remained unresolved. Differential-isolate phenotyping and genetic mapping of progenies derived from the cross MBR1012 × Gold (*Rph4*) identified two distinct but closely linked resistance loci. Mapping of 90 F3:4 families with 5,702 markers positioned the QTL peaks for *RphMBR1012* and *Rph4* at 1.92 and 2.71 cM, respectively. Eight co-segregating markers were subsequently evaluated across 143 diverse barley genotypes, with QBS217 showing the highest predictive accuracy (96.48%). High-resolution mapping and pangenome-based comparative genomics were then used to resolve the structurally complex *RphMBR1012* region. Comparison of Morex, Maximus and the resistant donor genome reduced the target interval to approximately 318–513 kb and identified two NLR candidate genes. For functional validation, 5,000 seeds of the resistant donor were EMS-mutagenized and 2,309 M2 families screened with *P. hordei* isolate I-80. Ten loss-of-function mutants were identified, of which five were selected for whole-genome sequencing. Phenotypic reversion from resistance to susceptibility, combined with mutant resequencing, provides direct evidence for identification of the underlying resistance candidate. Together, genetic mapping, pangenome analysis and mutagenesis support *RphMBR1012* as a distinct resistance locus, designated *Rph30*, and provide a route towards its molecular isolation.

Keywords: barley, *Puccinia hordei*, *Rph30*, leaf rust, pangenome, EMS mutagenesis, NLR, gene isolation

ISKORIŠĆAVANJE GENETIČKOG POTENCIJALA ZA UNAPREĐENJE TOLERANTNOSTI NA SUŠU

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Učestalija pojava suše predstavlja veliki izazov za proizvodnju suncokreta, posebno tokom reproduktivne faze, kada vodni deficit može smanjiti uspešnost oprašivanja, formiranje akenija i prinos. Divlje vrste roda *Helianthus* predstavljaju vredne izvore genetičke varijabilnosti za identifikaciju adaptivnih osobina i unapređenje otpornosti gajenog suncokreta na sušu. Ovo dvogodišnje istraživanje imalo je za cilj identifikaciju osobina odgovornih na sušu kod divljih genotipova roda *Helianthus* primenom postupnog pristupa koji objedinjuje terensko ispitivanje i funkcionalnu karakterizaciju. U prvoj fazi, pet divljih vrsta roda *Helianthus* procenjavano je u poljskim uslovima tokom cvetanja analizom morfologije cvasti, sastava šećera u nektaru i formiranja akenija. Utvrđena je izražena međuvrsna varijabilnost, pri čemu su *H. annuus* i *H. argophyllus* zadržale viši reproduktivni učinak, što ukazuje na njihovu veću reproduktivnu stabilnost u uslovima suše, dok je *H. debilis* pokazala značajno smanjenje produktivnosti sa približno 50% praznih akenija. Zbog toga je vrsta *H. debilis* odabrana za dalja istraživanja radi identifikacije funkcionalnih ograničenja koja određuju njen odgovor na sušu. U kontrolisanom eksperimentu, stres suše uveden je u fazi formiranja cvetnih pupoljaka tokom 10 dana smanjenjem vlažnosti supstrata sa 70% na 40%, a odgovori biljaka procenjeni su kroz morfo-anatomske i fiziološke analize vegetativnih i reproduktivnih organa. Ovakav integrativni pristup omogućava uvid u mehanizme koji ograničavaju reproduktivni uspeh pod uslovima suše i identifikaciju stabilnih i plastičnih osobina povezanih sa odgovorom na sušu, čime se podržava korišćenje genetičkih resursa divljih vrsta roda *Helianthus* u unapređenju suncokreta. Identifikovane osobine predstavljaju vredne selekzione kriterijume za introgresiju adaptivnih karakteristika na sušu iz divljih vrsta roda *Helianthus* u oplemenjivačke programe gajenog suncokreta.

Ključne reči: divlji suncokret, morfologija, anatomija, fiziologija, suša

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UNLOCKING GENETIC POTENTIAL FOR DROUGHT TOLERANCE

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Increasing drought frequency represents a major challenge for sunflower production, particularly during the reproductive phase, when water deficit can reduce pollination success, achene formation, and yield. Wild *Helianthus* species represent valuable sources of genetic variation for identifying adaptive traits and improving drought resilience in cultivated sunflower. This two-year study aimed to identify drought-responsive traits in wild *Helianthus* germplasm through a stepwise approach combining field screening and functional characterization. In the first phase, five wild *Helianthus* species were evaluated under field conditions during flowering by analyzing inflorescence morphology, nectar sugar composition and achene set. Pronounced interspecific variation was observed, with *H. annuus* and *H. argophyllus* maintaining higher reproductive performance indicating superior reproductive stability under drought., whereas *H. debilis* exhibited a severe reduction in productivity with approximately 50% empty achenes. Therefore, *H. debilis* was selected for further investigation to identify functional limitations underlying its drought response. In a controlled experiment, drought stress was imposed at the flower bud stage for 10 days by reducing substrate moisture from 70% to 40%, and responses were evaluated through morpho-anatomical and physiological analyses of vegetative and reproductive organs. This integrative approach provides insight into mechanisms limiting reproductive success under drought and identifies stable and plastic traits associated with drought response, supporting the utilization of wild *Helianthus* genetic resources for sunflower improvement. The identified traits provide valuable selection criteria for the introgression of drought-adaptive characteristics from wild *Helianthus* species into cultivated sunflower breeding programs.

Keywords: wild sunflower, morphology, anatomy, physiology, drought.

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ANATOMIJA KRIZE I STRATEGIJA REVITALIZACIJE: STRUKTURNA TRANSFORMACIJA STOČARSKOG SEKTORA SRBIJE (2026–2034)

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Stočarska proizvodnja u Republici Srbiji nalazi se na istorijskom minimumu zahvaljujući višedecenijskom smanjenju stočnog fonda. Najizraženiji pad proizvodnje beleži se u govedarstvu (pad brojnog stanja za 17,3% u odnosu na desetogodišnji prosek) i svinjarstvu (13,9%). Živinarstvo se transformisalo kroz gašenje malih proizvođača u korist industrijalizacije, dok ovčarstvo i pčelarstvo pokazuju otpornost zahvaljujući ekstenzivnom načinu proizvodnje. Uzroci ove degradacije uključuju demografsko prажnjenje sela, zastarelu tehnologiju proizvodnje, klimatske promene, nedostatak edukacije, neadekvatnu infrastrukturu u ruralnim područjima, nisku produktivnost i nepovoljne ekonomske uslove.

U cilju prevazilaženja navedenih problema izrađena je nova Strategija razvoja poljoprivrede (2026–2034) zasnovana na SWOT i PESTLE analizi postojećeg stanja u kojoj su definisani ključni pravci daljeg razvoja ovog sektora. Strategija predviđa kombinaciju regulatornih, podsticajnih, organizacionih i informativno-edukativnih mera radi obnove prehrambenog suvereniteta. Fokus se preusmerava na jačanje izvoznih kapaciteta kroz modernizaciju i unapređenje proizvodnje mleka i mesa, usklađivanje sa međunarodnim standardima i veterinarskim uslovima Evropske unije. U predstojećem periodu, posebna pažnja biće posvećena konceptu klimatski pametne poljoprivrede koji, kroz zaštitu pašnjaka, plodored i revitalizaciju integrisanih ratarsko-stočarskih sistema, omogućava zatvaranje ciklusa hranljivih materija i postavlja osnove za sveobuhvatno unapređenje i modernizaciju celog poljoprivrednog sektora. Okosnicu razvojnog plana činiće sinergija novih tehnologija, edukacija mladih preko agro-naučnog i inovacionog sistema prenosa znanja (AKIS) i predstojeća kapitalna ulaganja u osnovnu ruralnu infrastrukturu (putnu, vodovodnu i digitalnu mrežu). Sve ove mere projektovane su sa ciljem da se u bliskoj budućnosti (do 2034. godine) značajno ublaže migracije iz ruralnih područja, privuku nove investicije i izgradi konkurentan, ekološki održiv i izvozno orijentisan stočarski sektor.

Ključne reči: stočarstvo, strategija razvoja poljoprivrede, Republika Srbija.

ANATOMY OF THE CRISIS AND REVITALIZATION STRATEGY: THE STRUCTURAL TRANSFORMATION OF SERBIA'S LIVESTOCK SECTOR (2026–2034)

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Livestock production in the Republic of Serbia is at an all-time low due to a decades-long decline in livestock numbers, particularly in cattle (-17.3% compared to the ten-year average) and pig farming (-13.9%). Poultry farming has shifted toward large-scale industrialization, while sheep and bee farming remain resilient through extensive methods. This degradation is driven by rural depopulation, outdated technologies, climate change, infrastructure deficits, low productivity, and unfavorable economic conditions. To address these challenges, the new Agricultural Development Strategy (2026–2034) was drafted based on SWOT and PESTLE analyses. The Strategy outlines regulatory, incentive-based, organizational, and educational measures to restore food sovereignty and boost export capacities by modernizing milk and meat production in line with EU veterinary standards. In the coming period, focus will shift toward climate-smart agriculture. By protecting pastures, implementing crop rotation, and revitalizing integrated crop-livestock systems, this approach closes nutrient cycles and modernizes the entire agricultural sector. The plan relies on a synergy of new technologies, youth education via the Agricultural Knowledge and Innovation System (AKIS), and capital investments in rural road, water, and digital networks. These measures aim to mitigate rural out-migration by 2034, attract investment, and build a competitive, environmentally sustainable, and export-oriented livestock sector.

Keywords: livestock production, agricultural development strategy, Republic of Serbia.

RAZUMEVANJE GENETIČKE SLOŽENOSTI I MREŽA KOJE UPRAVLJAJU AGRONOMSKI VAŽNIM OSOBINAMA SOJE

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Unapređenje oplemenjivanja soje u sve većoj meri zavisi od razumevanja složene genetičke arhitekture agronomski važnih osobina. Većina osobina značajnih za oplemenjivanje se nasleđuje kvantitativno i određena je ne samo efektima pojedinačnih lokusa, već i interakcijama između genotipa i spoljašnje sredine, kao i epistatičkim interakcijama između lokusa, koje su još uvek nedovoljno istražene. Njihovo bolje poznavanje predstavlja osnovu za efikasniju primenu genomske informacije u savremenim oplemenjivačkim programima.

U ovom istraživanju su analizirane 182 genetički divergentne linije soje pomoću više od 30.000 SNP markera i ispitivanjem fenotipa za 12 agronomski važnih osobina koje obuhvataju prinos, hemijski kvalitet zrna, arhitekturu biljke i adaptaciju u dva agroekološka uslova (Srbija i Austrija) tokom dve vegetacione sezone. Asocijativne analize na nivou celog genoma su obavljene primenom metode 3VmrMLM radi identifikacije lokusa sa glavnim efektom, interakcija lokus–sredina i epistatičkih interakcija. Identifikovano je 133 QTN u analizama pojedinačnih sredina, 178 QTN i 95 interakcija QTN × sredina u analizama više sredina, kao i 57 epistatičkih QTN i 142 para epistatičkih interakcija. Integracijom rezultata za sve analizirane osobine formirana je mreža genetičkih interakcija koja je izdvojila devet lokusa povezanih sa najmanje tri agronomske osobine, pri čemu se nekoliko njih poklopilo sa ranije opisanim regionima odgovornih za vreme zrenja i visinu biljke. Dobijeni rezultati potvrđuju da su agronomski važne osobine soje kontrolisane složenom mrežom aditivnih i neaditivnih genetičkih efekata. Razumevanje genetičke arhitekture važnih osobina predstavlja snažnu osnovu za efikasnije korišćenje genomske informacije u oplemenjivanju i identifikaciju pouzdanih ciljnih regiona za razvoj visokoprinosa i adaptiranih sorti soje.

Ključne reči: GWAS, soja, genetičke mreže, genetička arhitektura

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UNDERSTANDING THE GENETIC COMPLEXITY AND NETWORKS UNDERLYING SOYBEAN AGRONOMIC TRAITS

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Soybean improvement increasingly relies on understanding the complex genetic architecture underlying agronomically important traits. Most breeding traits are quantitatively inherited and influenced not only by individual loci but also by genotype-by-environment interactions and epistatic effects, which remain insufficiently characterized. Improving our understanding of these genetic relationships is essential for the efficient application of genomic information in modern breeding. In this study, 182 genetically diverse soybean lines were genotyped using more than 30,000 SNP markers and phenotyped for 12 agronomic traits related to yield, grain quality, plant architecture, and adaptation across two environments (Serbia and Austria) over two growing seasons. Genome-wide association analyses were performed using the 3VmrMLM approach to simultaneously identify main-effect QTNs, QTN-by-environment interactions, and epistatic loci. The analyses identified 133 QTNs in single-environment analyses, 178 QTNs and 95 QEIs in multi-environment analyses, as well as 57 epistatic QTNs and 142 QQI pairs. Integration of association signals across traits enabled the construction of a genetic interaction network, revealing nine highly connected loci affecting at least three agronomic traits, several of which colocalized with previously reported maturity and plant height regions. These results demonstrate that soybean agronomic performance is controlled by an interconnected genetic architecture involving additive and non-additive effects. Characterizing these genetic networks provides a stronger biological foundation for genomic-assisted breeding and supports the identification of robust targets for developing high-yielding and climate-resilient soybean cultivars.

Keywords: GWAS, soybean, genetic networks, genetic architecture

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ADAPTIVNE STRATEGIJE RAZLIČITIH GENOTIPOVA ENGLESKOG LJULJA (*LOLIUM PERENNE* L.) NA USLOVE SUŠE

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Suša, pre svega neravnomerna raspodela padavina tokom vegetacione sezone smatra se jednim od najznačajnijih problema u zasnivanju i korišćenju sejanih travnjaka, gde predstavnici iz roda *Lolium* čine najvažniju travnu komponentu. Razumevanje njihovih adaptivnih strategija na uslove nedovoljnih količina vode polazna je osnova za procese oplemenjivanja i dobijanja prinosnijih genotipova i u takvim nepovoljnijim uslovima. Cilj istraživanja bio je da se utvrdi da li genotipovi *Lolium perenne* koriste različite strategije u prevazilaženju vodnog deficita. U eksperimentu su korišćene tri populacije, jedna je bila sa područja vlažne klime Zapadne Evrope (Shandon), dok su druge dve adaptirane na klimatske uslove centralne Srbije (sorta K-11 i eksperimentalna populacija). Gajene su u PVC cevima dužine 90 cm u polukontrolisanim uslovima sa uspostavljenim režimima vlažnosti supstrata od 100, 70, 50 i 30 procenata poljskog vodnog kapaciteta. Ispitivanja su vršena na morfološkom i biohemijskom nivou nadzemnog i podzemnog dela biljaka. Rezultati su pokazali značajne razlike u odgovoru na vodni stres. Eksperimentalna populacija uspela je da održi najveću produkciju biomase uprkos uslovima intenzivnog stresa suše, dok je sorta K-11 sa druge strane pokazala najmanje oksidativno oštećenje. Shandon kao sorta iz vlažnih klimatskih uslova razvila je najdominantniji koren u površinskim slojevima supstrata u svim režimima navodnjavanja. Na osnovu rezultata može se zaključiti da se ispitivane populacije različitim strategijama odupiru uslovima suše, ali je važno istaći da tolerantnost nije usko povezana samo sa jednom specifičnom osobinom, već kombinacijom više njih. Može se reći da je potencijal ispitivanih populacija, kao izvor različitih adaptivnih svojstava, značajan za buduće programe oplemenjivanja na sušu.

Ključne reči: Engleski ljulj, vodni stres, tolerantnost na sušu, oplemenjivanje

Zahvalnica: Istraživanja su finansirana sredstvima Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, br. Ugovora 451-03-33/2026-03/200217.

ADAPTIVE STRATEGIES OF DIFFERENT PERENNIAL RYEGRASS (*LOLIUM PERENNE* L.) GENOTYPES UNDER DROUGHT STRESS

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Drought, particularly the unequal distribution of precipitation during the growing season, is considered one of the significant problems in the establishment and utilisation of sown grasslands, where representatives of the genus *Lolium* constitute the most important grass component. Understanding their adaptive strategies to insufficient water availability provides a basis for breeding processes and obtaining more successful and productive genotypes under unfavourable conditions. This study aimed to determine whether *Lolium perenne* genotypes use different strategies to overcome water deficit. Three populations were used in the experiment, one originating from the humid climate of Western Europe (Shandon), while the other two were adapted to the climatic conditions of central Serbia (K-11 cultivar and experimental population). Plants were grown in 90 cm long PVC tubes under semi-controlled conditions with substrate moisture regimes of 100, 70, 50 and 30% of field water capacity. Morphological and biochemical characteristics of aboveground and belowground plant parts were evaluated. The results showed significant differences in response to water stress. The experimental population maintained the highest biomass production despite severe drought stress, while K-11 had the lowest oxidative damage. Shandon, as a cultivar from humid climatic conditions, developed the most pronounced root system in the upper substrate layers under all irrigation regimes. The results indicate that the investigated populations respond to drought through different strategies, but tolerance is not closely related to one specific trait, but rather to a combination of several traits. These populations have considerable potential for future drought breeding programs as sources of diverse adaptive traits.

Keywords: Perennial ryegrass, Water stress, Drought tolerance, Breeding

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PRIMENA BESPILOTNIH LETELICA U VISOKOPROPUSNOJ FENOTIPIZACIJI KUKURUZA

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RGB snimanje iz bespilotnih letelica (UAV) predstavlja ekonomičan pristup visokopropusnoj fenotipizaciji, koji omogućava brzo, efikasno i nedestruktivno prikupljanje podataka o važnim agronomskim svojstvima kukuruza, čime se otvaraju mogućnosti za unapređenje procesa oplemenjivanja. Panel od 400 genotipova kukuruza, koji je obuhvatio 200 hibrida i njihove roditeljske komponente, ocenjen je u poljskim ogledima na dve lokacije u Zemun Polju za broj i visinu biljaka primenom snimanja iz bespilotne letelice. RGB snimanje obavljano je jednom nedeljno tokom vegetacionog perioda kukuruza, a dva puta nedeljno u periodu oplodnje, korišćenjem bespilotne letelice DJI Mavic 3M. RGB snimci obrađeni su generisanjem ortomozaika i digitalnih modela elevacije (DEM), uz naknadnu ekstrakciju i analizu podataka na nivou pojedinačnih oglednih parcela. Na osnovu RGB ortomozaika snimljenih u ranim fazama razvoja kukuruza (2–5 listova), razvijena je skripta za automatsku detekciju i prebrojavanje pojedinačnih biljaka na nivou oglednih parcela. Postupak objedinjuje segmentaciju vegetacije na osnovu RGB podataka, određivanje orijentacije redova za svaku parcelu primenom analize glavnih komponenti (PCA) i prostorno grupisanje identifikovanih biljaka. Na ovaj način omogućeno je pouzdano određivanje broja biljaka u različitim uslovima na terenu, uz smanjenje uticaja zemljišne podloge i prostora između redova. Visina biljaka procenjena je na osnovu digitalnog modela površine (DSM) generisanog iz UAV snimaka, u odnosu na digitalni model elevacije (DEM) koji predstavlja površinu golog zemljišta. Na osnovu razlike između DSM-a i DEM-a generisan je model visine vegetacije (Canopy Height Model – CHM), iz kojeg su na nivou pojedinačnih oglednih parcela izračunati različiti statistički pokazatelji visine biljaka. Budući rad biće usmeren na dalji razvoj i optimizaciju postupaka obrade podataka, sa ciljem povećanja preciznosti i pouzdanosti visokopropusne fenotipizacije u različitim uslovima na terenu, kao i na njenu primenu u programima oplemenjivanja kukuruza.

Ključne reči: bespilotne letelice, visokopropusna fenotipizacija, kukuruz, broj biljaka, visina biljaka

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UAV-BASED RGB IMAGING FOR HIGH-THROUGHPUT PHENOTYPING OF MAIZE

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RGB imaging using unmanned aerial vehicles (UAVs) represents a cost-effective approach to high-throughput phenotyping, enabling rapid, efficient, and non-destructive data collection for important agronomic traits in maize and offering opportunities to improve breeding processes. A panel of 400 maize genotypes, comprising 200 hybrids and their parental components, was evaluated for plant number and height in field trials at two locations in Zemun Polje using UAV-based imaging. RGB imagery was collected weekly throughout the maize growing season and twice weekly during the pollination period using a DJI Mavic 3M UAV. The RGB images were processed to generate orthomosaics and digital elevation models (DEMs), followed by data extraction and analysis at the individual plot level. Based on RGB orthomosaics acquired during the early stages of maize development (2–5 leaf stage), a script was developed for automated detection and counting of individual plants at the plot level. The workflow integrates RGB-based vegetation segmentation, plot-wise row orientation using principal component analysis (PCA), and spatial clustering of detected plants. This approach enabled reliable plant counting under varying field conditions while reducing the influence of soil background and inter-row areas. Plant height was estimated from a digital surface model (DSM) generated from UAV imagery, referenced against a digital elevation model (DEM) representing the bare-soil surface. A canopy height model (CHM) was generated from the difference between the DSM and DEM, from which various statistical plant-height metrics were calculated at the individual plot level. Future work will focus on further development and optimization of data-processing procedures to improve the accuracy and reliability of high-throughput phenotyping under varying field conditions, as well as its application in maize breeding programs.

Keywords: unmanned aerial vehicles, high-throughput phenotyping, maize, plant number, plant height

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PREHRAMBENI SUVERENITET: STANJE I STRATEŠKI PRAVCI RAZVOJA POLJOPRIVREDNE PROIZVODNJE SRBIJE

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Obezbeđivanje dugoročnog prehrambenog suvereniteta danas direktno zavisi od adekvatnog odgovora na tri ključna globalna i lokalna izazova: klimatske promene, demografsku krizu ruralnih sredina i geopolitičke potrebe. Poslednjih godina, poljoprivrednu proizvodnju Srbije karakteriše sinergija izrazito nepovoljnih trendova: pad udela poljoprivrede u bruto domaćem proizvodu (BDP), smanjenje učešća agro-industrijskih proizvoda u ukupnom izvozu, redukcija raspoloživog poljoprivrednog zemljišta, permanentno smanjenje stočnog fonda, deficit radne snage, kao i konstantan pad broja poljoprivrednih gazdinstava. Situaciju dodatno uslođavaju tehnološka zaostalost, nizak udeo navodnjavanih površina, usitnjenost poseda, slaba integracija biljne i stočarske proizvodnje, kao i progresivna degradacija zemljišta usled erozije i gubitka humusa. Strateški prioriteti u narednom periodu moraju biti usmereni ka sveobuhvatnoj modernizaciji agrara kroz implementaciju inovativnih tehnoloških rešenja, digitalizaciju i primenu alata veštačke inteligencije (VI). Ključni pravci održivog razvoja obuhvataju tranziciju ka regenerativnoj, klimatski pametnoj i integrisanoj poljoprivredi, uz masovnu primenu sistema precizne poljoprivrede. Sinergija između dva ključna državna dokumenta – Strategije poljoprivrede i ruralnog razvoja (2026-2034) i Strategije nauke, tehnološkog razvoja i inovacija (2026-2030) ostvaruje se kroz nekoliko fundamentalnih stubova. To su, pre svega, operacionalizacija AKIS sistema (Sistem poljoprivrednog znanja i inovacija) radi direktnog transfera naučnih dostignuća iz instituta u primarnu praksu, intenzivna digitalizacija, strateški fokus na edukaciju i podršku mladima, kao i kreiranje poljoprivredno-prehrambenih proizvoda visoke dodate vrednosti. Krajnji cilj svih navedenih mera i strateškog povezivanja jeste obnova prehrambenog suvereniteta, dugoročno obezbeđivanje prehrambene sigurnosti stanovništva, kao i podizanje produktivnosti, konkurentnosti i održivosti domaće agrarne proizvodnje, uz snažan oslonac na domaći sortiment, revitalizaciju nacionalnog semenarstva i strateško jačanje stočarstva.

Ključne reči: prehrambeni suverenitet, biljna i stočarska proizvodnja, modernizacija poljoprivrede, održiva poljoprivreda.

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FOOD SOVEREIGNTY: CURRENT STATE AND STRATEGIC DIRECTIONS FOR THE DEVELOPMENT OF AGRICULTURAL PRODUCTION IN SERBIA

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Ensuring long-term food sovereignty currently depends directly on an adequate response to three key global and local challenges: climate change, the demographic crisis in rural areas, and geopolitical shocks. In recent years, agricultural production in Serbia has been characterized by a synergy of highly unfavorable trends: a decline in the share of agriculture in the Gross Domestic Product (GDP), a decrease in the share of agro-industrial products in total exports, a reduction in available agricultural land, a permanent reduction in livestock numbers, a labor shortage, as well as a constant decline in the number of farms. The situation is further complicated by technological backwardness, a low share of irrigated areas, fragmented land holdings, weak integration of crop and livestock production, and progressive soil degradation due to erosion and loss of humus. Strategic priorities in the coming period must be directed toward the comprehensive modernization of agriculture through the implementation of innovative technological solutions, digitalization, and the application of artificial intelligence (AI) tools. Key directions for sustainable development encompass the transition toward regenerative, climate-smart, and integrated agriculture, alongside the widespread application of precision agriculture systems. The synergy between two key national strategic documents – the Strategy of Agriculture and Rural Development and the Strategy of Science, Technological Development and Innovation – is achieved through several fundamental pillars. These primarily include the operationalization of the AKIS system (Agricultural Knowledge and Innovation System) for the direct transfer of scientific achievements from research institutes into primary agricultural practice, intensive digitalization, a strategic focus on education and youth support, and the creation of high-value-added agri-food products. The ultimate goal of all the aforementioned measures and strategic alignment is the restoration of food sovereignty, long-term food security for the population, and enhancing the productivity, competitiveness, and sustainability of domestic agricultural production, with a strong reliance on domestic varieties, the revitalization of national seed production, and the strategic strengthening of the livestock sector.

Keywords: food sovereignty, crop and livestock production, modernization of agriculture, sustainable agriculture

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USMENA PREDAVANJA
ORAL PRESENTATIONS

OPLEMENJIVANJE ALTERNATIVNIH ULJANIH BILJNIH VRSTA ZA RAZNOVRSNIJU PROIZVODNJU I SORTIMENT

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Dat je prikaz rezultata višedecenijskog oplemenjivanja lanika (*Camelina sativa* (L.) Crantz), šafranike (*Carthamus tinctorius* L.), bele i crne slačice (*Brassica alba* L., *Brassica nigra* L.), uljane rotkve (*Raphanus sativus* L. var. *oleifera*) i ricinusa (*Ricinus communis* L.) u Institutu za ratarstvo i povrtarstvo. Selekcijom, karakterizacijom germplazme i višegodišnjim poljskim ispitivanjima stvoren je domaći sortiment prilagođen različitim agroekološkim uslovima i proizvodnim sistemima. Sorte lanika NS Zlatka i NS Slatka sadrže preko 42% ulja, imaju vegetacioni period od približno 85-100 dana, a u prolećnoj i jesenjoj setvi ostvarile su prinose semena 1,48-1,68 t ha⁻¹, što omogućava uključivanje lanika u sisteme dvostruke setve. Sorte šafranike NS Lana i NS Una pri salinitetu od 200 mM NaCl zadržale su klijavost od 69%, odnosno 64%. Sorte slačice NS Bela i NS Crna ostvarile su prosečne prinose semena od 1.074 i 1.237 kg ha⁻¹, potvrđujući proizvodni potencijal selekcionisanog materijala u domaćim uslovima. Sorta uljane rotkve NS Bora ostvarila je 28.098 kg ha⁻¹ zelene mase i 5.603 kg ha⁻¹ suve materije, uz 16,60% sirovih proteina u biomasi i 36,8% ulja u semenu. Kod ricinusa, sorta Begej ostvarila je prosečan prinos semena od 2.213 kg ha⁻¹ u trogodišnjim ogledima, dok je u novijim ispitivanjima na marginalnom zemljištu sadržaj ulja sorti Begej, Ibar i Dunav iznosio 48,44%, 50,91% i 52,36%, redom. Stvoreni sortiment potvrđuje da dugoročno oplemenjivanje i očuvanje germplazme alternativnih uljanih vrsta mogu neposredno doprineti povećanju raznolikosti proizvodnje, korišćenju različitih rokova setve i razvoju otpornijih i funkcionalno raznovrsnijih sistema biljne proizvodnje.

Ključne reči: alternativne uljane biljne vrste, germplazma, oplemenjivanje, raznolikost, sortiment

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BREEDING OF ALTERNATIVE OILSEED CROPS FOR DIVERSE PRODUCTION AND CULTIVAR SELECTION

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This is a summary of long-term breeding of camelina (*Camelina sativa* (L.) Crantz), safflower (*Carthamus tinctorius* L.), white and black mustard (*Brassica alba* L., *Brassica nigra* L.), oil radish (*Raphanus sativus* L. var. *oleifera*), and castor bean (*Ricinus communis* L.) at the Institute of Field and Vegetable Crops. Germplasm characterization and multi-year field testing resulted in a cultivar selection adapted to different agroecological conditions and production systems. Camelina cultivars NS Zlatka and NS Slatka contain more than 42% oil, have a growing cycle of approximately 85–100 days, and produced seed yields of 1.48–1.68 t ha⁻¹ in spring and autumn sowing, enabling their integration into double-cropping systems. Safflower cultivars NS Lana and NS Una maintained germination of 69% and 64%, respectively, under 200 mM NaCl salinity. Mustard cultivars NS Bela and NS Crna achieved average seed yields of 1,074 and 1,237 kg ha⁻¹, confirming the production potential of the selected material under local growing conditions. Oil radish cultivar NS Bora produced 28,098 kg ha⁻¹ green biomass and 5,603 kg ha⁻¹ dry matter, with 16.60% crude protein in biomass and 36.8% seed oil. Castor bean cultivar Begej achieved an average seed yield of 2,213 kg ha⁻¹ in three-year trials, while recent testing on marginal soil showed oil contents of 48.44%, 50.91%, and 52.36% in Begej, Ibar, and Dunav, respectively. The developed cultivar assortment demonstrates that long-term breeding and conservation of alternative oilseed germplasm can directly contribute to production diversification, use of different sowing periods, and development of diverse cropping systems.

Keywords: alternative oilseed crops, breeding, cultivar selection, diversification, germplasm

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STANDARDIZACIJA I NOVE KARAKTERISTIKE U DUS ISPITIVANJU SUNCOKRETA

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Odsek za priznavanje sorti poljoprivrednog bilja Ministarstva poljoprivrede, šumarstva i vodoprivrede sprovodi postupak priznavanja sorti u skladu sa Zakonom o priznavanju sorti („Službeni glasnik RS“, br. 30/10), čime obezbeđuje da domaće i strane sorte budu upisane u Registar sorti tek nakon što ispune propisane kriterijume. Postupak obuhvata tri ključna testa: DUS (različitost, uniformnost i stabilnost), VCU (proizvodna i upotrebna vrednost) i proveru usklađenosti imena sa propisanim zakonima. Smernice za sprovođenje DUS ispitivanja izrađuje Međunarodna unija za zaštitu novih biljnih sorti (UPOV), dok Kancelarija Zajednice za biljne sorte (CPVO) donosi odgovarajuće tehničke protokole za primenu u Evropskoj uniji, koje primenjuju i zemlje kandidati. VCU testovi sprovode na osnovu pravilnika Ministarstva poljoprivrede, šumarstva i vodoprivrede. UPOV ima oko 250 test guidelines (TG) koje pokrivaju globalni spektar biljnih vrsta, dok CPVO trenutno ima oko 210 tehničkih protokola za različite biljne vrste. Cilj rada je uporedni prikaz najvažnijih izmena u DUS ispitivanju suncokreta uvedenih revizijom smernice UPOV TG/81/6 iz 2000. godine i usvajanjem nove verzije TG/81/7 u 2023. godini. Obe verzije smernica obuhvataju po 42 osobine, ali su revizijom uvedene nove, a pojedine postojeće osobine su izostavljene, redefinisane ili drugačije razvrstane. Izmene se odnose na osobine lista, cveta, stabla, glave i semena, kao i na proširenje skala ocenjivanja kod pojedinih kvantitativnih osobina. Nova verzija uvodi savremeniji sistem ocenjivanja zasnovan na BBCH skali za preciznije određivanje fenološke faze u kojoj se osobine ocenjuju, uz jasnije definisanje metode posmatranja i merenja (VG, VS, MG, MS). Navedene izmene doprinose ujedničenijem sprovođenju DUS ispitivanja, pouzdanijem razlikovanju genotipova, većoj preciznosti u priznavanju novih sorti, kao i međunarodnoj uporedivosti opisa sorti suncokreta.

Ključne reči: priznavanje sorti, DUS ispitivanje, UPOV smernice, BBCH skala, suncokret

STANDARDIZATION AND NEW CHARACTERISTICS IN SUNFLOWER DUS TESTING

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The Plant Variety Registration Department of the Ministry of Agriculture, Forestry and Water Management conducts the procedure of *registration of plant varieties* in accordance with the Law on the Registration of Plant Varieties ("Official Gazette of RS", No. 30/10). This ensures that both domestic and foreign varieties are entered into the Register of Varieties only after fulfilling the prescribed requirements. The procedure includes three key examinations: DUS test (Distinctness, Uniformity and Stability), VCU test (Value for Cultivation and Use), and verification of denomination compliance with the relevant legislation. Guidelines for conducting DUS examinations are prepared by the International Union for the Protection of New Varieties of Plants (UPOV), while the Community Plant Variety Office (CPVO) adopts the corresponding technical protocols for implementation within the European Union, which are also applied by candidate countries. VCU examinations are carried out on the basis of the Rulebook of the Ministry of Agriculture, Forestry and Water Management. UPOV has around 250 Test Guidelines (TG) covering a global spectrum of plant species, while CPVO currently has about 210 technical protocols for different plant species. The aim of this paper is to provide a comparative overview of the most important changes in sunflower DUS testing introduced by the revision of UPOV guideline TG/81/6 (2000) and the adoption of the new version TG/81/7 (2023). Both versions of the guidelines cover 42 characteristics, but the revision introduced new ones, while some existing characteristics were omitted, redefined, or reclassified. The changes relate to the characteristics of the leaf, flower, stem, head, and seed, as well as the expansion of scoring scales for certain quantitative traits. The new version introduces a modern evaluation system based on the BBCH scale for more precise determination of the phenological stage in which traits are assessed, along with clearer definitions of observation and measurement methods (VG, VS, MG, MS). These changes contribute to more harmonized implementation of DUS examinations, more reliable differentiation of genotypes, greater precision in the registration of new varieties, and improved international comparability of sunflower variety descriptions.

Keywords: registration of plant varieties, DUS examination, UPOV guidelines, BBCH scale, sunflower

DA LI OGRANIČEN BROJ MATERINSKIH STABALA DIVLJE KRUŠKE MOŽE OBEZBEDITI GENETIČKI VARIJABILNO POTOMSTVO?

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Divlja kruška (*Pyrus pyrastrer* (L.) Burgsd.) je retka šumska voćkarica, vredan genetički resurs i potencijalni izvor reproduktivnog materijala za potrebe pošumljavanja. Korišćenje reproduktivnog materijala nepoznatog ili neodgovarajućeg porekla može ugroziti genetički diverzitet prirodnih populacija. U registru Uprave za šume evidentirano je svega pet semenskih objekata divlje kruške poznatog porekla, pri čemu pojedine objekte čini samo jedno stablo. Ograničen broj dostupnih semenskih objekata otežava proizvodnju genetički raznovrsnog šumskog reproduktivnog materijala, neophodnog za očuvanje i održivo korišćenje genetičkih resursa divlje kruške. Cilj ovog istraživanja bio je da se proceni genetički diverzitet potomstva divlje kruške poreklom iz prirodne populacije. Plodovi su sakupljeni sa 15 materinskih stabala na Kosmaju radi izdvajanja semena. Nakon ručnog izdvajanja, seme je posejano u leju podeljenu na zasebna polja za svaku liniju polusrodника. Za molekularne analize iz svake linije polusrodника nasumično je odabrano po deset sadnica starosti 1+0, pri čemu je uspešno genotipizirano ukupno 148 sadnica. Genetički diverzitet procenjen je primenom deset polimorfnih jedarnih mikrosatelitskih lokusa. Utvrđen je visok nivo genetičkog diverziteta, sa prosečno 5,9 alela po lokusu, dobijenom heterozigotnošću od 0,836 i očekivanom heterozigotnošću od 0,703 u ukupnom uzorku. Nivo genetičkog diverziteta varirao je među linijama polusrodника, pri čemu se dobijena heterozigotnost kretala od 0,730 do 0,900, a očekivana od 0,666 do 0,733. Rezultati ukazuju da seme sakupljeno sa relativno ograničenog broja pažljivo odabranih materinskih stabala unutar prirodne populacije može obezbediti reproduktivni materijal sa visokim nivoom genetičkog diverziteta. Ovo naglašava značaj korišćenja pažljivo odabranih prirodnih izvora semena za očuvanje i održivo korišćenje genetičkih resursa divlje kruške.

Ključne reči: *Pyrus*, nSSR, genetički diverzitet, šumski reproduktivni materijal, genetički resursi

CAN A LIMITED NUMBER OF MATERNAL WILD PEAR TREES PROVIDE GENETICALLY DIVERSE OFFSPRING?

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Ključne reči: *Pyrus*, nSSR, genetički diverzitet, šumski reproduktivni materijal, genetički resursi

UTICAJ PRINOSA NA FITOHEMIJSKI PROFIL KUKURUZA ŠEĆERCA

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Kukuruz šećerac je široko zastupljen u ljudskoj ishrani, zbog čega je, pored njegovih agronomskih karakteristika, važno sagledati i njegov nutritivni kvalitet u obliku u kojem se najčešće konzumira. Cilj ovog istraživanja bio je da se tokom dve vegetacione sezone ispita povezanost prinosa svežeg zrna sa sadržajem fitohemikalija (karotenoidi, tokoferoli, tokotrienoli, slobodne fenolne kiseline, mono- i oligo- saharidi) četiri hibrida kukuruza šećerca, kao i uticaj termičke obrade na odabrana bioaktivna jedinjenja. Kod hibrida sa najvećim prinosom zabeležena je pozitivna korelacija sa sadržajem ukupnih karotenoida ($r=0,65$; $p\leq 0,05$), ukupnog vitamina E ($r=0,89$; $p\leq 0,05$), i α -tokoferola ($r=0,71$; $p\leq 0,05$), dok je negativna korelacija utvrđena sa sadržajem ukupnih fenolnih kiselina ($r=-0,82$; $p\leq 0,05$) i ferulinske kiseline ($r=-0,82$; $p\leq 0,05$). Kod hibrida sa najnižim dobijenim prinosom utvrđena je negativna korelacija sa sadržajem ukupnih šećera ($r=-0,89$; $p\leq 0,05$) i saharoze ($r=-0,77$; $p\leq 0,05$), kao i pozitivna korelacija sa sadržajem ukupnih fenolnih kiselina ($r=0,72$; $p\leq 0,05$). Međutim, kod pojedinih bioaktivnih jedinjenja, uprkos pozitivnoj povezanosti sa prinosom, tokom termičke obrade došlo je do statistički značajnog smanjenja njihovog sadržaja ($p\leq 0,05$), dok je kod drugih zabeleženo povećanje ($p\leq 0,05$). Dobijeni rezultati pokazuju da prinos i početni sadržaj fitohemikalija ne pružaju potpun uvid u nutritivnu vrednost proizvoda namenjenog potrošaču. Stoga je za sveobuhvatnu procenu fitohemijskog profila kukuruza šećerca neophodno povezati podatke iz poljskih oglada sa rezultatima laboratorijskih analiza, uključujući i promene koje nastaju tokom termičke obrade, jer integrisani pristup omogućava potpunije sagledavanje njegovog nutritivnog i funkcionalnog potencijala.

Ključne reči: genotipska varijabilnost, agroekološki faktori, rastvorljivi šećeri, antioksidativni potencijal, kvalitet zrna

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THE EFFECT OF YIELD ON THE PHYTOCHEMICAL PROFILE OF SWEET MAIZE

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Sweet maize is commonly used in the human diet, so it is critical to evaluate not only its agronomic properties but also its nutritional value in its most prevalent form. The study aimed to evaluate, during two growing seasons, the link between fresh grain yield and the phytochemical content (carotenoids, tocopherols, tocotrienols, free phenolic acid, mono- and oligo-saccharides) in four sweet maize hybrids, as well as the impact of thermal treatment on selected bioactive compounds. In the highest-yielding hybrid, positive correlations were recorded with total carotenoids ($r=0.65$; $p\leq 0.05$), total vitamin E ($r=0.89$; $p\leq 0.05$), and α -tocopherol ($r=0.71$; $p\leq 0.05$), while a negative correlations were established with total free phenolic acid ($r=-0.82$; $p\leq 0.05$) and free ferulic acid ($r=-0.82$; $p\leq 0.05$). In the lowest-yielding hybrid, negative correlations were observed with total sugars ($r=-0.89$; $p\leq 0.05$) and sucrose ($r=-0.77$; $p\leq 0.05$), while a positive correlation was recorded with total free phenolic acids ($r=0.72$; $p\leq 0.05$). However, despite a positive correlation with yield, thermal processing resulted in a statistically significant reduction in the content of some bioactive compounds ($p\leq 0.05$), whereas an increase was observed for others ($p\leq 0.05$). These results show that yield and initial phytochemical content do not provide a complete insight into the nutritional value of the product intended for consumers. Therefore, to assess the phytochemical profile of sweet maize comprehensively, field data must be combined with laboratory analyzes including changes occurring during thermal processing, as an integrated approach enables a more complete assessment of its nutritional and functional potential.

Keywords: genotypic variability, agroecological factors, soluble sugars, antioxidant potential, grain quality

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DUGOROČNI EFEKTI TRETMANA INSEKTICIDIMA NA KLIJAVOST SEMENA KUKURUZA

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Savremena dorada semena kukuruza podrazumeva obaveznu primenu fungicida radi zaštite u ranim fazama razvoja biljaka. Upotreba insekticida je sve više zastupljena zbog zahteva tržišta radi zaštite od napada zemljišnih insekata. Ipak njihova primena može negativno uticati na klijavost semena, pa je sprovedeno detaljnije ispitivanje. Cilj ovog rada bio je da se utvrdi dugoročni efekat insekticida (Fortenza i Force) koji su primenjeni u kombinaciji sa fungicidom Redigo-M, tokom 36 meseci čuvanja. Seme tri hibrida (ZP6263, ZP560 i ZP427) tretirano je navedenim fungicidno-insekticidnim kombinacijama i čuvano u skladišnim uslovima. Laboratorijska klijavost ispitivana je u intervalima od 6 meseci tokom trogodišnjeg perioda. Kao supstrat za naklijavanje korišćena je kombinacija zemlje i filter papira radi ublažavanja fitotoksičnog efekta insekticida na seme. Tokom prva 24 meseca, energija klijanja i klijavost su kod svih varijanti bile visoke i stabilne. Najveće razlike uočene su u periodu između 24. i 36. meseca skladištenja, gde je došla do izražaja jaka interakcija hibrida i tretmana. Hibridi ZP6263 i ZP427, pokazali su veliku stabilnost, zadržavajući klijavost od 80–82% nakon tri godine, bez obzira na tretman. Nasuprot tome, kod hibrida ZP560 zabeležen je oštar pad klijavosti nakon dve godine, pri čemu je kombinacija sa Redigo+Fortenza nakon 36 meseci dovela do značajnog smanjenja klijavosti na svega 32%, što je dvostruko niže u poređenju sa kontrolom tretiranom samo fungicidom (65%). Zaključuje se da se tretirano seme insekticidima može uspešno čuvati do 24 meseca, dok duže skladištenje preko ovog perioda nosi rizik koji direktno zavisi od osetljivosti genotipa i primenjene hemijske formulacije.

Ključne reči: kukuruz, klijavost semena, skladištenje, insekticidi

Zahvalnica: Ovo istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (broj ugovora: 451-03-33/2026-03/200040).

LONG - TERM EFFECTS OF INSECTICIDE TREATMENT ON GERMINATION OF MAIZE SEED

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Modern maize seed processing requires mandatory fungicide application for early-stage plant protection. Insecticide use is also rising due to market demands against soil pests. However, since their application can negatively impact seed germination, a detailed investigation was conducted. This study aimed to determine the long-term effects of insecticides (Fortenza and Force) combined with the fungicide Redigo-M over 36 months of storage. Seeds of three hybrids (ZP6263, ZP560, and ZP427) were treated and kept under warehouse conditions. Laboratory germination was tested at 6-month intervals. A combination of soil and filter paper was used as a substrate to mitigate insecticide phytotoxicity. During the first 24 months, germination energy and total germination remained high and stable across all variants. Significant differences emerged between the 24th and 36th months, revealing a strong hybrid-treatment interaction. Hybrids ZP6263 and ZP427 showed high stability, maintaining 80–82% germination after three years, regardless of treatment. Conversely, hybrid ZP560 exhibited a sharp decline after two years; the Redigo+Fortenza combination reduced germination to just 32% at 36 months, which was twice as low as the fungicide-only control (65%). In conclusion, insecticide-treated seed can be successfully stored for up to 24 months. Storage beyond this period carries risks directly dependent on genotype sensitivity and the specific chemical formulation.

Keywords: maize, germination, long-term storage, insecticides

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EVALUACIJA RAZLIČITIH GENOTIPOVA LUCERKE (*MEDICAGO SATIVA L.*) NA TOKSIČNO DEJSTVO ALUMINIJUMA KAO POTENCIJAL ZA PRIMENU U OPLEMENJIVANJU

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Toksičnost aluminijuma predstavlja značajno ograničenje proizvodnje lucerke na kiselim zemljištima, jer negativno utiče na rast i razvoj biljaka, biohemijski profil, kao i na usvajanje mineralnih elemenata. Genetička varijabilnost u odgovoru lucerke na prisustvo aluminijuma predstavlja osnovu za identifikaciju genotipova pogodnih za primenu u oplemenjivanju. Cilj istraživanja bio je evaluacija različitih genotipova lucerke u uslovima aluminijumskog stresa. Ogled je izveden u kontrolisanim uslovima, u hidroponskom sistemu. Biljke su tokom početnog perioda gajene u ½ Hoaglandovom hranljivom rastvoru pri pH 6, nakon čega je pH rastvora podešen na 4,5 i primenjen tretman sa 100 µM AlCl₃, uz odgovarajuću kontrolnu grupu bez aluminijuma. Nakon perioda izlaganja od dve nedelje, izvršena je evaluacija morfološkog i biohemijskog odgovora genotipova, kao i mineralnog sastava biljnog materijala. Morfometrijska analiza obuhvatila je dužinu korena, visinu biljke i svežu masu korena i nadzemnog dela. Od biohemijskih parametara određene su aktivnosti antioksidativnih enzima CAT, GPX, APX i SOD, aktivnost nitrata reduktaze (NR), kao i sadržaj MDA i prolina. Mineralni sastav biljnog materijala utvrđen je na osnovu sadržaja Al, Ca, Cu, Fe, Mg, Mn, K, Na, Zn i P. Analiza ispitivanih parametara ukazala je na kompleksan odgovor genotipova lucerke na prisustvo aluminijuma, koji je obuhvatao promene morfoloških i biohemijskih osobina, kao i mineralnog sastava biljaka. Korelacionom analizom sagledani su međusobni odnosi ispitivanih parametara kod genotipova izloženih toksičnom delovanju aluminijuma. Dobijeni rezultati ukazuju na značaj integrisanog pristupa u karakterizaciji genotipova i predstavljaju osnovu za identifikaciju osobina od potencijalnog značaja za selekciju genotipova lucerke prilagođenih uslovima kiselih zemljišta sa visokim sadržajem aluminijuma.

Ključne reči: lucerka, toksičnost aluminijuma, kiselost zemljišta, tolerantnost na stres

EVALUATION OF DIFFERENT ALFALFA (*MEDICAGO SATIVA L.*) GENOTYPES FOR ALUMINUM TOXICITY TOLERANCE AS A POTENTIAL FOR BREEDING

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Aluminum toxicity is a major limiting factor to alfalfa production on acidic soils, negatively affecting plant growth, biochemical profile, and mineral nutrient uptake. Genetic variability in alfalfa response to aluminum represents a basis for identifying genotypes suitable for breeding programs. The aim of this study was to evaluate different alfalfa genotypes under aluminum stress. The experiment was conducted in hydroponic system under controlled condition. Seedlings were initially grown in ½ Hoagland nutrient solution at pH 6.0, after which the pH was adjusted to 4.5 and treatment with 100 µM AlCl₃ was applied. After a period of two weeks of exposure, morphological and biochemical responses, as well as mineral composition, were evaluated. Morphometric analysis included root length, plant height, root fresh weight, and shoot fresh weight, while biochemical analysis included the activities of the enzymes CAT, GPX, APX, SOD, and NR, and MDA and proline contents. The mineral composition of the plant samples was assessed by determining Al, Ca, Cu, Fe, Mg, Mn, K, Na, Zn, and P contents. Analysis of all investigated parameters showed a complex genotype-dependent response to aluminum, which involved changes in morphological and biochemical traits as well as plant mineral composition. Correlation analysis was used to assess relations among the investigated parameters in genotypes exposed to aluminum stress. The obtained results indicate the importance of an integrated approach to genotype characterization under aluminum toxicity, and provide a foundation for identifying potentially important traits for alfalfa breeding on acidic soils with high aluminum availability.

Keywords: alfalfa, aluminum toxicity, acidic soils, stress tolerance

PROCENA EFIKASNOSTI BAKTERIJSKOG TRETMANA U SMANJENJU INTENZITETA PEPELNICE NA LISTOVIMA HRASTA KITNJAKA

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Hrast kitnjak (*Quercus petraea* (Matt.) Liebl.) je ekonomski i biološki važna autohtona vrsta hrasta evropskih šuma. Pepelnica hrastova predstavlja značajno oboljenje listova koje negativno utiče na rast i kvalitet sadnica, dovodeći do njihovog fiziološkog slabljenja. U Srbiji, najčešći prouzrokovatelj pepelnice hrastova je gljiva *Erysiphe alphitoides*. Mere zaštite najčešće podrazumevaju primenu fungicida, koji mogu štetno uticati na životnu sredinu i doprineti razvoju rezistentnosti patogena. U ovoj studiji je *ex situ* ispitivana efikasnost bakterijskog preparata na bazi pet bakterijskih sojeva u suzbijanju pepelnice na listovima kitnjaka. U Petri kutiji postavljeno je po četiri lista u tri ponavljanja. Eksperiment je obuhvatao šest tretmana u trajanju od 10 dana. Tretmani listova kitnjaka zaraženih pepelnicom su uključivali negativnu (zdravi listovi bez tretmana) i pozitivnu kontrolu (sumporni fungicid), rastvarač (10 mM MgSO₄) i bakterijski konzorcijum. Procenat površine listova sa pepelnicom je izmeren na početku i kraju ogleda, analizom skeniranih listova u programu ImageJ. Promena intenziteta pepelnice izračunata je kao razlika početne i krajnje vrednosti. Razlike između eksperimentalnih grupa su analizirane primenom Welch ANOVA i Games-Howell post hoc testa, a promene intenziteta pepelnice unutar svake grupe pomoću t-testa parova. Tretman bakterijskim konzorcijumom je statistički značajno ograničio povećanje površine lista zahvaćene pepelnicom u odnosu na negativnu kontrolu i tretman rastvaračem, dok razlika u odnosu na tretman fungicidom nije bila značajna. T-test parova je pokazao statistički značajne promene intenziteta pepelnice unutar svih tretmana tokom eksperimenta.

Dobijeni rezultati ukazuju na potencijal bakterijskog konzorcijuma u smanjenju intenziteta pepelnice na listovima kitnjaka i moguću primenu u biološkoj zaštiti.

Ključne reči: pepelnica, biokontrola, bakterije, *Quercus petraea*

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ASSESSMENT OF THE EFFICACY OF BACTERIAL TREATMENT IN REDUCING POWDERY MILDEW SEVERITY ON SESSILE OAK LEAVES

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Sessile oak (*Quercus petraea* (Matt.) Liebl.) is economically and biologically important native oak species in European forests. Oak powdery mildew is a significant foliar disease that negatively affects seedling growth and quality, causing physiological weakening. In Serbia, the most common causal agent of oak powdery mildew is fungus *Erysiphe alphitoides*. Control measures commonly involve fungicides, which may adversely affect the environment and contribute to the development of pathogen resistance. This study investigated the efficacy of a five-strain bacterial preparation in controlling powdery mildew on sessile oak leaves under ex situ conditions. Four leaves were placed in each Petri dish, with three replicates per treatment. The experiment included six treatments, and the treatments were applied over a period of 10 days. Treatments of powdery mildew-infected leaves included negative (untreated healthy leaves) and positive controls (sulfur fungicide), a solvent control (10 mM MgSO₄), and the bacterial consortium. The percentage of leaf area affected by powdery mildew was measured at the beginning and end of the experiment using ImageJ analysis of scanned leaves. Changes in powdery mildew intensity was calculated as the difference between initial and final values. Differences among experimental groups were analysed using Welch's ANOVA and the Games–Howell post hoc test, while within-group changes were analysed using a paired-samples t-test. The bacterial consortium significantly limited the increase in powdery mildew-affected leaf area, compared with the negative control and solvent treatment, while no significant difference was observed compared with the fungicide treatment. The paired-samples t-test showed significant changes in powdery mildew intensity within all treatments during the experiment. These results indicate the potential of the bacterial consortium for reducing powdery mildew intensity in sessile oak leaves and possible application in biological protection.

Keywords: powdery mildew, biocontrol, bacteria, *Quercus petraea*

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MULTILATERALNI SISTEM PRISTUPA I PODELE DOBROBITI U PRAKSI: KO KORISTI, KO DOPRINOSI I KAKO SE DELE DOBROBITI?

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Biljni genetički resursi za hranu i poljoprivredu ključni su za očuvanje agrobiodiverziteta, unapređenje oplemenjivanja novih sorti prilagođenih izazovima klimatski promena i potreba za povećanjem bezbednosti hrane. Uzajamna zavisnosti zemalja u korišćenju ovih resursa, podstakla je uspostavljanja Multilateralni sistem pristupa i podele dobrobiti (MLS), kao deo Međunarodnog ugovora o biljnim genetičkim resursima za hranu i poljoprivredu. Ovaj sistem predstavlja jedinstven okvir za olakšanu razmenu genetičkog materijala i pravednu raspodelu koristi nastalih njegovim korišćenjem. Cilj rada je prikaz principa funkcionisanja MLS-a i njegove primene u praksi, sa posebnim osvrtom na primenu ovog sistema u Srbiji, kao i na uloge različitih učesnika sistema – institucija koje čuvaju i daju genetički materijal, istraživača, oplemenjivača, poljoprivrednih proizvođača i drugih korisnika. Analizirani su osnovni mehanizmi sistema, uključujući pristup materijalu obuhvaćenom Aneksom I Međunarodnog ugovora, primenu Standardnog sporazuma o prenosu materijala (SMTA), kao i načine ostvarivanja novčanih i nenovčanih dobrobiti. MLS omogućava pristup biljnim genetičkim resursima za istraživanje, oplemenjivanje i obrazovanje, uz obavezu očuvanja njihove dostupnosti za buduće korisnike. Podela dobrobiti ostvaruje se kroz finansijske doprinose Fondu za podelu dobrobiti, ali i kroz razmenu informacija, dostupnost podataka o karakterizaciji i evaluaciji, transfer tehnologija, istraživačku saradnju i izgradnju kapaciteta. Praktična primena sistema pokazuje značaj povezivanja banaka gena, informacionih sistema i korisnika genetičkih resursa u cilju njihovog održivog korišćenja. Efikasnost Multilateralnog sistema zavisi od aktivnog učešća svih aktera – od očuvanja i dokumentovanja genetičkih resursa do njihove primene u stvaranju novih sorti i korisnika koji doprinose njegovom daljem unapređenju i održivom korišćenju.

Ključne reči: biljni genetički resursi, Međunarodni ugovor, multilateralni sistem, SMTA, podela dobrobiti

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THE MULTILATERAL SYSTEM OF ACCESS AND BENEFIT-SHARING IN PRACTICE: USERS, CONTRIBUTORS AND BENEFITS SHARED

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Plant genetic resources for food and agriculture are essential for conserving agrobiodiversity and for breeding of new crop varieties adapted to the challenges of climate change and the growing need for food security. The interdependence of countries in the use of these resources has led to the establishment of the Multilateral System of Access and Benefit-Sharing (MLS) under the International Treaty on Plant Genetic Resources for Food and Agriculture. This system provides a unique framework for facilitating access to plant genetic resources while ensuring the fair and equitable sharing of benefits arising from their use. The aim of this paper is to present the principles underlying the MLS and its practical implementation, with particular emphasis on its application in Serbia, as well as on the roles of different stakeholders involved, including institutions that conserve and distribute plant genetic resources, researchers, plant breeders, farmers, and other users. The paper reviews the key mechanisms of the system, including access to plant genetic resources listed in Annex I of the International Treaty, the application of the Standard Material Transfer Agreement (SMTA), and the mechanisms for monetary and non-monetary benefit-sharing. The MLS facilitates access to plant genetic resources for research, breeding, and training while ensuring their continued availability for future users. Benefit-sharing is achieved through financial contributions to the Benefit-sharing Fund, as well as through the exchange of information, access to characterization and evaluation data, technology transfer, scientific collaboration, and capacity building. Practical implementation of the system highlights the importance of linking gene banks, information systems, and users of plant genetic resources to promote their sustainable use. The effectiveness of the Multilateral System depends on the active participation of all stakeholders—from conserving and documenting plant genetic resources to their utilization in developing new varieties and the continued contribution of users to the improvement and sustainable operation of the system.

Keywords: plant genetic resources, International Treaty, Multilateral System, SMTA, benefit-sharing

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FENOTIPSE I BIOHEMIJSKE OSOBINE SEMENA PASULJA VEZANE ZA OTPORNOST PREMA PASULJEVOM ŽIŠKU

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Pasuljev žižak (*Acanthoscelides obtectus* Say) predstavlja najznačajniju i veoma opasnu štetočinu običnog pasulja u posle-žetvenom periodu. Štetočina može prouzrokovati i do 90% gubitka zrna, što predstavlja ozbiljnu pretnju po bezbednost hrane u određenim regionima, s obzirom na činjenicu da se pasulj smatra jednim od najvrednijih izvora proteina, vlakana i minerala u ishrani ljudi. Do sada je fumigacija bila najprihvatljivija metoda suzbijanja ove štetočine, ali zbog pojave rezistentnosti insekata na fumigante u pojedinim regionima, kao i zbog sve većih zahteva potrošača za "pesticide-free" hranom. Gajenje otpornih genotipova predstavlja jedan od najperspektivnijih pristupa u suzbijanju štetočina, iako ovaj pristup nije korišćen uslučaju ove vrste. Razvoj genotipova otpornih na insekte zahteva prethodnu identifikaciju i karakterizaciju biljnih svojstava koja uslovljavaju tu otpornost. Ova svojstva se trenutno istražuju u okviru projekta SafeSeed (#6691). Više od 50 genotipova pasulja različitog porekla analizirano je u pogledu fenotipskih svojstava (tvrdoća semena, boja, masa 1000 zrna, šara itd.) i hemijskog sastava (sadržaj nutrijenata, antioksidativni status, sadržaj fenolnih jedinjenja, aktivnost inhibitora proteinaza itd.). U ogledima „bez izbora“ (no-choice test) praćeni su produkcija potomstva i procenat konzumiranog zrna nakon perioda od 30 do 120 dana. Detaljna statistička analiza, koja objedinjuje sve dobijene rezultate, pruža informacije o razlikama u osetljivosti različitih genotipova pasulja prema ovoj štetočini i definiše svojstva od značaja. Sveukupni rezultati ukazuju na to da proučavana kolekcija običnog pasulja predstavlja dragocen izvor varijabilnosti za oplemenjivanje sa ciljem stvaranja sorti otpornih na pasuljevog žižka.

Ključne reči: štetočine semena, *Acanthoscelides obtectus*, tvrdoća semena, nutritivne osobine semena, otpornost

Zahvalnica: Istraživanje je sprovedeno uz podršku Fonda za nauku R. Srbije, (#6691), New biorational methods for stored seed pest control and protection: To serve and prevent - SafeSeed.

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PHENOTYPIC AND BIOCHEMICAL TRATS OF COMMOM BEAN ASSOCIATED WITH SEED RESISTANCE TO BEAN BEETLE

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Bean beetle (*Acanthoscelides obtectus* Say) is the most significant and very harmful pest of common bean in post-harvest period. Infestations can result in up to 90% of seed losses, posing a significant threat to food security in affected regions, especially because bean is considered one of the most valuable source of proteins, fibers and minerals in human consumption. So far, fumigation has been the most viable option for this pest's control, but due to occurrence of insect tolerance to fumigants in some regions, and rising consumers' demands for pesticide-free food, the exploitation of inherently resistant genotypes is one of the most promising pest management approaches, that hasn't yet been exploited in the case of this pest. The development of insect-resistant genotypes requires prior identification and characterization of the plant traits underlying the resistance. These traits are currently being explored within the SafeSeed project (#6691). Over 50 bean accessions, of different origin, are analyzed for phenotypic traits (seed hardness, color, 1000 seed weight, pattern etc.), and chemical composition (nutrient content, antioxidative status, phenolic compounds content, activity of proteinase inhibitors etc.). In "no-choice" test, we monitored beetle progeny production, and % of consumes seeds after 30-120 days. Detailed statistical analysis that combines all sets of results gives the information about difference in bean susceptibility to the bean beetle, across genotypes, and defines the traits of interest. Overall results indicate that studied common bean collection represent a valuable source of variation towards breeding for resistance to bean beetle.

Keywords: Stored product pests, *Acanthoscelides obtectus*, seed hardness, seed nutritieve traits, resistance

Acknowledgement: This research was supported by the Science Fund of the Republic of Serbia, #6691, New biorational methods for stored seed pest control and protection: To serve and prevent - SafeSeed.

POVRATAK STARIH SORTI NA TRŽIŠTE – PRIMER SLOVENIJE

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Postupak reintrodukcije autohtonih sorti voća, povrća i žitarica tradicionalno zastupljenih u ruralnim krajevima na tržište Slovenije predstavlja važan deo očuvanja biodiverziteta i kulturne baštine. Podstičući identifikaciju, zaštitu, i gajenje tradicionalnih i autohtonih sorti, čuvaju se genetički resursi prilagođeni specifičnim klimatskim i zemljišnim uslovima Slovenije, i održava gastronomska i kulturna raznolikost. Definisani zakonski okviri štite genetičke izvore i omogućavaju registrovanje i promociju starih sorti kao deo kulturne i biološke baštine. U Sloveniji je pokrenuto više projekata i inicijativa koje podržavaju vraćanje u proizvodnju i očuvanje starih sorti, uključujući saradnju između poljoprivrednika, naučnih institucija i nevladinih organizacija. Finansijskim podsticajima obezbeđenim kroz projekat EU CAP 2023-2027. predviđeno je preko 80 mera kojima se podstiče očuvanje biodiverziteta, pravilno upravljanje vodama i zemljištem, i ublažavanje efekata klimatskih promena. Mere, između ostalog, podstiču i gajenje autohtonih sorti, sertifikaciju, edukaciju poljoprivrednika, i promociju lokalnih proizvoda na tržištu. Sistem podrazumeva upisivanje starih sorti u registre i baze podataka, što omogućava realizaciju semenske proizvodnje, praćenje obima proizvodnje i zaštitu autohtonih genetičkih izvora. Na taj način, Slovenija želi da očuva svoju genetičku raznolikost i podstakne održivu poljoprivredu prilagođenu lokalnim uslovima.

Ključne reči: genetički resursi, autohtone sorte, održiva poljoprivreda

Zahvalnica: Ovo istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije u okviru projekta br. 451-03-33/2026-03/200040, i projekta Centra za promociju nauke 1377/24 koji se realizuju u Institutu za kukuruz „Zemun Polje“ Studija je usklađena sa Agendom Ujedinjenih nacija za održivi razvoj do 2030. godine i doprinosi ostvarivanju njenih Ciljeva održivog razvoja (CDG), posebno onih koji se odnose na održivu poljoprivredu, klimatske promene i odgovorno upravljanje prirodnim resursima.

THE REINTRODUCTION OF OLD VARIETIES TO THE MARKET - A SLOVENIAN EXAMPLE

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The process of reintroduction of autochthonous varieties of fruits, vegetables and cereals traditionally represented in rural areas to the Slovenian market is an important part of preserving biodiversity and cultural heritage. By encouraging the identification, protection, and cultivation of traditional and autochthonous varieties, genetic resources adapted to the specific climatic and soil conditions of Slovenia are preserved, and gastronomic and cultural diversity is maintained. Defined legal frameworks protect genetic resources and enable the registration and promotion of old varieties as part of cultural and biological heritage. Several projects and initiatives have been launched in Slovenia to support the return to production and preservation of old varieties, including cooperation between farmers, scientific institutions and non-governmental organizations. The financial incentives provided through the EU CAP 2023-2027 project envisage over 80 interventions that encourage the preservation of biodiversity, proper management of water and soil, and mitigation of the effects of climate change. The interventions, among other things, encourage the cultivation of autochthonous varieties, certification, education of farmers, and promotion of local products on the market. The system includes the registration of old varieties in registers and databases, which enables the implementation of seed production, the monitoring of production volume and the protection of autochthonous genetic resources. In this way, Slovenia wants to preserve its genetic diversity and encourage sustainable agriculture adapted to local conditions.

Key words: genetic resources, autochthonous varieties, sustainable agriculture

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FUNDAMENTALNI MEHANIZMI STARENJA SEMENA U KONTEKSTU TEHNOLOGIJE PLASMA FUSION

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Savremene diskusije o starenju semena često su usredsređene na sekundarne procese, kao što su „inflammaging“ ili nakupljanje ćelijskog „otpada“. Međutim, metodološki ispravan pristup podrazumeva razdvajanje simptomatike od primarnog uzroka. Kako bismo isključili uticaj načina i uslove čuvanja semena različitih ratarskih i povrtarskih kultura razmatramo modelsku grupu (seme starosti od 1 do 3 godine koje se čuvaju u optimalnim uslovima – model semena heljde i ječma). U takvim okvirima starenje se ne posmatra kao linearan proces, već kao sistemski poremećaj-kolaps epigenetičkog utišavanja (epigenetic silencing). Ključni pojam u ovom kontekstu jeste Critical Point of Aging (CPA) — kritična tačka starenja, odnosno fazni prelaz nakon kojeg mehanizmi samoregulacije semena gube stabilnost. U osnovi ovog procesa nalazi se indeks epigenetičke destabilizacije, koji obuhvata aktivaciju retrotranspozona, „drift“ metilacije i porast transkripcionog šuma. U ovoj modelskoj koncepciji, primarni i sekundarni metaboliti semena predstavljaju samo posledicu gubitka epigenetičke kontrole, a ne njegov inicijalni uzrok. Tehnologija Plasma Fusion usmerena je upravo na delovanje na ovaj fundamentalni okidač, što omogućava prelazak sa borbe protiv simptoma na upravljenje biološkom trajektorijom. Projekat plazma fuzije ima za cilj razvoj i komercijalizaciju poljoprivrednog i biomedicinskog hardverskog i softverskog sistema zasnovanog na niskotemperaturnoj lučnoj plazmi kako bi se uništili patogeni na površini semena i povećala njihova biološka vrednost i biološka aktivnost, omogućavajući proizvodnom ciklusu da dostigne genetski potencijal rodnosti. Projekat realizujemo sa kolegama iz Rusije, a u okviru start up tima Plasma Fusion. Naučno-tehnološki park u Nišu i laboratorija za bioinformacione sisteme i nano tehnologije Poljoprivrednog fakulteta Univerziteta u Beogradu su mesta izrade inovativnog proizvoda-uređaja i verifikacije rezultata najnovije tehnologije u svetu.

Ključne reči: starenje semena, heljda, ječam, tehnologija hladne plazme, Plasma Fusion

Zahvalnica: Rad je nastao kao rezultat projekta Start up tima (2025-2027): “Plasma Fusion” i Ministarstva nauke, tehnološkog razvoja i inovacija finansiranjem naučnois-traživačkog rada u 2026. godini za Poljoprivredni fakultet 451-03-34/2026-03/200116.

FUNDAMENTAL MECHANISMS OF SEED AGING IN THE CONTEXT OF PLASMA FUSION TECHNOLOGY

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Contemporary discussions of seed aging often focus on secondary processes, such as inflammation or the accumulation of cellular “waste.” However, a methodologically sound approach involves separating the symptoms from the primary cause. In order to exclude the influence of the method and conditions of preservation and storage of seeds of various field and vegetable crops, we consider a model group (seeds aged from 3 months to 1 year stored in optimal conditions - a model of buckwheat and barley seeds). In such frameworks, aging is not viewed as a linear process, but as a systemic disorder - the collapse of epigenetic silencing. The key term in this context is the critical point of aging (CPA) - a phase transition after which the self-regulatory mechanisms of the seed lose stability. At the heart of this process is an index of epigenetic destabilization, which includes retrotransposon activation, methylation drift, and increased transcriptional „noise“. In this model conception, the primary and secondary metabolites of the seed represent only the consequence of the loss of epigenetic control and not its initial cause. Plasma Fusion technology is aimed precisely at acting on this fundamental trigger, which enables the transition from combating symptoms to managing the biological trajectory. The Plasma Fusion Project aims to develop and commercialize an agricultural and biomedical hardware and software system based on low-temperature arc plasma to destroy pathogens on the surface of seeds and increase their biological value and biological activity, allowing the production cycle to reach the genetic potential of yield. We are implementing the project with colleagues from Russia, as part of the Plasma Fusion startup team. The Science and Technology Park in Niš and the Laboratory for Bioinformation Systems and Nanotechnology of the Faculty of Agriculture, University of Belgrade are the places where the innovative product-device is created and the results of the latest technology in the world are verified.

Keywords: aging of seeds, buckwheat, barley, cold plasma technology, Plasma Fusion

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POSTER PREZENTACIJE

POSTER PRESENTATIONS

POTENCIJAL EX-PVP GERMPLAZME KUKURUZA ZA OPLEMENJIVANJE U KLIMATSKIM USLOVIMA SRBIJE

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Ex-PVP (*Plant Variety Protection*) germplazma kukuruza je izvor gena za proširenje genetičke osnove oplemenjivačkih kolekcija. Međutim, genetsko poreklo i karakteristike linija nisu dovoljan pokazatelj pogodnosti u različitim agroekološkim uslovima. Testiranje ex-PVP linija kroz ukrštanja sa elitnim linijama različite heterotične osnove omogućava procenu njihove adaptiranosti i oplemenjivačke vrednosti, radi izdvajanja materijala visoke adaptabilnosti, dobrih kombinacionih sposobnosti i agronomskih osobina *per se* za nacionalne oplemenjivačke programe kukuruza. Cilj je bio ispitati prinos i agronomске performanse hibrida dobijenih ukrštanjem 17 ex-PVP inbred linija sa dva testera suprotnih heterotičnih osnova: *Lancaster* (ZPL-155/18-4/1 × L325/75-2) i *BSSS* (L75B106), i odaberu najbolje linije za formiranje početnih populacija za selekciju i razvoj novih inbred linija prilagođenih uslovima Srbije. Ogled je izveden na četiri lokacije u jednoj vegetacionoj sezoni, u dva ponavljanja, uz sedam hibrida: ZP4744, ZP4790, ZP5550, KWS Kašmir, KWS Smaragd, DKC5092 i P0217. ZP4790 je korišćen kao referentni standard. Analiza varijanse pokazala je značajan uticaj lokacije i hibridne kombinacije na prinos zrna, dok interakcija lokacija × hibrid nije bila značajna. Prosečan prinos bio je 8,610 t ha⁻¹. Najprinosnije kombinacije bile su L75B106 × PH1W0 (9,682 t ha⁻¹; vlažnost zrna 10,2%), L75B106 × PH1MR (9,390 t ha⁻¹; 9,7%) i L75B106 × PH1CP (9,157 t ha⁻¹; 10,1%), koje su ostvarile 107,9%, 104,7% i 102,1% prinosa u odnosu na standard ZP4790 (8,970 t ha⁻¹; 10,4%), respektivno. Rezultati ukazuju da sistematsko ispitivanje ex-PVP germplazme u lokalnim agroekološkim uslovima može identifikovati genotipove odgovarajuće adaptiranosti i oplemenjivačkog potencijala kao vredan početni materijal za selekciju novih inbred linija i hibrida prilagođenih uslovima Srbije.

Ključne reči: kukuruz, ex-PVP germplazma, genetska varijabilnost, adaptacija, oplemenjivanje

Zahvalnica: Istraživanja su potpomognuta institucionalnim projektom Instituta za kukuruz „Zemun Polje“, evidencioni broj 451-03-33/2026-03/200040, finansiranog od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije. Istraživanja su u saglasnosti sa Ciljevima održivog razvoja Ujedinjenih nacija, Cilj 15 (život na zemlji).

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POTENTIAL OF EX-PVP MAIZE GERMPLASM FOR BREEDING UNDER SERBIAN CLIMATIC CONDITIONS

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Ex-PVP (*Plant Variety Protection*) maize germplasm is a source of genes for broadening the genetic base of breeding working collections. However, genetic background and characteristics of lines do not indicate their suitability under different agroecological conditions. Evaluation of ex-PVP lines through crosses with elite lines of different heterotic backgrounds enables assessment of their adaptation and breeding value for national maize breeding programs. The aim was to evaluate grain yield and agronomic performance of hybrids obtained by crossing 17 ex-PVP inbred lines with two testers representing opposite heterotic backgrounds: *Lancaster* (ZPL-155/18-4/1 × L325/75-2) and *BSSS* (L75B106), and identify the best lines for forming base populations for selection and development of new inbred lines adapted to Serbian conditions. The trial was conducted at four locations in one growing season, with two replications, and included seven commercial hybrids: ZP4744, ZP4790, ZP5550, KWS Kashmir, KWS Smaragd, DKC5092 and P0217. ZP4790 was the reference standard. Analysis of variance showed significant effects of location and hybrid combination on grain yield, whereas the location × hybrid interaction was not significant. Mean yield was 8.610 t ha⁻¹. The highest yielding combinations were L75B106 × PH1W0 (9.682 t ha⁻¹; grain moisture 10.2%), L75B106 × PH1MR (9.390 t ha⁻¹; 9.7%) and L75B106 × PH1CP (9.157 t ha⁻¹; 10.1%), achieving 107.9%, 104.7% and 102.1% of the ZP4790 standard yield (8.970 t ha⁻¹; 10.4%), respectively. Systematic evaluation of ex-PVP germplasm under local agroecological conditions can identify genotypes with adaptation and breeding potential for developing new inbred lines and hybrids adapted to Serbian conditions.

Keywords: maize, ex-PVP germplasm, genetic variability, adaptation, breeding

Acknowledgement: The research was supported by the Institutional Project of the Maize Research Institute Zemun Polje, registration number 451-03-33/2026-03/200040, funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia. The research is aligned with the United Nations Sustainable Development Goals, specifically Goal 15 (Life on Land).

SPOSOBNOST OPORAVKA SEMENA LANIKA (CAMELINA SATIVA) NAKON RANOG OSMOTSKOG STRESA

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Lanik (*Camelina sativa* (L.) Crantz) je perspektivna uljarica koja se odlikuje prilagodljivošću različitim uslovima gajenja, ali nedostatak vode tokom klijanja može ograničiti početni razvoj biljaka. Sposobnost semena da se oporavi i nastavi klijanje nakon ponovnog uspostavljanja povoljnih uslova predstavlja važan pokazatelj njegove tolerantnosti na sušu. Cilj ovog istraživanja je bio da se ispita odgovor semena lanika, sorte NS Slatka, na osmotski stres i proceni stepen oporavka nakon ponovnog uspostavljanja povoljnih uslova. Sušni uslovi simulirani su primenom polietilen glikola (PEG 6000) pri osmotskom potencijalu od -0,6 MPa, na temperaturi od 20/30°C. Seme je tokom 6 dana bilo izloženo stresnim uslovima, nakon čega je prebačeno u destilovanu vodu tokom narednih 6 dana radi praćenja oporavka, kada je izvršena i ocena klijavosti. Poređena su tri tretmana: kontrola (voda - voda), kontinuirani osmotski stres (PEG - PEG) i tretman oporavka (PEG - voda). Kontrolni tretman pokazao je visoku i ujednačenu klijavost (96,4%), potvrđujući visok kvalitet ispitivanog semena. Izlaganje PEG-u dovelo je do smanjenja klijavosti nakon 6 dana na 65,4%, što ukazuje na usporavanje procesa usled ograničenog usvajanja vode. Nakon prenosa semena u vodu, 85% semena koje prethodno nije proklijalo nastavilo je razvoj, dok je konačna klijavost bila 94,8%. Produženo izlaganje PEG-u nije dovelo do značajnog povećanja klijavosti (68,6%). Dobijeni rezultati sugerišu da osmotski stres pre svega odlaže klijanje, dok nakon njegovog prestanka seme zadržava visoku sposobnost da nastavi klijanje. Testovi oporavka mogu predstavljati dopunski pristup proceni kvaliteta semena i odgovora genotipova na kratkotrajni deficit vode.

Ključne reči: *Camelina sativa*, suša, vitalnost semena, osmotski potencijal

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RECOVERY OF CAMELINA SATIVA SEEDS FOLLOWING EARLY OSMOTIC STRESS

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Camelina sativa (L.) Crantz is a promising oilseed crop that can adapt to different growing conditions. However, a lack of water during germination may limit early plant development. The ability of seeds to recover and continue germination after the stress is removed is an important indicator of their drought tolerance. This study aimed to investigate the response of camelina seed (variety NS Slatka) to osmotic stress and evaluate their recovery potential after restoration of favorable conditions. Drought conditions were simulated using polyethylene glycol (PEG 6000) at an osmotic potential of -0.6 MPa and temperatures of $20/30^{\circ}\text{C}$. Seeds were exposed to stress for 6 days and then transferred to distilled water for another 6 days to monitor recovery and assess germination. Three treatments were compared: control (water–water), continuous osmotic stress (PEG–PEG), and recovery treatment (PEG–water). The control treatment showed high and uniform germination (96.4%), confirming the high quality of the tested seed material. Exposure to PEG reduced germination after 6 days to 65.4%, indicating delayed germination due to limited water uptake. After the seeds were transferred to water, 85% of the previously non-germinated seeds continued to develop, while final germination reached 94.8%. Prolonged exposure to PEG did not significantly increase germination (68.6%). Results suggest that osmotic stress mainly delayed germination, while seeds retained a high recovery capacity to resume germination after stress removal. Recovery tests may contribute assess seed quality and genotype responses to short-term water deficit.

Keywords: *Camelina sativa*, drought, seed viability, germination recovery, osmotic potential

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PROCENA PRISUSTVA TOKSIGENIH GLJIVA U PROIZVODIMA NA BAZI ŽITARICA U SRBIJI

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U cilju procene prisustva toksigenih vrsta gljiva u proizvodima na bazi žitarica, izvršena je analiza 25 uzoraka sakupljenih u prodavnicama zdrave hrane. Ispitivanjem su obuhvaćeni različiti prehrambeni proizvodi (ovsene, kukuruzne, integralne kukuruzne, ječmene i ražane pahuljice), zrna pšenice, durum pšenice, ovasa, raži i heljde kao i integralni pirinač, proso, sočivo. Nakon površinske sterilizacije uzoraka rastvorom natrijum-hipohlorita, zrna su postavljena na KDA (Krompir dekstrozni agar) podlogu (10 zrna po Petrijevoj kutiji) i inkubirana sedam dana pri temperaturi od 25°C. Identifikacija izolovanih gljiva izvršena je na osnovu morfoloških karakteristika prema standardizovanim metodama. Identifikovane su gljive iz rodova *Fusarium*, *Alternaria* i *Aspergillus*. Najveću učestalost u ispitivanim uzorcima imale su vrste roda *Alternaria* (do 68%) i roda *Aspergillus* (do 75%). U okviru ovih rodova najčešće identifikovane vrste su *Aspergillus flavus* (prosečno 21,5%), *Fusarium verticillioides* (prosečno 16%) i *Aspergillus niger* (prosečno 10%). Najveći procenat zastupljenosti vrsta roda *Alternaria* zabeležen je na semenu pšenice (80%), dok je *A. flavus* najčešće izolovana vrsta iz kukuruznih pahuljica (85%). Dobijeni rezultati ukazuju da proizvodi na bazi žitarica mogu biti kontaminirani toksigenim vrstama gljiva koje imaju sposobnost da sintetišu mikotoksine, uključujući fumonizine, trihotecene i aflatoksine B₁ i B₂, što može predstavljati rizik po bezbednost hrane i zdravlja ljudi i životinja.

Ključne reči: mikotoksini, žitarice, *Fusarium*, *Aspergillus*, *Alternaria*

Zahvalnica: Ovo istraživanje je finansirano od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor br. 451-03-33/2026-03/200040; Ciljevi održivog razvoja – *zero hunger, climate action, life on land*).

OCCURRENCE OF TOXIGENIC FUNGI IN CEREAL-BASED PRODUCTS IN SERBIA

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In order to evaluate the occurrence of toxigenic species of fungi in cereal-based products, the analysis of 25 samples collected in health food stores was performed. The examination included various food products (oats, corn, whole corn, barley and rye flakes), grains of wheat, durum wheat, oats, rye and buckwheat, as well as whole grain rice, millet, lentils. Sample sterilization was performed using a sodium hypochlorite solution, after which the grains were placed on PDA (potato dextrose agar) medium (10 grains per Petri dish) and incubated for seven days at 25°C. The isolated fungi were identified based on morphological characteristics, following standardized methods. Fungi from the genera *Fusarium*, *Alternaria* and *Aspergillus* were identified. The species of the genus *Alternaria* (up to 68%) and the genus *Aspergillus* (up to 75%) had the highest frequency in the tested samples. Within these genera, the most frequently identified species are *Aspergillus flavus* (on average 21.5%), *Fusarium verticillioides* (on average 16%) and *Aspergillus niger* (on average 10%). The highest percentage of species of the genus *Alternaria* was recorded on wheat seeds (80%), while *A. flavus* was the most frequently isolated species from corn flakes (85%). The obtained results indicate that cereal-based products may be contaminated with toxigenic fungal species that have the ability to synthesize mycotoxins, including fumonisins, trichothecenes and aflatoxins B₁ and B₂, which may pose a risk to food safety and human and animal health.

Keywords: mycotoxins, cereals, *Fusarium*, *Aspergillus*, *Alternaria*

Acknowledgments: This study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040; Sustainable Development Goals—zero hunger, climate action, life on land).

EVALUACIJA AGRO-MORFOLOŠKE PERFORMANSE I GENETIČKE UNIFORMNOSTI INBRED LINIJA KUKURUZA U RAZLIČITIM USLOVIMA GAJENJA

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Inbred linije kukuruza se odlikuju izraženom osetljivošću na faktore spoljašnje sredine, te je poznavanje njihove performanse *per se* u određenom arealu gajenja neophodno. Pored fenotipske evaluacije, provera genetičke uniformnosti je ključna, jer isključivo visoko homozigotne linije mogu biti komponente komercijalnih hibrida. Evaluiran je set od 15 inbred linija (G1–G15) Instituta za kukuruz „Zemun Polje“, grupe zrenja FAO 300–700, kroz trogodišnji poljski ogled po kompletno randomiziranom blok dizajnu (RCBD) u uslovima polja. Agro-morfološka karakterizacija obuhvatila je 32 osobine prema UPOV deskriptoru, dok je fenotipska uniformnost procenjena na osnovu vizuelnih ocena biljaka (tj. prisustvo atipičnih biljaka - off tipova). Za ispitivanje genetičke uniformnosti primenjeno je ultra-tankoslojno izoelektrično fokusiranje (UTLIEF) rezervnih proteina (albumina i prolamina) i osam SSR markera preporučenih od strane ISTA za verifikaciju genotipova kukuruza. Za većinu osobina, četvorofaktorska analiza varijanse (ANOVA) je pokazala statistički značajan uticaj ispitivanih faktora (genotip, godina, gustina, rok setve i njihove interakcije). Analizom glavnih komponentata (PCA) utvrđeno je da su osobine rasta biljke, metlice i zrna najdiskriminativnije u proceni varijabilnosti linija za faktore genotip i godina. Po rokovima setve (R1 i R2), AMMI modelom je utvrđen značajan uticaj svih izvora variranja i njihovih interakcija na prinos zrna ($p < 0,01$). Linije G5, G6, G8 i G12 izdvojile su se stabilnošću i nadprosečnim prinosom, te se smatraju pogodnim za gajenje u širem agroekološkom arealu. Morfološka odstupanja kod linija G1 i G2 potvrđena su biohemijskim i SSR markerima. Pored upotrebe za verifikaciju sortnosti kukuruza, sposobnost prajmera *phi102228* i *umc1545* da detektuju nespecifične trake u atipičnim biljkama tj. off-tipovima pravdava njihovu preporuku za preciznu i vremenski efikasnu procenu genetičke uniformnosti inbred linija.

Ključne reči: agrotehničke mere, genetički markeri, stabilnost prinosa, *Zea mays* L.

Zahvalnica: Ovo istraživanje je finansirano od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor br. 451-03-33/2026-03/200040; Ciljevi održivog razvoja – *zero hunger, climate action, life on land*).

EVALUATION OF AGRO-MORPHOLOGICAL PERFORMANCE AND GENETIC UNIFORMITY OF MIZE INBRED LINES UNDER VARYING GROWTH CONDITIONS

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Maize inbred lines exhibit pronounced sensitivity to environmental factors, making knowledge of their *per se* performance within specific cultivation areas essential. Besides phenotypic evaluation, verifying genetic uniformity is crucial, since only highly homozygous lines serve as commercial hybrid components. A set of 15 inbred lines (G1–G15) developed at the Maize Research Institute Zemun Polje (FAO 300–700) was evaluated through a three-year field trial according to randomised complete block design (RCBD). Agro-morphological characterization encompassed 32 traits according to the UPOV descriptor, while the evaluation of phenotypic uniformity was done based on visual assessments of the plants (i.e., the presence of atypical plants - off-types). To examine genetic uniformity, ultra-thin layer isoelectric focusing (UTLIEF) of storage proteins (albumins and prolamins) and eight SSR markers recommended by ISTA for maize genotype verification were applied. Four-way ANOVA showed a statistically significant effect of the studied factors (genotype, year, density, sowing date, and their interactions) on most analyzed traits. PCA revealed that plant growth, tassel, and kernel traits were the most discriminative in assessing line variability under the influence of genotype and year. The AMMI model by sowing dates (R1 and R2) established a significant effect of all sources of variation and their interactions on grain yield ($p < 0.01$). Lines G5, G6, G8, and G12 stood out due to their stability and above-average yield, and can be considered suitable for growing in a wider agro-ecological area. Morphological deviations in lines G1 and G2 were confirmed by biochemical and SSR markers. In addition to their application in maize variety verification, the ability of primers *phi102228* and *umc1545* to detect non-specific bands in atypical plants (i.e., off-types) justifies their recommendation for a precise and more time-efficient assessment of inbred line genetic uniformity.

Keywords: agrotechnical practices, genetic markers, *Zea mays* L., yield stability

Acknowledgments: This study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040; Sustainable Development Goals—zero hunger, climate action, life on land).

INTEGRACIJA GENOMIKE, FENOMIKE I OPLEMENJIVANJA U STVARANJU PŠENICE OTPORNE NA KLIMATSKE PROMENE

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Ubrzavanje klimatskih promena povećava učestalost i intenzitet različitih stresnih faktora koji utiču na proizvodnju pšenice, uključujući toplotne talase, nepravilan raspored padavina, sušu i sve veći pritisak bolesti. Istovremena pojava više stresova predstavlja veliki izazov za konvencionalno oplemenjivanje, koje je uglavnom bilo usmereno na poboljšanje tolerantnosti na pojedinačne stresove. Reakcije pšenice na kombinovane stresove često nisu aditivne i u velikoj meri zavise od osnovnog fiziološkog stanja biljke, oblikovanog istovremenim delovanjem više faktora sredine. Zbog toga se osobine i genetičke determinante otpornosti na više stresova (OVS) mogu značajno razlikovati od onih utvrđenih za pojedinačne stresove, kako po prirodi tako i po relativnom značaju. U tom kontekstu, budući programi oplemenjivanja pšenice moraju primenjivati integrisane strategije koje eksplicitno uzimaju u obzir interakcije genotip × sredina (G×E) u uslovima višestrukih stresova. Napredni pristupi envirotipizacije od ključnog su značaja za povećanje preciznosti genetičkih analiza i modela genomske predikcije. Identifikacija regulatornih gena i fenotipskih osobina koje određuju plastičnost na stres i opštu OVS predstavlja važnu mogućnost za povećanje stabilnosti prinosa u sve promenljivijim uslovima sredine. Obećavajući pravci oplemenjivanja uključuju primenu visokoprotočnih tehnologija genotipizacije, selekcije pomoću markera i genomske selekcije, kao i novih platformi za fenotipizaciju. Lokalno prilagođeni genotipovi predstavljaju vredne izvore adaptivnih alela, čija identifikacija i plansko kombinovanje sa široko adaptiranim genetičkim osnovama može značajno povećati otpornost na promene sredine. Uključivanje poljoprivrednika i lokalnih aktera kroz participativnu selekciju dodatno će doprineti razvoju i primeni sorti pšenice otpornih na klimatske promene.

Ključne reči: klimatske promene, oplemenjivanje pšenice, otpornost na više stresova, genomska selekcija, lokalna adaptacija

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INTEGRETING GENOMICS, FENOMICS AND BREEDING FOR CLIMATE-RESILIENT WHEAT

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Accelerating climate change intensifies the frequency and severity of stresses affecting wheat production, including heat waves, irregular precipitation, drought, and rising disease pressure. The increasing co-occurrence of these stresses poses a major challenge to conventional breeding that has largely focused on single-stress tolerance improvement. Wheat responses to combined stresses are often non-additive and strongly dependent on the plant's basal physiological status, shaped by multiple concurrent environmental factors. Consequently, the traits and genetic determinants conferring multi-stress resilience (MSR) may differ substantially from those identified for individual stresses, both in their nature and in relative importance. In this context, future wheat breeding efforts must adopt integrated strategies that explicitly account for genotype $\times$ environment (G $\times$ E) interactions under multi-stress conditions. Advanced envirotyping approaches are essential for improving the accuracy of genetic analyses and genomic prediction models. Identifying upstream regulatory genes and phenotypic traits underlying stress plasticity and general MSR responses represents a key opportunity to enhance yield stability under increasingly variable environments. Promising breeding directions include the integration of high-throughput genotyping technologies, marker-assisted and genomic selection, and novel phenotyping platforms to support predictive crossing strategies. Location-specific pre-breeding and breeding approaches, supported by modeling and machine-learning tools, are critical for tailoring MSR to diverse pedoclimatic conditions. Locally adapted genotypes represent valuable reservoirs of adaptive alleles, whose identification and strategic stacking into broadly adapted backgrounds may significantly improve environmental resilience. Active involvement of farmers and local stakeholders through participatory selection will further facilitate the development and adoption of wheat cultivars resilient to climate change.

Keywords: climate change, wheat breeding, multi-stress resilience, genomic selection, local adaptation

ODNOS FITINSKOG I NEORGANSKOG FOSFORA U ZRNU HIBRIDA KUKURUZA ŠEĆERCA GAJENOM U ODRŽIVOM SISTEMU

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Za poboljšanje hemijskog sastava zrna kukuruza primena pokrovnih useva (PU) i mikrobioloških đubriva (MF) predstavlja važnu agrotehničku meru. Tokom dvogodišnjeg istraživanja (2014-2016) ispitivan je uticaj PU uz primenu MF na sadržaj fitinskog (Pphy) i neorganskog fosfora (Pi) u zrnu kukuruza šećerca (*Zea mays* L. var. *saccharata*). Fitinska kiselina kao antinutrijent doprinosi vezivanju esencijalnih minerala, dok je neorganski fosfor direktno dostupan i nutritivno povoljniji. Odnos ova dva oblika fosfora predstavlja važan pokazatelj kvaliteta zrna u svežem stanju i u tehnološkoj preradi. Ogled čine varijante sa leguminozama (obična grahorica, ozimi krmni grašak) i neleguminozama (ozimi ovas, ozimi krmni kelj), smeše obične grahorice i ozimog ovsa, ozimog krmnog graška i ozimog ovsa, varijantu sa malčem (slama) u poređenju sa kontrolom (bez pokrivača) sa i bez primene MF. PU su sejani na jesen, dok je setva hibrida ZP421su obavljena na proleće sledeće godine. Nakon zaoravanja PU primenjivano je MF na polovinu svake parcele (10 L/ha). Sadržaj fosfora je određivan pomoću Biochrom Libra S22 UV/Vis spektrofotometra (YK). Analizom varijanse je utvrđen statistički vrlo značajan uticaj faktora i njihovih interakcija. Najveći sadržaj Pphy u zrnu izmeren je u smeši obične grahorice i ozimog ovsa u 2015. ($3,55 \text{ mg g}^{-1}$) sa MF, dok je u kontroli $2,17 \text{ mg g}^{-1}$. Najveći sadržaj Pi u ozimom krmnom grašku je $2,53 \text{ mg g}^{-1}$ u 2016, a u kontroli $1,83 \text{ mg g}^{-1}$. Utvrđena je negativna korelacija između fitinskog i neorganskog fosfora. Kombinovana primena PU i MF predstavlja efikasnu strategiju za unapređenje nutritivne vrednosti i kvaliteta zrna kukuruza šećerca.

Ključne reči: *Zea mays* L. var. *saccharata*, kvalitet zrna, pokrovni usevi, održiva poljoprivreda.

Zahvalnica: Istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor br. 451-03-33/2026-03/200216 i 451-03-34/2026-03/200383). Istraživanje je usklađeno sa Agendom Ujedinjenih nacija za održivi razvoj do 2030. godine, posebno sa Ciljem 2: Iskorenjivanje glad

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THE RATIO OF PHYTIC AND INORGANIC PHOSPHORUS IN SWEET CORN HYBRID KERNELS GROWN IN A SUSTAINABLE SYSTEM

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The use of cover crops (CC) and microbial fertilizers (MF) represents an important agrotechnical measure for improving nutrient uptake and the chemical composition of maize kernels. A two-year study (2014–2016) investigated the effect of CC combined with MF application on the content of phytic (Pphy) and inorganic phosphorus (Pi) in sweet corn kernels (*Zea mays* L. var. *saccharata*). Phytic acid acts as an antinutrient by binding essential minerals, whereas inorganic phosphorus is directly available and nutritionally more beneficial. The ratio of these two phosphorus forms is an important indicator of kernel quality, both in the fresh state and for industrial processing. The experiment consists of variants with legumes (common vetch, winter forage pea) and non-legumes (winter oat, forage kale), mixtures of common vetch with winter oat and winter forage pea with winter oat, and a mulch (straw) treatment, all compared against a control (no cover) with and without MF application. Cover crops were sown in the autumn, while the ZP421su hybrid was sown the following spring. After incorporating the cover crops into the soil, MF was applied to half of each plot (10 L/ha). Phosphorus content was determined using a Biochrom Libra S22 UV/Vis spectrophotometer (UK). Analysis of variance revealed a statistically highly significant influence of the factors and their interactions. The highest content of Pphy in the grain was measured in the mixture of common vetch and winter oats in 2015 (3.55 mg g⁻¹) with MF, while in the control it was 2.17 mg g⁻¹. The highest content of Pi in winter fodder peas was 2.53 mg g⁻¹ in 2016, and in the control it was 1.83 mg g⁻¹. A negative correlation was established between phytic and inorganic phosphorus. The combined application of PU and MF represents an effective strategy for improving the nutritional value and quality of sweet corn kernel.

Keywords: *Zea mays* L. var. *saccharata*, kernel quality, cover crops, sustainable agriculture.

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MIKROBIOLOŠKI KVALITET KUKURUZA ŽUTOG OSMAKA

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Mikrobiološka kontaminacija zrna kukuruza može značajno uticati na njegovu zdravstvenu bezbednost, kvalitet i mogućnost dalje upotrebe u ishrani ljudi i životinja. Zbog toga je redovno praćenje prisustva patogenih i indikatorskih mikroorganizama važan segment kontrole kvaliteta u proizvodnji i skladištenju žita. Cilj ovog rada bio je da se izvrši procena mikrobiološke ispravnosti merkantilnog zrna žutog kukuruza Osmak, proizvedenog tokom 2024. godine u Institutu za kukuruz „Zemun Polje“. Mikrobiološka analiza obuhvatila je ispitivanje prisustva *Salmonella* spp., određivanje ukupnog broja kvasaca i plesni, sulfitoredukujućih klostridija i koagulaza-pozitivnih stafilokoka. Detekcija *Salmonella* spp. izvršena je metodom SRPS EN ISO 6579-1:2017, broj kvasaca i plesni određen je prema SRPS ISO 21527-2:2011, sulfitoredukujuće klostridije analizirane su metodom SRPS ISO 15213:2011, dok je određivanje koagulaza-pozitivnih stafilokoka sprovedeno primenom standarda SRPS EN ISO 6888-1:2009. Laboratorijska ispitivanja izvršena su u akreditovanoj laboratoriji korišćenjem validiranih metoda detekcije i brojanja mikroorganizama. Rezultati su pokazali odsustvo *Salmonella* spp. u 25 g uzorka, dok je broj kvasaca i plesni iznosio od 123.000 do 126.000 CFU g⁻¹. Sulfitoredukujuće klostridije i koagulaza-pozitivne stafilokoke utvrđene su u koncentracijama manjim od 10 CFU g⁻¹. Na osnovu dobijenih rezultata utvrđeno je da analizirani uzorak ispunjava zahteve Pravilnika o opštim i posebnim uslovima higijene hrane i mikrobiološkim kriterijumima za hranu (Službeni glasnik Republike Srbije, br. 30/2024). Dobijeni rezultati potvrđuju visok stepen mikrobiološke ispravnosti ispitivanog kukuruza i ukazuju na značaj primene standardizovanih metoda u sistemu kontrole kvaliteta, očuvanja zdravstvene bezbednosti i unapređenja tržišne vrednosti zrna kukuruza.

Ključne reči: *Zea mays* L., mikrobiološki kvalitet, higijenski indikatori, standardizovane metode, bezbednost hrane

Zahvalnica: Ovo istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (broj ugovora: 451-03-33/2026-03/200040, 451-03-34/2026-03/200116 i 451-03-66/2026-03/200032).

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MICROBIOLOGICAL QUALITY OF MAIZE YELLOW OSMAK

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Microbial contamination of maize grain may significantly affect its safety, quality, and suitability for human and animal consumption. Therefore, regular monitoring of pathogenic and indicator microorganisms represents an important component of quality control during cereal production and storage. The aim of this study was to evaluate the microbiological safety of yellow maize -OSMAK, produced during the 2024 growing season at the Maize Research Institute Zemun Polje. Microbiological analyses included the detection of *Salmonella* spp., enumeration of yeasts and molds, sulfite-reducing clostridia, and coagulase-positive staphylococci. *Salmonella* spp. were detected according to SRPS EN ISO 6579-1:2017, yeasts and molds were enumerated following SRPS ISO 21527-2:2011, sulfite-reducing clostridia were analyzed using SRPS ISO 15213:2011, while coagulase-positive staphylococci were determined according to SRPS EN ISO 6888-1:2009. All laboratory analyses were performed in an accredited laboratory using validated methods based on the detection and enumeration of microbial colonies. The results confirmed the absence of *Salmonella* spp. in 25 g of the analyzed sample, while the number of yeasts and molds ranged from 123,000 to 126,000 CFU g⁻¹. Sulfite-reducing clostridia and coagulase-positive staphylococci were detected at levels below 10 CFU g⁻¹. Based on the obtained results, the analyzed sample complied with the requirements of the Regulation on General and Specific Food Hygiene Requirements and Microbiological Criteria for Food (Official Gazette of the Republic of Serbia, No. 30/2024). The obtained findings confirm the high microbiological quality of the examined maize sample and emphasize the importance of applying standardized analytical methods in quality control systems to ensure food safety and enhance the market value of maize grain.

Keywords: *Zea mays* L., microbiological quality, hygiene indicators, standardized methods, food safety

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VARIJABILNOST ULJANIH GENOTIPOVA SUNCOKRETA ZA OSOBINE ZNAČAJNE U SELEKCIJI ORNAMENTALNIH FORMI

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Suncokret se u oplemenjivačkim programima najčešće posmatra kao uljana kultura, dok je mogućnost korišćenja takvog materijala za ornamentalnu namenu redak. Za proizvodnju rezanog cveta, pored izgleda cvasti, važna je i sposobnost očuvanja svežine nakon sečenja, pri čemu vreme do uvenuća predstavlja praktičan pokazatelj kvaliteta. Cilj rada bio je da se kod osam uljanih genotipova suncokreta proceni vreme do uvenuća rezanog cveta u različitim uslovima čuvanja. Ispitivani genotipovi potiču iz oplemenjivačke kolekcije Instituta za ratarstvo i povrtarstvo i predstavljaju monocefalne forme bez gena za obnovu fertilnosti, sa žutim jezičastim cvetovima. Ogled je izveden u dva roka setve i tri ponavljanja, u gustom sklopu (70x12,5 cm). Biljke su ubrane u R5.3 fazi, a zatim transportovane u laboratoriju i prekraćene na 55 cm. Tretmani su obuhvatali vodu (T1) i 5% rastvor saharoze (T2) pri sobnim uslovima (20–24 °C), odnosno vodu (T3) i 5% rastvor saharoze (T4) u hladnoj komori (4,5 °C). Faktorska ANOVA pokazala je značajan uticaj genotipa ($F = 49,98$; $p < 0,001$), roka setve ($F = 68,83$; $p < 0,001$), tretmana ($F = 166,05$; $p < 0,001$) i njihovih interakcija. Najduže prosečno vreme do uvenuća (broj dana) ostvareno je u tretmanima T4(12,79) i T3(12,52), dok su najkraće prosečne vrednosti utvrđene u tretmanima T1(6,77) i T2 (6,67). Posmatrano po genotipovima i tretmanima, najduže vreme do uvenuća zabeleženo je kod genotipa CMD-U-12 u tretmanu T4(23,33), dok je najkraće zabeleženo kod genotipa MA-SC-2 u tretmanu T1(2,33). Rezultati ukazuju da vreme do uvenuća može predstavljati koristan dopunski kriterijum za procenu kvaliteta uljanih genotipova suncokreta u selekciji za ornamentalnu namenu.

Ključne reči: suncokret, uljani genotipovi, rezani cvet, uvenuće, ornamentalna selekcija

Zahvalnica: Ovo istraživanje podržano je u okviru Inovativnog projekta AP Vojvodine „Oliva Plus – Inovativni hibrid suncokreta za unapređenje poljoprivredne konkurentnosti AP Vojvodine“, broj projekta 003793802 2025 09418 003 000 000 001/2, kao i od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, broj ugovora 451-03-33/2026-03/200032.

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VARIABILITY OF OIL-TYPE SUNFLOWER GENOTYPES FOR TRAITS IMPORTANT IN THE SELECTION OF ORNAMENTAL FORMS

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Sunflower breeding primarily focuses on oilseed production, while its ornamental potential remains underexplored. For cut flower production, in addition to inflorescence appearance, the ability to maintain freshness after cutting is important, with time to wilting representing a practical quality indicator. The aim of this study was to evaluate the time to wilting of cut flowers of eight oilseed sunflower genotypes under different storage conditions. Evaluated genotypes originated from the breeding collection of the Institute of Field and Vegetable Crops and represented monocephalic forms without fertility-restorer genes and were characterized by yellow ray flowers. The experiment was conducted at two sowing dates with three replications, using a high planting density (70×12.5 cm). Plants were harvested at the R5.3 growth stage, transported to laboratory where stems were trimmed to 55 cm. Treatments included water (T1) and a 5% sucrose solution (T2) under room conditions (20–24 °C), and water (T3) and a 5% sucrose solution (T4) in a cold chamber (4.5 °C). Factorial ANOVA revealed significant effects of genotype ($F = 49.98$; $p < 0.001$), sowing date ($F = 68.83$; $p < 0.001$), treatment ($F = 166.05$; $p < 0.001$), and their interactions. The longest mean time to wilting (days) was recorded in T4(12.79) and T3(12.52), while the shortest mean values were observed in T1(6.77) and T2 (6.67). Considering genotypex-treatment combinations, the longest time to wilting was recorded for ĆMD-U-12 under T4(23.33), whereas the shortest was recorded for MA-SC-2 under T1(2.33). The results indicate that time to wilting may serve as a useful complementary criterion for evaluating oilseed sunflower genotypes in selection for ornamental purposes.

Keywords: sunflower, oil-type genotypes, cut flower, wilting, ornamental selection

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KARAKTERIZACIJA I POTENCIJAL PRIMENE MAHUNA RAZLIČITIH GENOTIPOVA SOJE (GLYCINE MAX (L.) MERR.) KAO OBNOVLJIVE BIOSIROVINE

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Soja (*Glycine max* (L.) Merr.) predstavlja jednu od najznačajnijih poljoprivrednih kultura za proizvodnju hrane, stočne hrane i industrijsku preradu, ali istovremeno stvara znatne količine poljoprivrednog otpada koji ostaje u velikoj meri neiskorišćen. Cilj ovog istraživanja bio je da se ispita lignocelulozni profil i sadržaj proteina u mahunama soje četiri različita genotipa – tri komercijalne sorte (Selena, Lela i Crna soja) i jedne eksperimentalne linije (183) – kako bi se procenio njihov potencijal za dvostruku namenu: kao održivi izvori proteina i za primenu u procesima bioremedijacije. Mahune su imale prosečan sadržaj proteina od $5,50 \pm 0,71\%$. Uočene su značajne razlike u sastavu između ispitivanih genotipova. Sorta Lela pokazala je najviši sadržaj proteina ($6,39 \pm 0,04\%$), što njene mahune čini veoma pogodnim supstratom za ekstrakciju proteina visoke vrednosti. S druge strane, sorta Selena pokazala je znatno viši sadržaj vlakana, sa prosečnim vrednostima NDF-a od $62,78 \pm 0,33\%$, ADF-a od $43,86 \pm 0,57\%$ i sadržajem celuloze od $33,49 \pm 1,79\%$. Udeo lignoceluloznih frakcija bio je sličan kod preostalih uzoraka, pri čemu je Crna soja imala najniži udeo teško razgradljivog lignina (ADL) od $9,17 \pm 0,04\%$, što može omogućiti biohemijску preradu koja zahteva manje energije. Iako svi ispitani uzorci mahuna soje predstavljaju bogate izvore lignoceluloze, određeni genotipovi, poput sorte Selena, pokazuju najveći potencijal kao adsorbenti teških metala ili za primenu u bioremedijaciji pomoću biokompozita zahvaljujući visokom udelu komponenti ćelijskog zida, dok je Lela idealan kandidat za preradu biomase u cilju dobijanja proteina (tzv. *upcycling*). Prilagođavanje procesa tehnološke prerade specifičnom profilu genotipa može drastično smanjiti količinu poljoprivrednog otpada i poboljšati ekonomsku održivost proizvodnje soje.

Ključne reči: *Glycine max*, poljoprivredni ostaci, lignoceluloza, proteini, biomasa.

Zahvalnica: Ovo istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (451-03-33/2026-03/200040).

CHARACTERIZATION AND APPLICATION POTENTIAL OF SOYBEAN PODS OF DIFFERENT GENOTYPES (GLYCINE MAX (L.) MERR.) AS RENEWABLE BIORESOURCES

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Soybean (*Glycine max* (L.) Merr.) represents one of the most important crops for food production, animal feed, and industrial processing, but at the same time it creates considerable amounts of agricultural waste that remains largely unused. This study aimed to examine the lignocellulosic profile and protein content of soybean pods of four different genotypes - three commercial varieties (Selena, Lela, and Black soybean) and one experimental line (183) - to evaluate their potential for dual purposes: as sustainable protein sources and for application in bioremediation processes. The pods had an average protein content of $5.50 \pm 0.71\%$. Significant differences in the composition between the tested genotypes were observed. The variety Lela showed the highest protein content ($6.39 \pm 0.04\%$), making its pods a suitable substrate for high-value protein extraction. In contrast, the variety Selena showed significantly higher fiber content, with average NDF of $62.78 \pm 0.33\%$, ADF of $43.86 \pm 0.57\%$, and cellulose content of $33.49 \pm 1.79\%$. The proportion of lignocellulosic fractions was consistent across the other samples, with black soybean exhibiting the lowest level of difficult-to-degrade lignin (ADL) at $9.17 \pm 0.04\%$. This characteristic may facilitate biochemical processing that demands less energy. Although all tested samples of soybean pods represent rich sources of lignocellulose, certain genotypes, such as the Selena variety, show the greatest potential as adsorbents of heavy metals or for application in bioremediation using biocomposites due to the high proportion of cell wall components, while Lela is an ideal candidate for processing biomass to obtain protein (upcycling). Adapting the technological processing to the specific genotype profile can drastically reduce the amount of agricultural waste and improve the economic viability of soybean production.

Keywords: *Glycine max*, agricultural residues, lignocellulose, proteins, biomass.

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EKONOMSKI ZNAČAJ I PRODUKCIONI POTENCIJAL ZDRUŽENIH USEVA KUKURUZA I HELJDE

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Najefikasnija tehnika za proizvodnju biomase visoke nutritivne vrednosti je gajenje međuseva. Prednosti ovih metoda su efikasnije korišćenje prirodnih resursa, visoki prinosi, suzbijanje korova i očuvanje plodnosti zemljišta, smanjuju ispiranje nitrata i isparavanje amonijaka i azot oksida u atmosferu čime smanjuju gubitke azota iz poljoprivrednih sistema. Kukuruz se kod nas gaji kao glavni, naknadni ili postrni usev, čist ili u krmnim smešama. Ogledi sa kukuruzom i heljdom u monokulturi i u međusevu (kukuruz+heljda) izvedeni su na parcelama Instituta za ratarstvo i povrtarstvo, na zemljištu tipa černoze, u 4 ponavljanja, na parcelama 10m² po split-splot metodi, 15.04.2025. Predusev je bila soja. Ispitivana su dva genotipa: hibrid kukuruza: Kn435 (Instituta za kukuruz u Kneži) i sorta heljde: Novosadska (IFVCNS). Žetva je obavljena kada su usevi dostigli fiziološku zrelost. Cilj ovog istraživanja bio je da se proceni produktivnost ovih useva i utvrdi efikasnost zajedničkog gajenja heljde i kukuruza. Rezultati su pokazali da su usevi, u monokulturi i u međusevu, ostvarili dobre prosečne vrednosti za visinu i masu biljke i prinose kukuruza i heljde. U poređenju sa monokulturom, gajenje međuseva povećava ukupnu biljnu biomasu i proizvodnju semena, čime se podržava regenerativna poljoprivreda. Hibrid kukuruza imao je bolje prosečne rezultate za sve parametre u monokulturi u odnosu međusev kukuruzom+heljdom, ali zbirno u međusevu je ostvaren veći prinos zrna i biomase kukuruza+heljde. Ukupna masa biljaka i masa zrna bila je veća u združenom usevu zbog čega se preporučuje setva združenih useva kukuruza i heljde.

Ključne reči: kukuruz, heljda, združeni usevi, černoze, prinos.

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ECONOMIC SIGNIFICANCE AND PRODUCTION POTENTIAL OF INTERCROPPING MAIZE AND BUCKWHEAT

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Growing intercrops is the most effective technique to producing biomass with high nutritional value. Advantages of these method includemore efficient use of natural resources, high yields, weed suppression, and soil fertility preservatio; they reduce nitrate leaching and volatilization of ammonia and nitrogen oxides into the atmosphere thereby reducing nitrogen losses from agricultural system. In our region, maize is cultivated as a primary, second crop, either in a pure stand or in forage mixtures. Experimental trials involving maize and buckwheat genotypes-grown both in monoculture and intercrop (maize+buckwheat) were conducted on plots belonging to Institute of Field and Vegetable Crops, on chernozem soil, using a split-plot design with four replications on 10m² plots, with planting on April 15, 2025. Soybean was the preceding crop. Two genotypes were evaluated: maize hybrid, Kn435 (Maize Research Institute,Kneža), and buckwheat variety, Novosadska (IFVCNS). Harvesting took place when the crops reached technological maturity. The aim of this study was to assess the productivity of these crops and determine the efficiency of growing buckwheat and maize together. The results showed that crops-in monoculture and in intercropping-achieved good values for plant height and mass, and maize and buckwheat yields. Compared to monoculture, intercropping increases total plant biomass and seed production, thereby supporting regenerative agriculture. Maize hybrid performed better across all parameters in the monoculture compared to intercrop, however, the intercrop system achieved a higher combined yield (maize+buckwheat). Total plant mass and grain mass were higher in the intercrop which is sowing maize and buckwheat as an intercrop is recommended.

Keywords: maize, buckwheat, intercrops, chernozem, yield.

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MOLEKULARNA I FENOTIPSKA EVALUACIJA VISINE BILJKE RAZLIČITIH GENOTIPOVA PŠENICA

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Oplemenjivanje pšenice usmereno je ka stvaranju sorti visokih i stabilnih prinosa, adaptiranih na specifične agroekološke uslove. Adaptabilnost pšenice je između ostalog rezultat varijabilnosti gena za visinu biljke (*Rht*). Cilj ovog istraživanja bio je ispitivanje varijabilnosti 186 genotipova pšenica iz Instituta za ratarstvo i povrtarstvo primenom mikrosatelitskih markera dovedenih u vezu sa visinom biljke i primenom funkcionalnih markera za detekciju dominantnog, (*Rht-B1b*, *Rht-D1b*) i recesivnog (*Rht-B1a*, *Rht-D1a*) alela *Rht* gena B i D genoma hlebne pšenice kao i ocena visine biljke u dvogodišnjem poljskom ogledu, na Rimskim šančevima. Analizom 22 lokusa zabeleženo je ukupno 211 alela. Srednja vrednost očekivane heterozigotnosti iznosila je 0,70, a indeks polimorfizma (PIC) 0,72. Najveći broj alela utvrđen je za markere *wmc617-4D* (22 alela), *wmc125* i *gwm495* (14 alela). Analizom glavnih koordinata (PCoA) pokazano je da su prva i druga koordinata zajedno objasnile 71,9% varijacije gde su se jasno izdvojile grupe pšenice po ploidnosti odnosno poreklu. Najveća zastupljenost *Rht-B1a* alela uočena je kod genotipova hlebne pšenice iz Amerike (78,95%) a najmanja kod genotipova hlebne pšenice iz Azije (61,54%). Najmanja zastupljenost *Rht-D1b* alela uočena je kod genotipova hlebne pšenice iz južne i jugoistočne Evrope (66,66%) a najveća kod genotipova hlebne pšenice iz Amerike (78,95%). Analizom varijanse pokazano je da su se genotipovi hlebne pšenice iz južne i jugoistočne Evrope odlikovali statistički značajnom najmanjom visinom biljke (96,73 cm) a genotipovi spelte najvećom visinom biljke (151,6 cm). Odabrani materijal odlikuje velika raznovrsnost, na molekularnom i fenotipskom nivou što ih čini pogodnim za korišćenje u selekciji i stvaranju visokoprinosnih, adaptabilnih genotipova.

Ključne reči: pšenica, mikrosateliti, visina biljke, marker

Zahvalnica: Istraživanje je podržano od Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, broj ugovora: 451-03-33/2026-03/ 200032. Istraživanje je deo aktivnosti Centra izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na promene klime „Climate Crops“, Instituta za ratarstvo i povrtarstvo, Instituta od nacionalnog značaja za Republiku Srbiju.

MOLECULAR AND PHENOTYPIC EVALUATION OF PLANT HEIGHT AMONG DIFFERENT WHEAT GENOTYPES

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Wheat breeding is directed at creating varieties with high and stable yields adapted to specific agroecological conditions. The adaptability of wheat is the result of the variability of *Rht* genes. The aim of this study was to explore the variability of 186 genotypes from the Institute of Field and Vegetable Crops with microsatellite markers linked with plant height and functional markers for detection of dominant (*Rht-B1b*, *Rht-D1b*) and recessive (*Rht-B1a*, *Rht-D1a*) alleles as well as the evaluation of plant height in two years field trial at an experimental site at Rimski šančevi. A total of 211 alleles was observed. The mean value of expected heterozygosity was 0.70 and the polymorphism information content was 0.72. The highest allele number was found for markers *wmc617-4D* (22 alleles), *wmc125* (14 alleles) and *gwm495* (14 alleles). The first two axis of principal coordinates analysis explained 71.9% of variance and the analysis clearly separated the genotypes according to ploidy level or origin. The highest frequency of *Rht-B1a* allele was found among genotypes from America (78.95%) while the lowest among genotypes from Asia (61.54%). The lowest frequency of *Rht-D1b* allele was found among genotypes from south and southeast Europe (66.66%) and the highest among genotypes from America (78.95%). The analysis of variance showed that genotypes from south and southeast Europe had the statistically lowest plant height (96.73 cm) while the spelt wheat the highest (151.6 cm). The selected material is characterized by great diversity which makes it suitable for use in creation of high-yielding, adaptable genotypes.

Keywords: wheat, microsatellite, plant height, marker

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MEĐUGODIŠNJA KONZISTENTNOST I FENOTIPSKA PLASTIČNOST SEZONSKIH PROFILA VEGETACIONIH INDEKSA DOBIJENIH UAV SNIMANJEM KOD GENOTIPOVA PŠENICE

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Vegetacioni indeksi dobijeni multispektralnim snimanjem pomoću bespilotnih letelica (UAV) sve više se koriste za fenotipizaciju pšenice, ali njihova pouzdanost za karakterizaciju genotipova zavisi od međugodišnje konzistentnosti sezonskih profila i od toga u kojoj meri se ekspresija profila specifična za genotip menja tokom vegetacionih sezona. U ovom istraživanju ispitivane su međugodišnja konzistentnost i fenotipska plastičnost (ovde tumačena u odnosu na nižu međugodišnju korelaciju profila), sezonskih profila NDVI, NDRE i GNDVI kod genotipova pšenice, nezavisno od odnosa sa prinosom i kvalitetom zrna. Dvadeset genotipova ozime pšenice gajeno je po slučajnom blok-sistemu u dva ponavljanja tokom sezona 2022/2023. i 2023/2024. Multispektralno snimanje pomoću UAV-a (DJI Phantom 4 Multispectral) sprovedeno je od faze bokorenja do pune zrelosti, sa šest snimanja u sezoni 2022/2023. i pet u sezoni 2023/2024. Za svaki genotip i indeks sezonska dinamika je opisana deskriptorima (maksimalna vrednost, vreme maksimuma, površina ispod krive, brzina opadanja), a međugodišnja konzistentnost je ocenjena korelacijom krivih istog genotipa u dve sezone. Sezonski profili NDVI pokazali su najveću konzistentnost ($r = 0,97$), zatim NDRE ($r = 0,88$), dok je GNDVI pokazao znatno manju konzistentnost ($r = 0,59$). Prosek tri korelacije po indeksu kretao se od $r = 0,78$ (genotip G9) do $r = 0,89$ (genotip G17), što ukazuje na razlike među genotipovima u međugodišnjoj konzistentnosti profila. Analiza glavnih komponenti deskriptora objasnila je 63,8% ukupne varijanse (PC1 45,6%, PC2 18,3%) i pokazala kontinuiranu, genotipski specifičnu varijabilnost, a ne postojanje odvojenih fenotipskih klasa. Dobijeni rezultati pokazuju da se vegetacioni indeksi značajno razlikuju u međugodišnjoj konzistentnosti kao ponovljive fenotipske osobine, pri čemu se NDVI izdvaja kao najrobustniji izbor za višegodišnje praćenje dinamike sklopa na nivou genotipa u oplemenjivanju pšenice.

Ključne reči: pšenica, UAV daljinska detekcija, vegetacioni indeksi, fenotipska plastičnost, genotip.

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CROSS-YEAR CONSISTENCY AND PHENOTYPIC PLASTICITY OF UAV-DERIVED SEASONAL VEGETATION INDEX PROFILES IN WHEAT GENOTYPES

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UAV-derived vegetation indices are increasingly used for high-throughput wheat phenotyping, yet their reliability as genotype-level traits depends on the cross-year consistency of seasonal profiles and the extent to which genotype-specific profile expression changes across growing seasons. This study evaluated the cross-year consistency and phenotypic plasticity, interpreted here in relation to weaker cross-year profile correlation, of season-long NDVI, NDRE and GNDVI profiles in wheat genotypes, independent of their relationship with yield or grain quality. Twenty winter wheat genotypes were grown in a randomized complete block design with two replications during the 2022/2023 and 2023/2024 growing seasons. UAV-based multispectral imaging (DJI Phantom 4 Multispectral) was performed from tillering to full maturity, with six surveys in 2022/2023 and five in 2023/2024. For each genotype and index, the seasonal profile was summarized using canopy dynamics descriptors (peak value, timing of peak, area under the curve and post-peak decline rate), while cross-year consistency was assessed by correlating each genotype's profiles between the two seasons. NDVI profiles were the most consistent across years (mean $r = 0.97$), followed by NDRE ($r = 0.88$), whereas GNDVI was markedly less consistent ($r = 0.59$). The mean of the three index-specific correlations ranged from $r = 0.78$ (genotype G9) to $r = 0.89$ (genotype G17), indicating genotype-specific differences in cross-year profile consistency. Principal component analysis of the descriptors captured 63.8% of total variance (PC1 45.6%, PC2 18.3%) and revealed continuous, genotype-specific variation rather than discrete phenotypic classes. These results show that UAV-derived indices differ markedly in their cross-year consistency as repeatable phenotyping traits, with NDVI emerging as the most robust choice for genotype-level, multi-year monitoring of canopy dynamics in wheat breeding.

Keywords: wheat, UAV remote sensing, vegetation indices, phenotypic plasticity, genotype.

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OSMACI ZAPADNOG BALKANA-NEISKORIŠĆEN POTENCIJAL KOLEKCIJE INSTITUTA ZA KUKURUZ ZEMUN POLJE

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Povećani zahtevi prehrambene industrije, kao i potreba proizvođača organske hrane za genotipovima sa dodatnom vrednošću, nameću potrebu za razvojem sorti sa poboljšanim nutritivnim svojstvima zrna. Takođe, tradicionalni proizvodi od slobodnooprašujućih sorti kukuruza osmaka zauzimaju i danas važno mesto u ishrani stanovništva Srbije, ali i celog Zapadnog Balkana. Oplemenjivanju ovog tipa kukuruza, koji se odlikuje zrnem visokog kvaliteta, nije posvećena odgovarajuća pažnja. Cilj ovog istraživanja je da se analiziraju postojeći podaci Banke gena Instituta za kukuruz „Zemun Polje“ (MRIZP) kako bi se ustanovilo u kojoj meri su kukuruzi osmaci zastupljeni u kolekciji, kakva je njihova raznolikost, potencijal za direktnu preporuku za gajenje, ali i za unapređenje kroz oplemenjivanje. Pasoški podaci su ukazali da MRIZP kolekcija od 2217 lokalnih populacija sadrži 168 genotipova koji u svom imenu sadrže reč osmak, a 101 u proseku ima $\leq 8,8$ redova zrna. Diskriminacionom analizom, odabranih 216 populacija su se klasifikovale u 10 agro-ekoloških grupa na osnovu 28 fenotipskih osobina. Najveći broj uzoraka klasifikovan je u Osmorede meke zubane, Osmake severoistočne Amerike, Meke tvrduce i Tvrde zubane (40, 33, 31 i 28). Raspored/bliskost centroida pojedinih definisanih grupa na teritorijalnoj mapi ukazuje na njihovu lošu diskriminaciju, odnosno veliku verovatnoću da populacije tih grupa vode zajedničko poreklo i/ili da je između njih postojala znatna razmena genetičkog materijala. Dobijeni rezultati su dobra polazna osnova za dalja istraživanja ovog tipa kukuruza.

Ključne reči: agro-ekološke grupe, numerička klasifikacija, *Zea mays* L.

Zahvalnica: Istraživanja su delom potpomognuta projektima: NEST – evidencioni broj:1377/24, 2024-2026 i Institucionalni projekat Instituta za kukuruz „Zemun Polje“, evidencioni broj 451-03-33/2026-03/200040. Istraživanja su u saglasnosti sa Ciljevima održivog razvoja Ujedinjenih nacija, Cilj 15 (život na zemlji).

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EIGHTS-ROWED MAIZE OF THE WESTERN BALKANS - THE UNUTILIZED POTENTIAL OF THE MRIZP GENE BANK

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The escalating demands of the food industry, alongside organic producers' requirements for value-added genotypes, necessitate the development of crop varieties with enhanced grain nutritional profiles. Furthermore, traditional foods derived from open-pollinated maize landraces remain central to human nutrition across Serbia and the Western Balkans. Despite their exceptional grain quality, these varieties have received inadequate breeding attention. This study evaluates historical records from the Maize Research Institute Zemun Polje (MRIZP) Gene Bank to ascertain the prevalence, diversity, direct cultivation potential, and breeding utility of eight-rowed maize. Passport and Further Characterisation and Evaluation data for 2217 local accessions revealed that 168 incorporate "eight" within their nomenclature, while 101 display an average row count of ≤ 8.8 . Discriminant analysis categorized 216 selected landraces into 10 agro-ecological groups based on 28 phenotypic traits. The predominant classifications were Eight-rowed soft dents ($n=40$), Eight-rowed corn type of North East America ($n=33$), Denty flints ($n=31$), and Flinty dents ($n=28$). The spatial distribution and proximity of group centroids on territorial projections demonstrated poor discrimination, indicating a likely shared ancestry or extensive historical gene flow among populations. These findings establish a robust foundation for future conservation and breeding initiatives targeting high-quality eight-rowed maize germplasm.

Keywords: agro-ecological groups, numerical classification, *Zea mays* L.

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IDENTIFIKACIJA GENOTIPOVA SOJE TOLERANTNIH NA SUŠU U FAZI KLIJANJA

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Suša predstavlja jedan od najznačajnijih abiotičkih stresova koji negativno utiče na rast, razvoj i prinos soje. Soja je naročito osetljiva na deficit vode tokom klijanja semena, što može negativno uticati na nicanje, početni razvoj i kasniji rast biljaka. Stoga je identifikacija genotipova tolerantnih na sušu u fazi klijanja od velikog značaja za razvoj sorti soje sa poboljšanom tolerancijom na sušu. U ovom istraživanju ispitivana je tolerantnost pet genotipova soje na sušu primenom polietilen glikola (PEG)-6000 u koncentracijama od 0, 5, 10, 15, 20 i 25% (w/v). Nakon tretmana, seme je inkubirano u komori za klijanje pri temperaturi od 25 °C i relativnoj vlažnosti vazduha od 60%. Klijanje je praćeno tokom osam dana, nakon čega su određeni parametri energija klijanja, klijavost i indeks klijanja u uslovima suše. Simulirani stres suše nepovoljno je uticao na klijanje, pri čemu su utvrđene statistički značajne razlike između genotipova i koncentracija PEG-a za sve ispitivane parametre. Takođe su utvrđene statistički značajne interakcije genotip × tretman za energiju klijanja i klijavost semena. Energija klijanja, klijavost i indeks klijanja u uslovima suše smanjivali su se sa povećanjem koncentracije PEG-6000 kod svih genotipova. Vrednosti ispitivanih parametara smanjile su se pri koncentraciji od 15% PEG-6000, koja odgovara umerenom nivou suše, što ukazuje da ova koncentracija može predstavljati odgovarajući prag za procenu tolerantnosti soje u fazi klijanja. Identifikovani tolerantni genotipovi predstavljaju osnovu za dalja istraživanja u kontrolisanim i poljskim uslovima, kako bi se potvrdila njihova tolerantnost na sušu i razjasnili mehanizmi koji leže u osnovi njihovog odgovora na stres izazvan sušom.

Ključne reči: *Glycine max* (L.) Merrill, PEG-indukovana suša, klijavost semena

Zahvalnica: Istraživanje je podržalo Ministarstva za nauku, tehnološki razvoj i inovacije Republike Srbije, Ugovor br. 451-03-33/2026-03/200032; i Pokrajinski sekretarijat za visoko obrazovanje i naučnoistraživačku delatnost; AP Vojvodina, projekat "SOYMICROBREED – Unapređenje otpornosti soje na sušu putem selekcije rizosfernog mikrobioma", Ugovor br. 003872014 2025 09418 003 000 000 001 04 004.

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IDENTIFICATION OF DROUGHT-TOLERANT GENOTYPES IN THE GERMINATION STAGE OF SOYBEAN

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Drought is one of the most important abiotic stresses limiting soybean production, negatively affecting plant growth and development and causing considerable yield losses. Soybean is particularly sensitive to water deficit during seed germination, which can adversely affect seedling establishment and subsequent growth. Therefore, the identification of drought-tolerant germplasm at the germination stage is crucial for developing soybean cultivars with improved drought tolerance. This study evaluated the drought tolerance of five soybean genotypes using polyethylene glycol (PEG)-6000 at concentrations of 0, 5, 10, 15, 20, and 25% (w/v). Following treatment, seeds were incubated in a germination chamber at 25 °C and 60% relative humidity. Germination was monitored for eight days, after which germination energy, final germination, and the germination drought index (GDI) were determined. Simulated drought stress impaired soybean germination, with significant differences among genotypes and PEG concentrations observed for all examined parameters. Significant genotype × treatment interactions were also detected for germination energy and final germination. Germination energy, final germination, and GDI decreased with increasing PEG-6000 concentration in all genotypes. All examined parameters declined at 15% PEG-6000, corresponding to a moderate level of drought stress, suggesting that this concentration may represent a suitable threshold for assessing drought tolerance in soybean at the germination stage. The identified drought-tolerant genotypes provide a basis for further studies under controlled and field conditions to confirm their drought tolerance and elucidate the mechanisms underlying their response to drought stress.

Keywords: *Glycine max* (L.) Merrill, PEG-induced drought, seed germination

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Vasiljević, M. (0000-0001-9331-5252), Đorđević, V. (0000-0003-1186-4640), Marinković, J. (0000-0003-3984-7930), Miljaković, D. (0000-0001-7308-8769), Tintor, B. (0000-0002-2437-5064), Čeran, M. (0000-0002-1337-3522), Miladinović, J. (0000-0002-4061-4037)

ZNAČAJ EKOLOŠKIH USLOVA NA PRINOS I KVALITET INBRED LINIJA KUKURUZA

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U poslednjih deset godina, agroekološki uslovi u Vojvodini bitno utiču na prinos semenskog kukuruza, kao i na optimizaciju procesa proizvodnje. Stoga, cilj istraživanja bio je ispitivanje varijabilnosti inbred linija semenskog kukuruza zavisno od stepena defolijacije u različitim uslovima sredine. U ogledima su testirane tri inbred linije (L217RfC, L335/99 i L76B004). Poljski eksperimenti su izvedeni na dve lokacije (Zemun Polje i Parage) tokom 2016. i 2017. godine primenom dve gustine setve (50.000 biljaka/ha i 65.000 biljaka/ha). Tretman defolijacije obuhvatio je pet različitih intenziteta - od prvog (uklanjanje samo metlice) do petog (uklanjanje metlice sa četiri lista). Tokom istraživanja analizirani su: prinos zrna i njegove komponente, klijavost i energija klijanja, kao i frakcioni udeo u masi semena. Rezultati pokazuju najmanji stepen variranja prinosa zrna pri različitim ekološkim uslovima (godina x lokacija) kod inbred linije L217RfC. Najvišu srednju vrednost () prinosa zrna od 5549,4 kg/ha u svim ekološkim uslovima ostvarila je inbred linija L335/99, dok su kod genotipa L76B004 zabeležene najniže srednje vrednosti ovog parametra. Dobijeni rezultati potvrđuju visoku statističku značajnost uticaja ekoloških uslova na prinos zrna, pri čemu se kao agroekološki povoljnije izdvajaju 2016. godina i lokacija Parage. Pored toga, ustanovljen je visoko značajan uticaj ekoloških činilaca na frakcioni udeo u masi semena. Značaj samog tretmana defolijacije posebno je došao do izražaja u povoljnim agroekološkim uslovima. Konačno, rezultati analize varijanse (ANOVA) potvrdili su da ispitivani faktori – ekološki uslovi, genotip i tretmani defolijacije – kao i njihove međusobne interakcije, ostvaruju visoko značajan uticaj na ispoljavanje prinosa zrna i njegovih komponenti.

Ključne reči: ekološki uslovi, prinos zrna, inbred linija

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THE SIGNIFICANCE OF ENVIRONMENTAL CONDITIONS FOR THE YIELD AND QUALITY OF MAIZE INBRED LINES

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Over the past decade, agroecological conditions in Vojvodina have significantly affected seed maize yield and production optimization. Therefore, this study aimed to investigate the variability of seed maize inbred lines in response to different degrees of defoliation under contrasting environmental conditions. Three inbred lines (L217RfC, L335/99, and L76B004) were evaluated in field trials conducted at two locations (Zemun Polje and Parage) during 2016 and 2017, using two plant densities (50,000 and 65,000 plants ha⁻¹). Five defoliation intensities were applied, ranging from tassel removal to removal of the tassel and four leaves. Grain yield and its components, germination capacity and energy, and the fractional distribution of seed mass were analyzed. The lowest variation in grain yield across environmental conditions (year × location) was observed in L217RfC. L335/99 achieved the highest mean grain yield (5,549.4 kg ha⁻¹) across all environments, whereas L76B004 had the lowest mean yield. Environmental conditions had a highly significant effect on grain yield, with 2016 and Parage identified as the most favorable conditions. Environmental factors also significantly affected the fractional distribution of seed mass, while the effect of defoliation was particularly pronounced under favorable agroecological conditions. ANOVA confirmed highly significant effects of environmental conditions, genotype, defoliation treatment, and their interactions on grain yield and its components.

Keywords: environmental conditions, grain yield, inbred line

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IDENTIFIKACIJA GENETIČKE ČISTOĆE SEMENA I GENOTIPA PŠENICE

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Za identifikaciju genotipa i ocenu čistoće semena trenutno se koriste različite metode, uključujući konvencionalne metode zasnovane na morfološkim karakteristikama, kao i hemijske, molekularne i biohemijske tehnike. Cilj ovog istraživanja je identifikacija genotipova pšenice na osnovu determinacije njihovih glijadinskih i gluteninskih alela. Kisela PAGE elektroforeza (pH 3.1) na 8.33% poliakrilamidnom gelu korišćena je za identifikaciju alela gliadina (*Gli-1* i *Gli-2*), dok je SDS-PAGE (pH 8.6) na 11.8% gelu korišćena za određivanje alela glutenina (*Glu-1*). Aleli identifikovani na svakom lokusu predstavljeni su u formulama gliadina i glutenina genotipa, koje predstavljaju specifičnu kombinaciju alela na lokusima. Analizirani genotipovi pokazali su specifične proteinske formule (glijadinske i gluteniske), iako su kod pojedinih sorti na određenim lokusima bili prisutni identični aleli. Identifikovana je alelna heterogenost na pojedinim lokusima, što ukazuje na nepotpunu genetičku čistoću -konkretno na *Gli-D1* (*a + b*) kod genotipova G-3512 i G-3540, kao i na lokusu *Gli-D2* (*b + a*) kod genotipova G-3530 i G-3535. Genetička formula gliadina pokazala je da se svi genotipovi razlikuju jedni od drugih, dok je genetička formula glutenina bila identična za tri para genotipova (*b, c, d*), (*b, b, d*) i (*a, c, d*), kao i za jednu grupu od tri genotipa (*c, c, a*). Identifikacija genetičke čistoće genotipova semena pšenice ima značajnu ulogu u razvoju i očuvanju semenarstva, oplemenjivanju biljaka, zaštiti sorti i pravima intelektualne svojine, zasnivanju useva kao i u proizvodnji semena i proizvoda od semena.

Ključne reči: pšenica, genotip, protein, čistoća semena

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IDENTIFICATION OF GENETIC PURITY OF SEED AND GENOTYPE OF WHEAT

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Various methods are currently used to identify genotypes and assess seed purity, including conventional methods based on morphological characteristics, as well as chemical, molecular, and biochemical techniques. The aim of this study was to identify wheat genotypes by determining their gliadin and glutenin alleles. Acid PAGE electrophoresis (pH 3.1) on an 8.33% polyacrylamide gel was used to identify gliadin alleles (*Gli-1* and *Gli-2*), while SDS-PAGE (pH 8.6) on an 11.8% gel was used to determine glutenin alleles (*Glu-1*). The alleles identified at each locus are presented in the genotype's gliadin and glutenin formulas, which represent the specific combination of alleles across the loci. The analyzed genotypes exhibited specific protein formulas (gliadin and glutenin), even though identical alleles were present at certain loci in some genotypes. Allelic heterogeneity was observed at specific loci—indicating incomplete genetic purity - namely at *Gli-D1* (*a + b*) in G-3512 and G-3540, and at *Gli-D2* (*b + a*) in G-3530 and G-3535. The gliadin genetic formula showed that all genotypes differed from one another, whereas the glutenin genetic formula was identical for three pairs of genotypes (*b, c, d*), (*b, b, d*), and (*a, c, d*) as well as for one group of three genotypes (*c, c, a*). Identifying the genetic purity of wheat seed genotypes plays a significant role in the development and preservation of the seed industry, plant breeding, variety protection and intellectual property rights, as well as in crop establishment and the production of seed and seed-derived products.

Keywords: wheat, genotype, protein, seed purity

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UTICAJ HIBRIDA I TRETMANA NA KVALITET SEMENA PAPRIKE

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Cilj rada je bio da se utvrdi uticaj hibrida i tretmana semena na glavne pokazatelje kvaliteta semena dva hibrida paprika (Merak i Ordesa). Ogled je izveden 2024. godine u Laboratoriji za kontrolu kvaliteta semena i sadnog materijala Instituta za zaštitu bilja i životnu sredinu u Beogradu. Kao materijal u ogledu korišćeno je seme hibrida paprika proizvedeno u 2023. godini. Tretman semena je izveden sa 1% rastvorom natrijum hipohlorida u trajanju od 10 minuta, zatim je ispirano i osušeno. Ispitivanje kvaliteta semena izvršeno je standardnom laboratorijskom metodom na filter papiru navlaženom 0,2% vodenim rastvorom KNO₃ na 4 x 100 semena. Seme je inkubirano 14 dana na temperaturi 20 - 30°C i relativnoj vlažnosti vazduha od 95%. Sedmog dana inkubacije ocenjena je energija klijanja, a 14 dana ukupna klijavost. Zdravstvena ispravnost semena ocenjivana je vizuelnom metodom. Dobijeni rezultati ukazuju da su pojedinačni faktori hibrid i tretman semena značajno uticali ($p < 0,01$) na energiju klijanja, ukupnu klijavost i procenat bolesnog semena. Ispitivani faktori nisu uticali na procenat nenormalnih klijanaca. Uticaj interakcije faktora na posmatrane pokazatelje kvaliteta semena je izostao. Primenjeni tretman na semenu uticao je u proseku na povećanje energije klijanja i ukupne klijavosti za po 4% kod oba ispitivana hibrida paprike. Na varijanti kontrola (bez tretmana semena) kod hibrida paprika utvrđeno je prisustvo samo patogena *Alternaria* sp., čija se zastupljenost kretala od 5 do 9%. Primenom tretmana semena kod ispitivanih hibrida procenat zaraženog semena *Alternaria* sp. se značajno smanjio ispod 5%, što predstavlja zakonski maksimum za stavljanje semena paprike u promet.

Ključne reči: paprika, klijavost, *Alternaria* sp.

Zahvalnica: Ministarstvo obrazovanja, nauke i tehnološkog razvoja Republike Srbije, Ugovor br. 451-03-33/2026-03/ 200010

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IMPACT OF HYBRIDS AND TREATMENTS ON PEPPER SEED QUALITY

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The aim of the work was to determine the influence of hybrids and seed treatment on the main indicators of seed quality of two pepper hybrids (Merak and Ordesa). The experiment was carried out in 2024 at the Laboratory for Quality Control of Seeds and Planting Material of the Institute for Plant Protection and the Environment in Belgrade. Pepper hybrid seeds produced in 2023 were used as material in the experiment. The seeds were treated with a 1% sodium hypochlorite solution for 10 minutes, then rinsed and dried. Seed germination was tested using a standard laboratory method on filter paper moistened with a 0.2% aqueous solution of KNO₃ on 4 x 100 seeds. The seeds were incubated for 14 days at a temperature of 20 - 30°C and a relative humidity of 95%. On the seventh day of incubation, the energy of germination was evaluated, and on the 14th, the total germination, that is, the number of typical seedlings. The healthiness of the seeds was assessed by the visual method. The obtained results indicate that the individual factors hybrid and seed treatment significantly influenced ($p < 0.01$) the energy of germination, total germination and the percentage of diseased seeds. The investigated factors did not affect the percentage of abnormal seedlings. The influence of the interaction of factors on the observed indicators of seed quality was absent. The treatment applied to the seeds affected on increase in the energy of germination and total germination by 4% in both tested pepper hybrids. On the control variant (without seed treatment) in pepper hybrids, the presence of only the pathogen *Alternaria* sp., whose representation ranged from 5 to 9%, was determined. By applying seed treatment in the examined hybrids, the percentage of infected seeds of *Alternaria* sp. has significantly decreased below 5%, which is the legal maximum for placing pepper seeds on the market.

Keywords: pepper, germination, *Alternaria* sp.

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SKRINING INBRED LINIJA SUNCOKRETA NA OTPORNOST PREMA SUŠI IN VITRO

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Suncokret (*Helianthus annuus* L.) je ekonomski značajna uljana biljna vrsta, ali je njegova produktivnost sve više ugrožena stresom koji izaziva suša. U ovom radu ocenjivana je reakcija različitih inbred linija (IL) suncokreta na stress sušom indukovani tretmanom sa polietilen glikolom (PEG) kako bi se identifikovale tolerantne i osetljive inbred linije. Od 51 IL postavljeno na podlogu, ukupno 39 IL je uspešno testirano, dok je 12 isključeno zbog loše reakcije na kulturu *in vitro*. Statistička analiza je sprovedena korišćenjem Mann-Whitney U-testa i indeksa poređenja tretmana i kontrole. Rezultati su pokazali da je sveža masa izdanka imala najveću varijabilnost između tretmana, što potvrđuje da ovaj parameter može biti dobar pokazatelj odgovora genotipova suncokreta na stres izazvan PEG-om. Nasuprot tome, suva masa izdanka je imala veoma nisku varijabilnost (kod samo 3 od 39 IL) i može biti isključena iz budućih analiza. Na osnovu evaluacije, 5 IL je identifikovano kao potpuno tolerantno na PEG tretman, dok se 7 IL pokazalo kao veoma netolerantno. Ovi rezultati bi mogli imati značajnu praktičnu vrednost, jer bi odabrane tolerantne IL mogle biti dobri kandidati za uključivanje u programe oplemenjivanja usmerene na poboljšanje otpornosti suncokreta na sušu.

Ključne reči: suncokret; PEG; stres na sušu; osmotska tolerancija; Mann-Whitney U-test

Zahvalnica: Ovaj rad je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (ugovor broj 451-03-33/2026-03/200032) i RUNFASTER4EU projekat (ugovor broj 101214206), CARINA projekat (ugovor broj 101081839) i MIDAS projekat (ugovor broj 101082070). Istraživanja su urađena u okviru Centra izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na promene klime – Climate Crops, Institut za ratarstvo i povrtarstvo, Novi Sad.

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SCREENING SUNFLOWER INBRED LINES FOR IN VITRO DROUGHT RESILIENCE

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Sunflower (*Helianthus annuus* L.) is an economically important oilseed crop, but its productivity is increasingly threatened by drought stress. This study evaluated the response of different sunflower inbred lines (ILs) to simulated drought induced by polyethylene glycol (PEG) to identify tolerant and susceptible lines. Out of 51 initial ILs placed on the medium, a total of 39 ILs were successfully analysed, while 12 were excluded due to low *in vitro* culture responsiveness. Statistical analysis was performed using the Mann-Whitney U-test and the treatment-to-control comparison index. The results revealed that shoot fresh weight exhibited the highest variability between treatments, confirming it as a strong indicator of genotypic response to PEG-induced drought stress. Conversely, shoot dry weight showed minimal variability (in only 3 out of 39 ILs) and can be excluded from future analyses. Based on the evaluation, 5 ILs were identified as completely tolerant to PEG treatment while 7 genotypes proved to be highly intolerant. These findings could be of significant practical value, as selected tolerant ILs could be of value for inclusion in breeding programs aimed at improving sunflower drought resilience.

Keywords: sunflower; PEG; drought stress; osmotic tolerance; Mann-Whitney U-test

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ZNAČAJ PRIMENE HIDROLATA ANGELIKE (*ANGELICA ARCHANGELICA L.*) NA KLIJAVOST SEMENA I DUŽINU KLIJANACA RAZLIČITIH LINIJA DVOREDNOG JEČMA (*HORDEUM SATIVUM SSP. DISTICHUM L.*) U IN VIVO USLOVIMA

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Seme dvorednog ječma (*Hordeum sativum ssp. distichum L.*) predstavlja ključnu sirovinu u pivarskoj industriji za dobijanje slada. Jedna od esencijalnih karakteristika semena je njegova klijavost, koja zavisi od brojnih faktora. Cilj ovog istraživanja bio je da se na osnovu prethodno dobijenih rezultata *in vitro* eksperimenata, ispita potencijalni efekat hidrolata *Angelica archangelica* u *in vivo* uslovima, pri koncentraciji od 10 %, koja je pokazala najveći potencijal u prethodnim ispitivanjima. Eksperiment je postavljen u saksijama na šest različitih linija ječma (J1–J6) u tri ponavljanja, sa po pet saksija po tretmanu i pet semena u svakom ponavljanju. Kao kontrola korišćeno je seme tretirano destilovanom vodom. Ogled je praćen u periodu od sedam dana nakon čega je određen broj klijalih semena, merena je dužina stabaceta, sveža i suva masa nadzemnog dela po tretmanu. Utvrđen je značajan uticaj linije i tretmana na analizirane osobine ječma. U proseku za oba tretmana, J3 imala je najveću dužinu stabloceta (8,10 cm), a J6 najmanju (6,90 cm), dok je najveću svežu i suhu masu ostvarila linija J5 (7,10 i 0,45 g), a najmanju J3 (5,22 i 0,35 g). Tretman hidrolatom pozitivno je uticao na sve analizirane osobine kod svih linija ječma, sa značajno većim vrednostima u odnosu na kontrolu. Interakcija linije × tretman nije bila statistički značajna ni za jednu osobinu, što ukazuje na sličan odgovor linija i izostanak promene njihovog rangiranja usled tretmana. Rezultati ukazuju na potencijal hidrolata kao prirodnog biostimulatora u proizvodnji ječma. Međutim, neophodna je sprovesti dalja istraživanja u poljskim uslovima radi potvrde njegove efikasnosti.

Ključne reči: hidrolat, *Angelica archangelica*, linije ječma, seme

Zahvalnica: Istraživanje je finansirano sredstvima Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, broj ugovora 451-03-33/2026-03/200054. Studija je sprovedena u skladu sa Ciljevima održivog razvoja Ujedinjenih nacija (Agenda 2030), a posebno sa ciljem 2 (Iskorenjivanje gladi).

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THE SIGNIFICANCE OF THE APPLICATION OF ANGELICA HYDROLATE (*ANGELICA ARCHANGELICA* L.) ON SEED GERMINATION AND SEEDLING LENGTH OF DIFFERENT LINES OF TWO-ROW BARLEY (*HORDEUM SATIVUM* SSP. *DISTICHUM* L.) IN VIVO CONDITIONS

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Two-row barley seed (*Hordeum sativum* ssp. *distichum* L.) is a key raw material in the brewing industry for malt production. One of the essential characteristics of the seed is its germination capacity, which depends on numerous factors. The aim of this study was to evaluate, based on previously obtained results from *in vitro* experiments, the potential effect of *Angelica archangelica* hydrolate under *in vivo* conditions, at a concentration of 10 %, which showed the greatest potential in previous experiments. The experiment was conducted in pots using six different barley lines (J1–J6) in three replicates, with five pots per treatment and five seeds per replicate. Seeds treated with distilled water were used as the control. The experiment was monitored for seven days, after which the number of sprouted seeds was determined, shoot length was measured for each individual plant, and fresh and dry biomass of the aboveground plant parts was determined for each treatment. A significant effect of line and treatment on the analyzed barley traits. Across both treatments, line J3 had the greatest shoot length (8.10 cm), while J6 had the lowest (6.90 cm). The highest fresh and dry biomass values were recorded in J5 (7.10 and 0.45 g, respectively), whereas J3 had the lowest values (5.22 and 0.35 g, respectively). Treatment with hydrolate had a positive effect on all analyzed traits across all barley line, with significantly higher values compared with the control. The line × treatment interaction was not statistically significant for any of the analyzed traits, indicating a similar response of the line to the treatment and no change in their ranking as a result of hydrolate application. The obtained results, indicate the potential of hydrolate as a natural biostimulant in barley production. However, it is necessary to conduct further research in field conditions to confirm its effectiveness.

Keywords: hydrolate, *Angelica archangelica*, barley lines, seeds

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POREĐENJE PERFORMANSI DVA SREDNJE KASNA HIBRIDA KUKURUZA U RAZLIČITIM MULTILOKACIJSKIM OGLEDIMA

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U toku procesa identifikacije perspektivne hibridne kombinacije, priznavanja hibrida u sortnoj komisiji i odabira najboljih priznatih hibrida za semesku proizvodnju, jedna hibridna kombinacija prođe veći broj ogleda na različitim lokacijama i u različitim godinama gajenja. U ovom radu pokušali smo da prikazemo proces testiranja, kroz ostvarene rezultate dva srednje kasna hibrida kukuruza sa radnim nazivima NS 64613 i NS 64611. Naime reč je o hibridima FAO 500 grupe zrenja, koji imaju jednu liniju-komponentu istu, a druge linije potiču iz iste biparentalne populacije. Performanse hibrida su procenjivane na osnovu rezultata različitih višegodišnjih multilokacijskih ogleda i to: pretkomisijskih 2024, komisijskih 2025. i postkomisijskih 2026. godine. Ako se posmatraju sve lokacije hibrid NS 64613 ostvaruje veći prinos na 56,3% lokacija, međutim ukoliko se u iz obračuna isključi 1/4 odnosno 1/2 lokacija sa najmanjim prinosima, odnos performansi hibrida se značajno menja, te navedeni hibrid bolji od hibrida NS 64611 na tek 50%, odnosno 44,4% lokacija. Na osnovu svega navedenog da bi se napravio odgovarajući izbor hibrida za komercijalno iskorišćavanje treba uzeti u obzir što je veći broj multilokacijskih opservacija, a takođe i performanse roditeljskih linija u semenskoj proizvodnji, odnosno prinos zrna i zdravstveno stanje.

Ključne reči: Kukuruz, prinos zrna, *Zea mays L.*, multilokacijski ogledi, hibridna kombinacija

Zahvalnica: Rad je podržan od strane projekta Fonda za nauku Republike Srbije – program PRIZMA, # 6691, *New biorational methods for stored seed pest control and protection: To serve and prevent – Safeseed*

EVALUATING THE PERFORMANCE OF TWO MID-LATE MAIZE HYBRIDS IN MULTI-LOCATION TRIALS

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During the process of identifying a promising hybrid combination, variety registration and selection the best registered hybrids for seed production, one hybrid combination undergoes a number of trials at different locations and in different growing years. In this paper, we tried to show the testing process, through the achieved results of two mid-late maize hybrids with the working names NS 64613 and NS 64611. Both hybrids are FAO 500 group, having one component line the same, and other lines originating from the same biparental population. The performance of hybrids was evaluated based on the results of various multi-year multi-location trials, namely: pre-registration 2024, registration 2025 and post-registration 2026. If all locations are considered, the hybrid NS 64613 achieves a higher grain yield in 56.3% of locations, however, if 1/4 or 1/2 of the locations with the lowest yields are excluded from the calculation, the performance ratio of the hybrid changes significantly, and the mentioned hybrid is better than the NS 64611 hybrid in only 50%, i.e. 44.4% of locations. Based on all of the above, in order to make an appropriate choice of hybrids for commercial exploitation, it is necessary to take into account as many multi-location observations as possible, as well as the performance of parental lines in seed production, i.e. grain yield and health status.

Keywords: Maize, grain yield, *Zea mays* L., multilocation trials, hybrid combination

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HERITABILNOST KVANTITATIVNIH OSOBINA PŠENICE (*TRITICUM AESTIVUM* L.)

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Heritabilnost (naslednost) osobina pšenice predstavlja značajan kriterijum u oplemenjivanju i predviđanju prinosa useva. Cilj ovog istraživanja je utvrđivanje heritabilnosti pojedinih kvantitativnih osobina biljaka kod 50 sorti ozime pšenice. Eksperiment je sproveden po potpuno slučajnom blok sistemu u tri ponavljanja tokom vegetacione sezone 2016/17. Seme 50 sorti pšenice posejano je na rastojanju od 0,10 m u redovima dužine 1,0 m sa međurednim razmakom od 0,2 m. Šezdeset biljaka u fazi pune zrelosti (20 biljaka po ponavljanju) analizirano je na visinu biljke, dužinu klasa, masu klasa, masu biljke i masu 1000 semena. Rezultati su pokazali značajne razlike između sorti za sve ispitivane osobine. Visoka heritabilnost u širem smislu utvrđena je za sve proučavane osobine: visinu biljke ($h^2 = 98,8\%$), dužinu klasa ($h^2 = 95,0\%$), masu klasa ($h^2 = 83,2\%$), masu biljke ($h^2 = 88,90\%$) i masu 1000 semena ($h^2 = 94,90\%$). Utvrđene su visoko značajne pozitivne korelacije između mase biljke i visine biljke ($r = 0,475$), dužine klasa ($r = 0,326$) i mase semena po biljci ($r = 0,782$), kao i između visine biljke i dužine klasa ($r = 0,656$), i između mase klasa i mase 1000 semena ($r = 0,290$). Na osnovu visokih vrednosti heritabilnosti i genetičke dobiti, može se zaključiti da selekcija za proučavane osobine predstavlja važan kriterijum za efikasnije oplemenjivanje i stvaranje novih sorti.

Ključne reči: genetička varijabilnost, pšenica, heritabilnost, sorta

Zahvalnica: Ovo istraživanje je finansijski podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije, putem grantova br. 451-03-33/2026-03/200040, 451-03-33/2026-03/200054, 451-03-33/2026-03/200216 i projekta TR31092. Ovo istraživanje je usklađeno sa ciljem održivog razvoja 2 (Iskorenjivanje gladi) Agende Ujedinjenih nacija 2030.

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HERITABILITY OF QUANTITATIVE TRAITS IN WHEAT (*TRITICUM AESTIVUM* L.)

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The heritability of wheat traits represents a significant criterion in breeding and predicting crop yields. The goal of the research is to identify the heritability of some quantitative plant traits in 50 winter wheat varieties. The experiment conducted using a randomized complete block design with three replications during the 2016/17 vegetation season. The seeds of 50 wheat varieties were sown at a 0.10 m distance in 1.0 m long rows spaced apart by 0.2 m. Sixty plants at full maturity stage (20 plants per replication) were analyzed for plant height, spike length, spike mass, plant mass, and 1000-grain mass. The results revealed significant differences among varieties for all studied traits. High broad sense heritability was established for all traits studied: plant height ($h^2 = 98.8\%$), spike length ($h^2 = 95.0\%$), spike mass ($h^2 = 83.2\%$), plant mass ($h^2 = 88.90\%$), and 1000-grain mass ($h^2 = 94.90\%$). Highly significant positive correlations were established between plant mass and plant height ($r = 0.475$), spike length ($r = 0.326$), and seed mass per plant ($r = 0.782$), as well as between plant height and spike length ($r = 0.656$), and between spike mass and 1000-grain mass ($r = 0.290$). Based on the high heritability values and genetic gain, it can be concluded that selection for the traits studied represents an important criterion for more efficient breeding and the development of new varieties,

Keywords: Genetic variability, wheat, heritability, variety

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ISTRAŽIVANJE GENOMSKE OSNOVE KVALITETA MESA KOD BUŠE

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Buša predstavlja značajan autohtoni genetički resurs, dobro prilagođen ekstenzivnim sistemima gajenja, ali su kvalitet njenog mesa i genomska osnova relevantnih osobina nedovoljno istraženi, što ograničava mogućnosti njenog održivog korišćenja i selekcijskog unapređenja. Cilj istraživanja bio je da se utvrde fizičko-hemijske osobine i masnokiselinski profil mesa mladih bikova buše i identifikuju SNP markeri i kandidatski geni povezani sa ispitivanim osobinama. Analizirani su uzorci mišića *longissimus dorsi* 40 bikova, prosečne starosti 18 meseci, gajenih u ekstenzivnom sistemu na području Stare planine. Određeni su sadržaj proteina, pH, sposobnost zadržavanja vode, tvrdoća mesa, prečnik mišićnih vlakana i masnokiselinski sastav. Genotipizacija je izvršena BovineSNP50 v3 čipom, a nakon kontrole kvaliteta GWAS analiza je obuhvatila 39 grla i 45.363 SNP markera. Prosečan sadržaj proteina iznosio je 21,64%, pH 5,69, sposobnost zadržavanja vode 12,11 cm², tvrdoća 8,20 kg, a prečnik mišićnih vlakana 32,59 μm. U masnokiselinskom profilu dominirale su zasićene masne kiseline (57,70%), dok je oleinska kiselina bila najzastupljenija pojedinačna masna kiselina (36,13%). Sadržaj proteina bio je negativno povezan sa pH ($r = -0,64$), a pozitivno sa PUFA ($r = 0,58$; $p < 0,05$). Utvrđeno je 13 genomski značajnih SNP-ova povezanih sa prečnikom mišićnih vlakana i jedan sa pH mesa. Kao najvažniji kandidatski geni izdvojeni su APOD, NTMT2 i ZBTB37, dok je ANGPTL3 prepoznat kao mogući kandidat za masnokiselinski profil. Rezultati predstavljaju prvu genomsku osnovu za selekciju buše prema kvalitetu mesa, ali ih je zbog malog uzorka potrebno potvrditi na većoj populaciji.

Ključne reči: buša, kvalitet mesa, masne kiseline, GWAS, SNP

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EXPLORING THE GENOMIC BACKGROUND OF MEAT QUALITY IN BUSHA CATTLE

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Busha cattle are an indigenous genetic resource adapted to extensive production systems, but their meat quality and genomic determinants remain poorly understood, constraining sustainable use and genetic improvement. This study characterised the physicochemical properties and fatty acid profile of meat from young Busha bulls and identified single nucleotide polymorphism (SNP) markers and candidate genes associated with these traits. *Longissimus dorsi* samples were collected from 40 bulls, averaging 18 months of age, reared extensively in the Stara Planina region. Protein content, pH, water-holding capacity, tenderness, muscle fibre diameter and fatty acid composition were determined. Genotyping was performed using the BovineSNP50 v3 BeadChip. Following quality control, the genome-wide association study (GWAS) included 39 animals and 45,363 SNP markers. Mean protein content was 21.64%, pH 5.69, water-holding capacity 12.11 cm², tenderness 8.20 kg and muscle fibre diameter 32.59 µm. Saturated fatty acids predominated (57.70%), while oleic acid was the most abundant fatty acid (36.13%). Protein content was negatively correlated with pH ($r = -0.64$) and positively correlated with polyunsaturated fatty acids ($r = 0.58$; $p < 0.05$). Thirteen genome-wide significant SNPs were associated with muscle fibre diameter and one with meat pH. APOD, NTMT2 and ZBTB37 were key candidate genes, while ANGPTL3 emerged as a candidate for the fatty acid profile. These findings provide an initial genomic basis for selecting Busha cattle for meat quality traits; however, validation in a larger population is required due to the limited sample size.

Keywords: Busha cattle, meat quality, fatty acids, GWAS, SNP

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OCENA I KORELACIJA AGRONOMSKIH KARAKTERISTIKA I KVALITETA KOKIČAVOSTI HIBRIDA KUKURUZA KOKIČARA (ZEA MAYS L. EVERTA)

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Kukuruz kokičar predstavlja specifičan tip kukuruza tvrdunca, koji se kroz istoriju gajio prvenstveno kao namirnica za ljudsku ishranu. Njegova agronomska i tehnološka vrednost ogleda se u kombinaciji prinosa i kvaliteta kokičavosti. U ovom istraživanju ocenjivane su osobine: zapremina kokičavosti (cm^3/g), prinos (t/ha), broj zrna u 10 g, procenat neiskokanih zrna (%), kao i izvedena osobina zapremina kokičavosti po hektaru (m^3/ha). Ogled je izveden u toku jedne godine na dve lokacije u tri ponavljanja, po RCBD modelu. Ispitavano je 12 ZP hibrida, od kojih su dva bili standardi, a 10 eksperimentalnih. Povezanost osobina analizirana je prostom korelacijom, a uticaj na zapreminu kokičavosti path analizom. Najveći prinos ostvarili su Hibrid 8 ($8,006 \text{ t}/\text{ha}$) i Hibrid 3 ($7,517 \text{ t}/\text{ha}$). Prema zapremini kokičavosti Hibrid 8 je rangiran na 11. mestu ($40,5 \text{ cm}^3/\text{g}$), a Hibrid 3 na 8. ($42,75 \text{ cm}^3/\text{g}$), svi hibridi su ispunili komercijalne zahteve ($>40 \text{ cm}^3/\text{g}$). Prema izvedenoj osobini zapremina po hektaru, Hibrid 8 zauzeo je prvo mesto ($324 \text{ m}^3/\text{ha}$), a Hibrid 3 drugo ($321,35 \text{ m}^3/\text{ha}$). Svi hibridi svrstani su u krupnozrne ($<62 \text{ zrna}/10 \text{ g}$), dok je procenat neiskokanih zrna bio nizak ($0,55\text{--}3,46\%$). Korelacionom analizom utvrđena je jaka negativna veza između prinosa i zapremine kokičavosti ($r=-0.716$) i umereno pozitivna između broja zrna i zapremine kokičavosti ($r=0.402$). Path analizom utvrđen je najveći direktan (-0.632) i ukupni efekat (-0.678) prinosa na zapreminu kokičavosti, dok je broj zrna imao pozitivan direktan (0.355) i ukupan efekat (0.402). Korišćeni model objasnio je $63,4\%$ varijabilnosti zapremine kokičavosti ($R^2=0,634$). Dobijeni rezultati ukazuju na značaj istovremenog sagledavanja agronomskih i tehnoloških osobina u selekciji hibrida kukuruza kokičara, pri čemu zapremina kokičavosti po hektaru predstavlja korisnu izvedenu osobinu za procenu njihove ukupne proizvodne i tehnološke vrednosti.

Ključne reči: kukuruz kokičar, zapremina kokičavosti, korelacija, path analiza

Zahvalnica: Ova istraživanja predstavljaju rezultat rada u okviru Institucionalnog projekta Instituta za kukuruz „Zemun Polje“, evidencioni broj 451-03-33/2026-03/200040, finansiranog od strane Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije. Istraživanja su u skladu sa Ciljevima održivog razvoja Ujedinjenih nacija, posebno sa Ciljem 2 – Iskorenjivanje gladi (Zero Hunger).

EVALUATION AND CORRELATION OF AGRONOMIC TRAITS AND POPPING QUALITY OF POPCORN MAIZE (ZEA MAYS L. EVERTA) HYBRIDS

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Popcorn is a specific type of flint maize, historically cultivated as food for human consumption. Its agronomic and technological value is derived from the combination of yield and popping quality. In this study, the following traits were evaluated: popping volume (cm³/g), yield (t/ha), number of kernels per 10 g, percentage of unpopped kernels (%), and the derived trait—popping volume per hectare (m³/ha). The experiment lasted one year, conducted at two locations with three replications, using the RCBD model. Twelve hybrids were examined, two standards and ten experimental. Correlations among traits were calculated using simple correlation, while the effects on popping volume were analyzed with path analysis. The highest yields were achieved by Hybrid 8 (8.006 t/ha) and Hybrid 3 (7.517 t/ha). According to popping volume, Hybrid 8 ranked 11th (40.5 cm³/g) and Hybrid 3 ranked 8th (42.75 cm³/g), with all hybrids meeting commercial requirements (>40 cm³/g). Based on popping volume per hectare, Hybrid 8 ranked first (324 m³/ha), while Hybrid 3 ranked second (321.35 m³/ha). All hybrids were classified as large-kernel types (<62 kernels/10 g), while the percentage of unpopped kernels was low (0.55–3.46%). Correlation analysis revealed a strong negative correlation between yield and popping volume ($r=-0.716$) and a moderate positive correlation between kernel number and popping volume ($r=0.402$). Path analysis showed that yield had the greatest direct (-0.632) and total effect (-0.678) on popping volume, while kernel number had a positive direct (0.355) and total effect (0.402). The applied model explained 63.4% of the variability in popping volume ($R^2=0.634$). The obtained results highlight the importance of simultaneously considering agronomic and technological traits in popcorn hybrid selection, with popping volume per hectare representing a useful derived trait for evaluating their overall production and technological value.

Keywords: popcorn maize, popping volume, correlation, path analysis

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ZAŠTITA PRAVA OPLEMENJIVAČA BILJNIH SORTI IZ PERSPEKTIVE ZAKONA O SEMENU I SADNOM MATERIJALU

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Intelektualna svojina u oblasti prava oplemenjivača biljnih sorti je u Srbiji pravno uređena Zakonom o zaštiti prava oplemenjivača biljnih sorti. Zakon daje pravo vlasništva oplemenjivaču u pogledu date sorte. Zatim definiše obim prava i propisuje aktivnosti koje je dozvoljeno preduzimati kao i one koje nije dozvoljeno preduzimati koristeći materijal zaštićene sorte uz saglasnost nosioca prava. U slučaju povrede prava u našem pravnom sistemu moguća je upravna i građansko pravna zaštita. Za ostvarivanje upravne zaštite do sada je bila nadležna samo Uprava carina, dok su za građansku zaštitu nadležni sudovi. Građanska zaštita obezbeđuje se: tužbom u vezi sa kršenjem prava oplemenjivača i tužbom za utvrđivanje prava oplemenjivača. Novim Zakonom o semenu i sadnom materijalu poljoprivrednog i ukrasnog bilja obezbeđena je upravna zaštita za oplemenjivače. Ovaj zakon se primenjuje na grupe i vrste semena i sadnog materijala poljoprivrednog i ukrasnog bilja. U tekstu zakona je naglašeno da se zaštićena sorta za proizvodnju i uvoz semena i sadnog materijala može koristiti samo iz ovlašćenje nosioca prava oplemenjivača, odnosno uz zaključen ugovor o licenci u skladu sa propisima koji uređuju zaštitu sorti. Kontrola postojanja ovlašćenja se vrši prilikom prijave proizvodnje, prilikom inspekcijskog nadzora i uvoza. Ukoliko pravno lice nije nosilac prava, a nema ovlašćenje nosioca, odnosno ugovor o licenci za proizvodnju semena zaštićene sorte kažnjava se novčanom kaznom za privredni prestup, pri čemu može da mu se izrekne i zaštitna mera zabrane bavljenja određenom privrednom delatnošću.

Ključne reči: oplemenjivač, biljna sorta, seme, sadni materijal

PROTECTION OF PLANT BREEDERS RIGHTS FROM THE PERSPECTIVE OF THE LAW ON SEEDS AND PLANTING MATERIAL

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Intellectual property in the field of plant breeders' rights is legally regulated in Serbia by the Law on the Protection of Plant Breeders' Rights. The law assigns ownership rights to the breeder in respect of a given variety. It defines the scope of the right and prescribes the activities that are allowed to be undertaken as well as those that are not allowed to be undertaken using the material of the protected variety with the consent of the right holder. In case of violation of rights in our legal system, administrative and civil legal protection is possible. Until now, only the Customs Administration was responsible for administrative protection, while courts are responsible for civil protection. Civil protection is ensured by: a lawsuit related to the violation of the breeder's rights and a lawsuit to determine the rights of the breeder. The new Law on Seeds and Planting Material of Agricultural and Ornamental Plants provides administrative protection for breeders. This law applies to groups and types of seeds and planting material of agricultural and ornamental plants. The text of the law emphasizes that a protected variety for the production and import of seeds and planting material can only be used with the authorization of the breeder's right holder, i.e. with a concluded license agreement in accordance with the regulations governing the protection of varieties. Control of the existence of authorization is carried out during the registration of production, during inspection supervision and importation. If the legal entity is not the holder of the right, and does not have the authorization of the holder, i.e. the contract for the license for the production of seeds of a protected variety, it is punished with a fine for an economic offense, whereupon it can also be imposed a protective measure prohibiting it from engaging in a certain economic activity.

Keywords: breeder, plant variety, seed, planting material

ZASTUPLJENOST VRSTA KOMPLEKSA *FUSARIUM FUJIKUROI* NA ZRNU STRNIH ŽITA U SRBIJI

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Ukupno 380 uzoraka zrna strnih žita (pšenica, ječam, tritikale i durum pšenica) sakupljeni su iz skladišta sedam dana nakon žetve sa 55 lokaliteta u Srbiji radi analize zastupljenosti vrsta kompleksa *Fusarium fujikuroi*. Zrna su sterilisana, i zatim postavljena na KDA (krompir dekstrozni agar) podlogu gde su u termostatu inkubirana pri 25°C. Nakon sedam dana posmatrane su kolonije gljiva razvijene na i oko zrna. Na osnovu mikroskopskih karakteristika (lanci mikrokonidija, način grananja i formiranje monofijalida i polifijalida) ukupno 146 izolata je preliminarno identifikovano kao izolati vrsta *F. fujikuroi* kompleksa. Za identifikaciju svih izolata korišćeni su prajmeri VER1/VER2 i FV-F2/FV-R (specifični za vrstu *Fusarium verticillioides*), PRO1/PRO2 par prajmera (specifičan za vrstu *Fusarium proliferatum*), FS-F1/FS-R, FS-F2/FS-R i SUB1/SUB2 (specifični za vrstu *Fusarium subglutinans*). Molekularnom analizom, 68 izolata identifikovano je kao vrsta *F. verticillioides*, 46 izolata kao *F. proliferatum* dok je 32 izolata identifikovano kao *F. subglutinans*. Sve tri vrste gljiva izolovane su sa zrna sve četiri biljne vrste. Najčešće izolovana vrsta sa zrna pšenice bila je *F. verticillioides* (52% izolata), zatim *F. proliferatum* (30% izolata) i *F. subglutinans* (18% izolata). Izolati vrsta *F. verticillioides* i *F. proliferatum* sa zrna durum pšenice bile su približno isto zastupljeni (36% i 35% izolata), dok je vrsta *F. subglutinans* bila manje zastupljena (18% izolata). Iz zrna ječma zastupljenost izolata sve tri vrste bila je ista. Sa zrna tritikalea, kao i sa zrna pšenice, *F. verticillioides* je bila najčešće izolovana vrsta (42% izolata), a zatim *F. proliferatum* (33% izolata) i *F. subglutinans* (25% izolata).

Ključne reči: *F. verticillioides*, *F. proliferatum*, *F. subglutinans*, strna žita, molekularna identifikacija

Zahvalnica: Ovo istraživanje je finansirano od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor br. 451-03-33/2026-03/200040; Ciljevi održivog razvoja – *zero hunger, climate action, life on land*).

OCCURRENCE OF *FUSARIUM FUJIKUROI* SPECIES COMPLEX ON CEREAL GRAINS IN SERBIA

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A total of 380 samples of small grain cereals (wheat, barley, triticale and durum wheat) were collected from storage seven days after harvest from 55 localities in Serbia to analyze the occurrence of *Fusarium fujikuroi* species complex. The grains were sterilized, and then placed on a PDA (Potato dextrose agar) substrate and incubated in a thermostat at 25°C. After seven days, fungal colonies developed on and around the grains were observed. Based on microscopic characteristics (chains of microconidia, type of branching and presence of monophialides and polyphialides), a total of 146 isolates were preliminarily identified as isolates of *F. fujikuroi* complex species. For the identification of all isolates, primers VER1/VER2 and FV-F2/FV-R (specific for *Fusarium verticillioides* species), PRO1/PRO2 pair of primers (specific for *Fusarium proliferatum* species), FS-F1/FS-R, FS-F2/FS-R and SUB1/SUB2 (specific for *Fusarium subglutinans* species) were used. After molecular analysis, 68 isolates were identified as *F. verticillioides*, 46 isolates as *F. proliferatum*, while 32 isolates were identified as *F. subglutinans*. All three species were isolated from the grains of all four plant species. The most frequently isolated species from wheat grain was *F. verticillioides* (52% of isolates), followed by *F. proliferatum* (30% of isolates) and *F. subglutinans* (18% of isolates). Isolates of the species *F. verticillioides* and *F. proliferatum* from durum wheat grains were approximately equally represented (36% and 35% of the isolates), while the species *F. subglutinans* was identified in 18% of the isolates. The presence of all three species in barley grains was equal. Species *F. verticillioides* was the most frequently isolated from triticale grains (42% of isolates), followed by *F. proliferatum* (33% of isolates) and *F. subglutinans* (25% of isolates).

Keywords: *F. verticillioides*, *F. proliferatum*, *F. subglutinans*, small grain cereals, molecular identification

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GENETIČKA EVALUACIJA MORFOLOŠKIH OSOBINA KLIPA KOD KUKURUZA ŠEĆERCA

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Poboljšanje morfoloških osobina klipa hibridizacijom predstavlja jedan od osnovnih pravaca savremenog oplemenjivanja kukuruza (šećerca) usmerenog ka povećanju prinosa. Eksperimentalna ukrštanja sprovedena su tokom 2024 i 2025 godine, dok su ispitivanja fenotipa linija i eksperimentalnih hibrida rađena 2026 godine. Kao majčinska komponenta korišćena je inbred linija L27, dok su kao očinske komponente korišćene linije L24 i L25. Ukrštanjem su dobijeni eksperimentalni hibridi EXH1 (L27 × L24) i EXH2 (L27 × L25). Analizom varijanse (ANOVA) utvrđen je statistički vrlo značajan uticaj genotipa na dužinu klipa (CL), broj redova zrna (NKR) i ukupnu težinu klipa (TWC). Hibrid EXH1 ostvario je najveće prosečne vrednosti dužine (23,6 cm) i težine klipa (348,0 g), dok je linija L25 zabeležila najniže vrednosti (12,0 cm i 134,5 g). Isti prosečan broj redova zrna (18,0) utvrđen je kod hibrida EXH1 i EXH2, kao i kod linije L27. Analiza glavnih komponenti (PCA) pokazala je da prve dve komponente objašnjavaju 90,0 % ukupne varijanse (PC1 = 65,8 %, PC2 = 24,2 %). Utvrđena je veoma jaka pozitivna korelacija između dužine klipa i njegove ukupne težine, uz dominantan uticaj dužine klipa na ukupnu težinu klipa. Dobijeni rezultati potvrđuju izražen heterozis za morfološke osobine klipa kod hibrida EXH1, što ga čini perspektivnim genotipom za dalje oplemenjivačke programe usmerene ka povećanju prinosa.

Ključne reči: kukuruz šećerac, hibridizacija, heterozis, dužina klipa, težina klipa.

Zahvalnica: Istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor broj 451-03-33/2026-03/200216). Naša studija je usklađena sa Agendom Ujedinjenih nacija za održivi razvoj do 2030. godine, tačnije sa Ciljem 2: iskorenjavanje gladi, Ciljem 12: Održiva proizvodnja.

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GENETIC EVALUATION OF THE MORPHOLOGICAL CHARACTERISTICS OF THE EAR IN SWEET CORN

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Improving the morphological characteristics of the ear through hybridisation represents one of the basic directions in modern corn (sugar) breeding aimed at increasing yields. We carried out experimental crossings in 2024 and 2025, and conducted phenotypic tests on lines and experimental hybrids in 2026. We used inbred line L27 as the maternal component, while lines L24 and L25 served as paternal components. Experimental hybrids EXH1 (L27 × L24) and EXH2 (L27 × L25) were obtained by crossing. Analysis of variance (ANOVA) revealed a significant influence of genotype on ear length (CL), number of kernel rows (NKR), and total ear weight (TWC). The EXH1 hybrid achieved the highest average values for length (23.6 cm) and ear weight (348.0 g), while the L25 line recorded the lowest values (12.0 cm and 134.5 g). Hybrids EXH1 and EXH2, as well as line L27, had the same average number of kernel rows (18.0). Principal component analysis (PCA) showed that the first two components explained 90.0% of the total variance (PC1 = 65.8%, PC2 = 24.2%). An extremely strong positive correlation was found between ear length and total ear weight, with ear length strongly influencing TWC. The obtained results confirm pronounced heterosis for the morphological characteristics of the ear in the EXH1 hybrid, which makes it a promising genotype for further breeding programs aimed at increasing yield.

Keywords: sweet corn, hybridization, heterosis, ear length, ear weight.

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FIZIOLOŠKI I BIOHEMIJSKI ODGOVORI AUTOHTONE I UVEZENE SORTE PASULJA (*PHASEOLUS VULGARIS* L.) NA DEFICIT VODE U USLOVIMA PRIMENE BIOLOŠKIH TRETMANA

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Biološki tretmani predstavljaju perspektivan pristup unapređenju održivosti poljoprivredne proizvodnje, posebno u uslovima sve izraženijih abiotičkih stresova povezanih sa klimatskim promenama. Pasulj (*Phaseolus vulgaris* L.) je značajna proteinska i povrtarska kultura, čiji su rast i produktivnost posebno osetljivi na deficit vode i visoke temperature. Ispitivanje autohtonih genotipova pruža uvid u njihove adaptivne mehanizme i potencijal za održivu proizvodnju, kao i osnovu za poređenje sa uvezenim sortama. Cilj ovog istraživanja bio je da se uporede odbrambeni mehanizmi autohtone sorte Tetovac i uvezene sorte belog pasulja u uslovima deficita vode, sa fokusom na odgovor biljaka na primenu različitih biopreparata. Sadržaj hlorofila *a*, *b* i karotenoida određen je spektrofotometrijski nakon ekstrakcije u 80% acetonu, dok je koncentracija prolina određena metodom sa kiselim ninhidrinom. Među ispitivanim tretmanima, *Prolagin* je bio povezan sa najvećim sadržajem ukupnog hlorofila kod obe sorte, sa vrednostima od 34.46 mg/g FW kod Tetovca i 29.46 mg/g FW kod uvezene sorte. Suprotno tome, primena suspenzije kvasca (*S. cerevisiae*) bila je praćena izraženim smanjenjem sadržaja fotosintetskih pigmenata. Najizraženiji porast prolina zabeležen je kod Tetovca nakon tretmana *Levoaminom* u poređenju sa kontrolom, uz istovremeno smanjenje ukupnog hlorofila. Rezultati ukazuju na izraženiji adaptivni odgovor autohtone sorte Tetovac, potvrđujući značaj genotipskih karakteristika u odgovoru pasulja na deficit vode i primenu bioloških tretmana.

Ključne reči: pasulj; suša; biostimulatori; genotip; fotosintetski pigmenti.

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PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF AUTOCHTHONOUS AND INTRODUCED COMMON BEAN CULTIVARS (*PHASEOLUS VULGARIS* L.) TO WATER DEFICIT UNDER BIOLOGICAL TREATMENTS

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Biological treatments represent a promising approach to enhancing the sustainability of agricultural production, particularly under increasingly pronounced abiotic stresses associated with climate change. Common bean (*Phaseolus vulgaris* L.) is an important protein and vegetable crop, whose growth and productivity are particularly sensitive to water deficit and high temperatures. The investigation of autochthonous genotypes provides insight into their adaptive mechanisms and potential for sustainable production, as well as a basis for comparison with introduced cultivars. The aim of this study was to compare the defense mechanisms of the autochthonous cultivar Tetovac and an introduced white bean cultivar under water deficit conditions, with a focus on plant responses to the application of different biopreparations. The contents of chlorophyll *a*, *b*, and carotenoids were determined spectrophotometrically following extraction in 80% acetone, while proline concentration was determined using the acid ninhydrin method. Among the treatments evaluated, *Prolagin* was associated with the highest total chlorophyll content in both cultivars, with values of 34.46 mg/g FW in Tetovac and 29.46 mg/g FW in the introduced cultivar. In contrast, application of a yeast suspension (*S. cerevisiae*) was associated with a pronounced reduction in photosynthetic pigment content. The most pronounced increase in proline was recorded in Tetovac following *Levoamin* treatment compared with the control, accompanied by a decrease in total chlorophyll content. The results indicate a more pronounced adaptive response of the autochthonous cultivar Tetovac, highlighting the importance of genotype-specific characteristics in determining bean responses to water deficit and biological treatments.

Keywords: common bean; drought stress; biostimulants; genotype; photosynthetic pigments

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MORFOLOŠKA VARIJABILNOST SEMENA BUKVE (FAGUS SYLVATICA L.) U FUNKCIJI OČUVANJA GE- NETIČKIH RESURSA

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Bukva je najbrojnija vrsta drveća u šumskom fondu Srbije, čije se sastojine primarno obnavljaju metodom prirodne obnove. Očuvanje varijabilnosti prirodnih populacija predstavlja važan preduslov dugoročne stabilnosti i adaptacije bukovih šuma, posebno u uslovima klimatskih promena. Morfološke karakteristike semena, kao jedna od komponenti fenotipske varijabilnosti populacija, mogu pružiti korisne informacije za karakterizaciju genetičkih resursa vrste. Cilj ovog rada bio je da se utvrdi nivo varijabilnosti morfoloških karakteristika semena bukve poreklom iz 11 populacija: Fruška gora, Južni Kučaj, Boranja, Stara planina, Rudnik, Goč, Severni Kučaj, Jelova gora, Kukavica, Jastrebac i Javor. Izmereno je 180 semena po populaciji, ukupno 1980. Izmerene su dužina, širina i debljina semena, kao i masa. Sve analize obavljene su u R okruženju. Utvrđene su statistički značajne razlike između populacija ($p < 0,001$), pri čemu je u ukupnoj varijansi udeo unutarpopulacione varijabilnosti bio znatno veći od međupopulacione ($R^2=0,889152$ i $R^2=0,110848$, respektivno). Analizom glavnih komponenti objašnjeno je 80,2% ukupne varijabilnosti, pri čemu je dužina semena imala najveći, a širina najmanji doprinos diferencijaciji analiziranog materijala. Prosečna dužina semena iznosila je $16,5 \pm 1,4$ mm, sa prosečnim vrednostima populacija od 15,1 mm (Stara planina) do 17,3 mm (Jastrebac i Rudnik). Masa semena bila je najvarijabilniji ($CV=21,8\%$), a dužina najmanje varijabilan parametar ($CV=8,8\%$). Dobijeni rezultati ukazuju na dominantan udeo unutarpopulacione varijabilnosti, izraženu morfološku raznovrsnost semena unutar istraživanih populacija i doprinose morfološkoj karakterizaciji bukve u Srbiji, predstavljajući polaznu osnovu za dalja istraživanja, konzervaciju i održivo korišćenje genetičkih resursa.

Ključne reči: evropska bukva, morfometrija semena, varijabilnost, populacije, genetički resursi

MORPHOLOGICAL VARIABILITY OF BEECH (*FAGUS SYLVATICA* L.) SEEDS FOR THE CONSERVATION OF GENETIC RESOURCES

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Beech is the most numerous tree species in the forest fund of Serbia, with its stands primarily regenerated through natural regeneration. Maintaining the variability of natural populations is important basis for the long-term stability and adaptation of beech forests, especially in conditions of climate change. Seed morphological traits, as one of the components of phenotypic variability of populations, can provide useful information for the characterization of genetic resources of a species. The aim of this study was to assess the variability of morphological traits of beech seeds originating from 11 populations: Fruška gora, Južni Kučaj, Boranja, Stara planina, Rudnik, Goč, Severni Kučaj, Jelova gora, Kukavica, Jastrebac and Javor. A total of 1980 seeds were analyzed (180/population). Seed length, width and thickness, as well as seed mass, were measured, with all analyses performed in the R environment. Statistically significant differences between populations were found ($p < 0.001$). Total variance the share of intrapopulation variability was significantly higher than interpopulation ($R^2 = 0.889152$ and $R^2 = 0.110848$, respectively). Principal component analysis explained 80.2% of the total variation, with seed length contributing most and seed width least to the differentiation of the analyzed material. Mean seed length was 16.5 ± 1.4 mm, with population means ranging from 15.1 mm (Stara planina) to 17.3 mm (Jastrebac, Rudnik). Seed mass was the most variable trait ($CV = 21.8\%$), whereas seed length was the least variable ($CV = 8.8\%$). The obtained results indicate a dominant share of intrapopulation variability, and pronounced morphological diversity of seeds within the studied populations. They contribute to the morphological characterisation of beech in Serbia and provide a basis for further research, conservation and sustainable use of genetic resources.

Keywords: European beech, seed morphometry, variability, populations, genetic resources

HEMIJSKI SASTAV RAZLIČITIH DELOVA BILJKE BOBA U FAZI CVETANJA I FORMIRANJA MAHUNA

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Hemijski sastav biljke boba (*Vicia faba* L.) značajno se menja tokom faze cvetanja i formiranja mahuna na prelazu iz vegetativne u generativnu fazu. Početkom faze formiranja mahuna, počinje aktivna preraspodela hranljivih materija i njihovo usmeravanje iz vegetativnih u generativne organe. Tokom 2024. i 2025. godine na oglednom polju Instituta za krmno bilje Kruševac, ispitivano je šest perspektivnih linija boba koje su se u prethodnim ispitivanjima istakle po agronomskim osobinama. Postavljen je ogled po slučajnom blok sistemu u tri ponavljanja a uzorci su uzimani u dve faze: 1) pre cvetanja: listovi i stablo; i 2) na početku formiranja mahuna: listovi, stablo i mlade mahune. Ispitivane su sledeće osobine: suva materija, skrob, mineralne materije, sirovi proteini, celuloza, ukupni šećeri i monosaharidi. Dobijene su značajne razlike kod većine ispitivanih osobina, kako između linija, tako i između različite faze razvoja biljke. Najveći prosečni sadržaj sirovih proteina bio je kod mladih mahuna sa zrnom (28,6%) a sličan sadržaj proteina (28%) je bio kod listova u fazi pre cvetanja. Najveći prosečni sadržaj ukupnih šećera (9,3%) i monosaharida (8,7%) je bio kod listova u fazi pre cvetanja. Najniži sadržaj proteina, ukupnih šećera i monosaharida je bio u stablu u obe faze uzorkovanja. Sa stanovišta korišćenja cele biljke boba za stočnu hranu, najbolje je koristiti svežu biomasu u fazi formiranja mladih mahuna jer tada već postoji dovoljna količina listova, koji osim nezrelih mahuna, najviše doprinose kvalitetu biomase.

Ključne reči: sveža biomasa, proteini, ukupni šećeri, monosaharidi

Zahvalnica: Ovo istraživanje je deo Institucionalnog projekta finansiranog od strane Ministarstva nauke, tehnološkog razvoja i inovacija, broj ugovora 451-03-33/2026-03/200217

CHEMICAL COMPOSITION OF DIFFERENT PARTS OF THE FABA BEAN PLANT DURING FLOWERING AND POD FORMATION

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The chemical composition of the faba bean plant (*Vicia faba* L.) varies significantly throughout the flowering and pod production phase, which marks the transition from the vegetative to the generative phase. During the pod formation phase, nutrients are actively redistributed and directed from vegetative to generative organs. During 2024 and 2025, six promising faba bean lines that stood out in previous tests for their agronomic properties were tested on the experimental field of the Institute for forage crops Kruševac. The experiment was set up in three repetitions using the random block design, with samples collected in two phases: 1) before flowering: leaves and stem, and 2) at the start of pod development: leaves, stem, and immature pods. The dry matter, starch, minerals, crude protein, cellulose, total sugars, and monosaccharides were all measured. The majority of the investigated traits showed significant variations between lines and between plant developmental stages. Young pods containing seeds had the highest average crude protein content (28.6%), while leaves at the pre-flowering stage had a comparable protein level (28%). The leaves in the pre-flowering period had the highest average total sugar content (9.3%), and monosaccharides (8.7%). The stem had the lowest protein, total sugars, and monosaccharide content during both samplings. In terms of using faba bean plant for fodder, it is better to use fresh biomass during the formation of young pods because there is already a sufficient amount of green leaves, which, aside from immature pods, contribute the most to the biomass quality.

Keywords: fresh biomass, proteins, total sugars, monosaccharides

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INHIBITOR TRIPSINA KAO EKOLOŠKO REŠENJE U SKLADIŠTIMA: EFEKAT NA KLIJAVOST SEMENA I RANI PORAST KLIJANACA

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Jedan od najvažnijih zadataka u semenarstvu je očuvanje kvaliteta i životne sposobnosti semena, kao i smanjenje gubitaka u poslešetvenom periodu. Usled klimatskih promena i povećanja brojnosti štetni insekti predstavljaju sve veći problem prilikom skladištenja. Donedavno je primena hemijskih sredstava bila ključna za održavanje brojnosti insekata u skladištima, ali su negativne posledice usloville ograničenja ili zabranu upotrebe većine insekticida, te su se istraživanja usmerila na iznalaženje bioracionalnog i ekološki prihvatljivog rešenja. Tripsin inhibitori imaju visoku efikasnost u suzbijanju štetnih insekata skladišta, međutim ostaje nerazjašnjeno njihovo dejstvo na kvalitet semena i parametre rasta klijanaca. U tom smislu, cilj istraživanja je bio da se utvrdi da li tretman semena inhibitorima tripsina utiče na klijavost semena i rani porast klijanaca. Istraživanje je sprovedeno na semenu običnog pasulja (tip žutozeleni) i kukuruza (tip zubana), a testiran je inhibitor soje u koncentraciji 0,5%, 1% i 5%, dok je kontrola bila netretirano seme. Klijavost je ispitana standardnim testom na filter papiru, u četiri ponavljanja. Ispitivane koncentracije imale su pozitivan uticaj na klijavost pasulja, značajno kod tretmana sa 5%, dok kod kukuruza uticaja nije bilo. Primenjeni tretmani usloveli su i povećanje dužine klijanaca pasulja, utičući pre svega na značajno povećanje dužine korena pri tretmanima sa 5% i 1%. S druge strane, kod kukuruza je uočeno negativno dejstvo inhibitora na rast klijanaca, i značajno smanjenje dužine korena pri tretmanu sa 0,5%. Može se zaključiti da inhibitor tripsina soje ima potencijal kao rešenja za bezbedno skladištenje semena, ali i da istraživanja treba proširiti i na druge biljne inhibitore kako bi se iznašlo rešenje za širi spektar semena.

Ključne reči: pasulj, kukuruz, tripsin inhibitor, klijavost, dužina klijanaca

Zahvalnica: Istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (451-03-33/2026-03/ 200032) i Fond za nauku Republike Srbije, #6691, New biorational methods for stored seed pest control and protection: To serve and prevent – SafeSeed. Ovaj rad je deo aktivnosti u okviru Centra izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na promene klime – Climate Crops Instituta za ratarstvo i povrtarstvo, Instituta od nacionalnog značaja za Republiku Srbiju, Novi Sad, Srbija.

TRYPSIN INHIBITOR AS AN ECOLOGICAL SOLUTION IN STORAGE: THE EFFECT ON SEED GERMINATION AND EARLY SEEDLING GROWTH

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One of the most important tasks in seed production is preserving seed quality and viability, as well as reducing losses in the post-harvest period. Due to climate change and increasing populations, insect pests represent a growing problem during storage. Until recently, the application of chemical agents was crucial for managing insect populations in warehouses; however, negative consequences have led to restrictions or bans on the use of most insecticides, shifting research toward finding biorational and environmentally friendly solutions. Trypsin inhibitors exhibit high efficacy in controlling stored-product insect pests; however, their effect on seed quality and seedling growth parameters remains unclear. In this regard, the aim of this research was to determine whether trypsin inhibitors seed treatments affects germination and early seedling growth. The study was conducted on common bean seeds (yellow-green type) and maize (dent type), testing a soybean inhibitor at concentrations of 0.5%, 1%, and 5%, while untreated seeds served as the control. Germination was tested with a standard test on filter paper, in four replicates. The tested concentrations had a positive effect on bean germination, which was significant in the 5% treatment, while there was no effect on maize. The applied treatments also led to an increase in bean seedling length, primarily affecting a significant increase in root length at the 5% and 1% treatments. On the other hand, a negative effect of the inhibitor on seedling growth was observed in maize, with a significant reduction in root length at the 0.5% treatment. It can be concluded that the soybean trypsin inhibitor has potential as a solution for safe seed storage, but also that research should be expanded to other plant inhibitors to find a solution for a wider range of seeds.

Keywords: bean, maize, trypsin inhibitor, germination, seedling length

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EFIKASNOST UPOTREBE AZOTA U ISTORIJSKOJ KOLEKCIJI SORTI PŠENICE

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U savremenom oplemenjivanju pšenice, pored stvaranja sorti visokog potencijala za prinos, sve više pažnje se posvećuje osobinama koje obezbeđuju stabilnu i racionalnu proizvodnju. Efikasnost upotrebe azota (NUE) se izdvaja kao ključna osobina koja omogućava ostvarivanje visokih i stabilnih prinosa uz smanjenu primenu azotnih đubriva. Unapređenje ove osobine dobija sve veći značaj zbog potrebe za optimizacijom troškova proizvodnje, ograničavanjem gubitaka azota i smanjenjem njegovog negativnog uticaja na životnu sredinu. U cilju proučavanja promena u NUE i njenim komponentama – efikasnosti usvajanja azota (NUpE) i efikasnosti iskorišćenja usvojenog azota (NUE), na eksperimentalnom polju Instituta za ratarstvo i povrtarstvo na Rimskim Šančevima, ispitivana je istorijska kolekcija sorti ozime pšenice razvijenih u periodu od 1930. do 2015. godine. Sorte su gajene pri dva nivoa obezbeđenosti azotom – bez primene mineralnog azota i uz 100 kg N ha⁻¹. Vrednosti ispitivanih osobina su značajno zavisile od sorte, nivoa obezbeđenosti azotom i njihove interakcije, pri čemu je uticaj đubrenja bio najizraženiji. Na kontrolnom tretmanu zabeležena je veća prosečna vrednost NUE za približno 32 kg zrna kg⁻¹ N, u odnosu na varijantu sa primenom azotnog đubriva. Najniža vrednost NUE na kontrolnom tretmanu je zabeležena kod najstarije sorte Banatka (54,5 kg zrna kg⁻¹ N), dok su savremene sorte NS Mila, Sirtaki i Apač ostvarile vrednosti iznad 90 kg zrna kg⁻¹ N. Utvrđena je pozitivna linearna povezanost između godine priznavanja sorte i ispitivanih osobina, posebno na kontrolnom tretmanu. Rezultati potvrđuju napredak u oplemenjivanju pšenice ka većoj NUE i ukazuju na njen značaj za racionalnije korišćenje azota u proizvodnji.

Ključne reči: azot, sorta, *Triticum aestivum* L.

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NITROGEN USE EFFICIENCY IN A HISTORICAL COLLECTION OF WHEAT CULTIVARS

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Modern wheat breeding focuses not only on developing high-yielding cultivars but also on improving traits that contribute to stable and resource-efficient production. Nitrogen use efficiency (NUE) is recognized as an important trait for achieving high and stable yields under reduced nitrogen fertilizer application. Improving this trait is becoming increasingly important for enhancing input-use efficiency, reducing nitrogen losses, and minimizing environmental impacts. Changes in NUE and its components, nitrogen uptake efficiency (NUpE) and nitrogen utilization efficiency (NUE) were examined in a historical set of winter wheat cultivars released between 1930 and 2015 under field conditions at the Institute of Field and Vegetable Crops, Rimski Šančevi, Serbia. The cultivars were evaluated under two nitrogen supply levels: without mineral nitrogen fertilization and with 100 kg N ha⁻¹. The values of the investigated traits were significantly influenced by cultivar, nitrogen fertilization level, and their interaction, with the effect of nitrogen fertilization being the most pronounced. The control treatment showed a higher average NUE value, by approximately 32 kg grain kg⁻¹ N, compared with the fertilized treatment. The lowest NUE value under the control treatment was recorded for the oldest cultivar, Banatka (54.5 kg grain kg⁻¹ N) whereas the modern cultivars NS Mila, Sirtaki, and Apač achieved values above 90 kg grain kg⁻¹ N. A positive linear relationship was found between the year of cultivar release and the investigated traits, particularly under the control treatment. The results indicate genetic progress towards improved NUE and its importance for efficient nitrogen use in wheat production.

Keywords: nitrogen, variety, *Triticum aestivum* L.

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OCENA RODITELJSKIH GENOTIPOVA I F₁ HIBRIDA INDUSTRIJSKOG PARADAJZA U CILJU UNAPREĐENJA PRINOSA I KVALITETA PLODA

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Proizvodnja industrijskog paradajza u velikoj meri zavisi od genotipa, zbog čega oplemenjivači teže stvaranju hibrida koji objedinjuju visok prinos i poželjne tehnološke osobine ploda. Cilj ovog istraživanja bio je da se procene komponente prinosa i kvalitet roditeljskih genotipova i F₁ hibrida industrijskog paradajza, kao i da se izdvoje perspektivne kombinacije za dalje oplemenjivanje. Ispitivani materijal obuhvatio je četiri roditeljska genotipa, SP-109, Chico, Narvik i C3, i četiri F₁ kombinacije: 1IH (SP-109 × Chico), 2IH (Chico × SP-109), 8IH (Chico × Narvik) i 9IH (Chico × C3). Analizirane su masa ploda, prečnik i visina ploda, debljina perikarpa, sadržaj ukupno rastvorljivih suvih materija (TSS) i pH vrednost. Dobijeni podaci statistički su obrađeni analizom varijanse, dok je heterozis procenjen u odnosu na srednju vrednost roditelja i boljeg roditelja. Utvrđene su značajne razlike između genotipova za ispitivane osobine. Narvik je imao najveću masu i prečnik ploda, dok se među hibridima 8IH izdvojio po visokoj masi i prečniku ploda, kao i najnižoj pH vrednosti. Hibrid 2IH izdvojio se visokom vrednošću visine ploda i najvećom debljinom perikarpa, uz istovremeno nisku pH vrednost. Dodatno, 2IH je ispoljio pozitivan heterozis za više ispitivanih osobina, sa posebno izraženim efektom za masu ploda, debljinu perikarpa i TSS, dok je za TSS i debljinu perikarpa nadmašio i boljeg roditelja. Hibrid 9IH je imao najviši TSS među hibridima, dok je roditeljski genotip C3 imao najveću vrednost ove osobine. Dobijeni rezultati ukazuju na različit potencijal ispitivanih roditeljskih kombinacija i izdvajaju 2IH i 8IH kao perspektivne hibride za dalje oplemenjivanje industrijskog paradajza, posebno u pogledu kombinovanja proizvodnih i tehnoloških osobina ploda.

Ključne reči: *Solanum lycopersicum* L., komponente prinosa, tehnološki kvalitet ploda, heterozis

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EVALUATION OF PARENTAL GENOTYPES AND F1 HYBRIDS OF INDUSTRIAL TOMATOES TO IMPROVE FRUIT YIELD AND QUALITY

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The production of industrial tomatoes largely depends on the genotype, which drives breeders to develop hybrids that combine high yield with desirable technological fruit traits. This study aimed to evaluate the yield components and quality of parental genotypes and F1 hybrids of industrial tomatoes, as well as to identify promising combinations for further breeding. In this study we examined four parental genotypes: SP-109, Chico, Narvik, and C3, alongside four F₁ hybrid combinations: 1IH (SP-109 × Chico), 2IH (Chico × SP-109), 8IH (Chico × Narvik), and 9IH (Chico × C3). Fruit weight, fruit diameter and height, pericarp thickness, total soluble solids content (TSS), and pH value were analyzed. The obtained data were statistically analyzed using analysis of variance (ANOVA), while heterosis was evaluated relative to the mid-parent and better-parent values. The results indicated significant differences among the genotypes for the traits examined. Narvik had the highest fruit weight and diameter, while among hybrids, 8IH stood out for its high fruit weight and diameter, as well as the lowest pH value. Hybrid 2IH was characterized by high fruit height and the greatest pericarp thickness, along with a concomitantly low pH value. Furthermore, 2IH displayed positive heterosis for several examined traits, with a particularly pronounced effect on fruit weight, pericarp thickness, and TSS, outperforming the better parent for both TSS and pericarp thickness. Hybrid 9IH had the highest TSS among the hybrids, whereas the parental genotype C3 had the highest value of this trait. The obtained results indicate the different potential among the evaluated parental combinations, highlighting 2IH and 8IH as promising hybrids for further breeding of industrial tomatoes, particularly regarding the integration of productive and technological fruit traits.

Ključne reči: *Solanum lycopersicum* L., yield components, technological fruit quality, heterosis

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POTENCIJAL ZA PRINOS NOVIH SORTI PŠENICE

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Povećanje prinosa pšenice predstavlja jedan od ključnih faktora za unapređenje poljoprivredne proizvodnje. Pored poboljšanja agrotehničkih mera, uvođenje novih sorti pšenice značajno doprinosi daljem povećanju prinosa zrna. U radu su prikazani rezultati mikroogleda sa 10 sorti pšenice, stvorenih u Institutu za ratarstvo i povrtarstvo u Novom Sadu, gajenih na tri lokaliteta tokom vegetacione sezone 2024/2025. godine. Cilj istraživanja bio je evaluacija potencijala za prinos ispitivanih sorti radi donošenja preporuka za njihovo uvođenje u široku proizvodnju. Analiza varijanse ukazala je na statistički značajan uticaj sorte, lokaliteta, kao i njihove interakcije na prinos zrna. Prosečan prinos zrna u zavisnosti od sorte kretao se u rasponu od 6,38 t ha⁻¹ (Zvezdana) do 8,62 t ha⁻¹ (NS Supernova), dok je prosečan prinos po lokalitetima varirao od 5,98 t ha⁻¹ (Subotica) do 9,59 t ha⁻¹ (Novi Sad). Usled značajne interakcije između sorte i spoljašnje sredine, pojedinačne sorte su imale različite performanse na specifičnim lokalitetima. Sorta NS Supernova ostvarila je najveći prinos na lokalitetu Novi Sad (11,02 t ha⁻¹), dok je sorta NS Alnora ostvarila najviši prinos na lokalitetu Subotica (6,67 t ha⁻¹). Dobijeni rezultati potvrđuju neophodnost multilokacijskih ispitivanja radi precizne procene proizvodnog potencijala novih genotipova. Na osnovu sprovedenih istraživanja, kao najperspektivnija nova sorta se izdvojila NS Supernova, koja je visok potencijal rodnosti pokazala na većini posmatranih lokaliteta.

Ključne reči: interakcija genotip × sredina, prinos zrna, pšenica

Zahvalnica: Ovo istraživanje je finansirano od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (broj ugovora: 451-03-33/2026-03/200032).

YIELD POTENTIAL OF NEW WHEAT VARIETIES

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Increasing wheat yield represents one of the key factors for enhancing agricultural production. In addition to improving agrotechnical measures, the introduction of new wheat cultivars significantly contributes to further increases in grain yield. This study presents the results of micro-trial with 10 wheat cultivars, developed at the Institute of Field and Vegetable Crops in Novi Sad, grown at three locations during the 2024/2025 growing season. The aim of the research was to evaluate the yield potential of the tested cultivars in order to provide recommendations for their introduction into large-scale production. Analysis of variance revealed a statistically significant effect of cultivar, location, and their interaction on grain yield. The average grain yield depending on the cultivar ranged from 6,38 t ha⁻¹ (Zvezdana) to 8,62 t ha⁻¹ (NS Supernova), while the average yield across locations ranged from 5,98 t ha⁻¹ (Subotica) to 9,59 t ha⁻¹ (Novi Sad). Due to the significant cultivar-by-environment interaction, individual cultivars exhibited different performance at specific locations. The cultivar NS Supernova achieved the highest yield at the Novi Sad location (11,02 t ha⁻¹), whereas the cultivar NS Alnora recorded the highest yield at the Subotica location (6,67 t ha⁻¹). The obtained results confirm the necessity of multi-location trials for the accurate assessment of the production potential of new genotypes. Based on the conducted research, NS Supernova emerged as the most promising new cultivar, which demonstrated high yield potential at most of the observed locations.

Keywords: genotype × environment interaction, grain yield, wheat

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KARAKTERIZACIJA EVROPSKE KOLEKCIJE JAROG GOLOZRNOG JEČMA KAO RESURSA ZA OPLEMENJIVANJE U SRBIJI

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U Srbiji se golozrni ječam gaji na manje od 5% ukupnih površina pod ječmom. Imajući u vidu pozitivan uticaj svakodnevnog konzumiranja golozrnog ječma na ljudsko zdravlje, jedan od prioriteta u njegovom oplemenjivanju je stvaranje novih sorti adaptiranih na našu agroklimatsku zonu. Stoga, ispitivanje genetičkog materijala iz kolekcija banaka gena predstavlja važan korak u identifikaciji genotipova pogodnih za dalje oplemenjivanje. Cilj ovog rada bio je da se u našim agroklimatskim uslovima izvrši karakterizacija bogate kolekcije genotipova poreklom iz banke gena IPK, Nemačka. Ogled je obuhvatao 300 genotipova postavljenih po proširenom blok dizajnu u 2023. i 2024. godini na Rimskim šančevima. Ekperimentalni dizajn uključivao je 6 blokova sa po 10 standarda u svakom bloku, što je činilo ukupno 360 parcelica veličine 1 m². Tokom i nakon vegetacionih sezona beleženi su vreme klasanja, visina biljaka, broj klasova po m², masa hiljadu zrna (MHZ), prinos zrna po parcelici, žetveni indeks, biomasa, hektolitar, dužina klasa i broj zrna po klasu. Rezultati su pokazali izraženu varijabilnost ispitivanih svojstava između genotipova i godina. Najveća varijabilnost utvrđena je za prinos u 2023. godini (58,1%), a najmanja za hektolitar u 2024. godini (4,6%). Analiza međusobne povezanosti svojstava pokazala je najveću pozitivnu korelaciju između biomase i prinosa (0,89), dok je najveća negativna korelacija utvrđena između hektolitarske mase i MHZ (-0,39). U poređenju sa 2023. godinom, tokom 2024. godine zabeležene su veće prosečne vrednosti broja klasova, MHZ i broja zrna po klasu, što je bilo praćeno i većim prosečnim prinosom zrna, koji je iznosio 317,8 g u odnosu na 120 g u 2023. godini. Dobijeni rezultati ukazuju da kolekcija IPK poseduje značajan genetički diverzitet ispitivanih svojstava, **što je važan preduslov za izbor početnog materijala sa potencijalom za stvaranje novih sorti sa poboljšanim agronomskim performansama.**

Ključne reči: *Hordeum vulgare* L. var. *nudum*, genetički diverzitet, predoplemenjivanje, komponente prinosa

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CHARACTERIZATION OF A EUROPEAN COLLECTION OF SPRING HULLESS BARLEY AS A RESOURCE FOR BREEDING IN SERBIA

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In Serbia, hulless barley is grown on less than 5% of the total area under barley. Considering the potential health benefits associated with regular consumption of hulless barley, one of the priorities in its breeding is the development of new varieties adapted to our agroclimatic zone. Therefore, the evaluation of genetic material from genebank collections represents an important step in identifying genotypes suitable for further breeding. The aim of this study was to characterize, under our agroclimatic conditions, a rich collection of genotypes originating from the IPK genebank, Germany. The experiment included 300 genotypes arranged according to an augmented block design in 2023 and 2024 at Rimski Šančevi. The experimental design included 6 blocks with 10 checks in each block, resulting in a total of 360 plots of 1 m². During and after the growing seasons, heading time, plant height, number of spikes per m², thousand-grain weight (TGW), grain yield per plot, harvest index, biomass, hectolitre mass, spike length, and number of grains per spike were recorded. The results showed pronounced variability in the evaluated traits among genotypes and years. The highest variability was observed for grain yield in 2023 (58.1%), while the lowest was observed for hectolitre mass in 2024 (4.6%). Analysis of the relationships among traits showed the strongest positive correlation between biomass and grain yield (0.89), whereas the strongest negative correlation was found between hectolitre mass and TGW (-0.39). Compared with 2023, higher mean values for the number of spikes, TGW, and number of grains per spike were recorded in 2024, accompanied by a higher mean grain yield, which amounted to 317.8 g compared with 120 g in 2023. The obtained results indicate that the IPK collection possesses substantial genetic diversity for the evaluated traits, which is an important prerequisite for the selection of starting material with the potential to develop new varieties with improved agronomic performance.

Keywords: *Hordeum vulgare* L. var. *nudum*, genetic diversity, pre-breeding, yield components

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UTICAJ NISKIH TEMPERATURA NA MORFOLOŠKE OSOBINE ADAPTIRANIH LINIJA KUKURUZA POVEĆANOG KVALITETA PROTEINA

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Kukuruz je jedna od najznačajnijih gajenih kultura širom sveta. Međutim, suša i visoke temperature tokom reproduktivne faze razvoja negativno utiču na prinos i kvalitet zrna. Jedna od strategija za izbegavanje ovih stresnih uslova jeste rana setva, ali niske prolećne temperature mogu nepovoljno uticati na klijanje i rast u ranim fazama razvoja. Zbog toga je cilj ovog rada bio ispitivanje odgovora četiri linije (L1-L4) kukuruza povećanog kvaliteta proteina (QPM) na stres niskim temperaturama tokom germinacije i rasta klijanaca, kako bi se identifikovali genotipovi pogodni za ranu setvu. Klijanci su gajeni 14 dana u fitotronsnoj komori (vlažnost vazduha 60%, fotoperiod 12/12h, intenzitet svetlosti 700 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Primenjena su dva temperaturna režima: optimalni uslovi za rano proleće (19 °C/11 °C) i stres niskim temperaturama (dva dana 19 °C/11 °C, zatim 20 °C/13,7 °C, 9,4 °C/6,3 °C, 6,5 °C/3,5 °C, svaka po tri dana). Nakon perioda stresa (11. dan) i nakon oporavka (14. dan), analizirane su morfološke osobine korena, izdanka i celog klijanca, uključujući površinu, dužinu, svežu i suhu masu. U odnosu na koren, osobine nadzemnog dela klijanca jače su bile pogođene niskim temperaturama, verovatno zbog njihove direktne izloženosti stresu. Nakon perioda oporavka, kod svih ispitivanih linija uočeno je značajno poboljšanje većine ispitivanih osobina. Posebno se izdvojila L4, kod koje su sve praćene osobine pokazale statistički značajno poboljšanje, ukazujući na potpuniji oporavak i efikasnije uspostavljanje normalnih fizioloških procesa nakon izlaganja stresu. Dobijeni rezultati predstavljaju značajan doprinos oplemenjivačkim programima usmerenim na razvoj QPM genotipova sa povećanom tolerantnošću prema niskim temperaturama u ranim fazama razvoja.

Ključne reči: kukuruz povećanog kvaliteta proteina, rana setva, stres niskim temperaturama, klijanci, morfološke osobine

Zahvalnica: Ovaj rad je podržan od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor No. 451-03-33/2026-03/200040). Istraživanje je u skladu sa ciljem 2 – Svet bez gladi Ujedinjenih Nacija 2030 Agende o Održivom Razvoju.

COLD STRESS EFFECTS ON MORPHOLOGICAL TRAITS IN ADAPTED QUALITY PROTEIN MAIZE SEEDLINGS

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Maize is one of the world's most important crops. However, its productivity is severely affected by the combined effects of drought and high-temperature stress during the reproductive phase, resulting in reduced grain yield and quality. Early sowing may help plants avoid these stresses, but low spring temperatures can negatively affect germination and early seedling growth. Therefore, this study evaluated the response of four (L1-L4) quality protein maize (QPM) lines to low-temperature stress during germination and early seedling development to identify genotypes suitable for early sowing. Seedlings were grown in a growth chamber (humidity 60%, photoperiod 12/12 h, and light intensity $700 \mu\text{mol m}^{-2} \text{s}^{-1}$) under early spring optimal (19 °C/11 °C) and cold-stress (19 °C/11 °C for two days, followed by 20 °C/13.7 °C, 9.4 °C/6.3 °C, 6.5 °C/3.5 °C, and 19 °C/11 °C, three days each) conditions for 14 days. Root, shoot and seedling morphological traits (surface area, length, fresh and dry weight) were measured after the stress period (day 11) and after recovery (day 14). Compared with root traits, shoot traits exhibited more pronounced responses, possibly because shoots are directly exposed to low temperatures. Following recovery, most traits showed significant improvement across all lines. Notably, L4 was the only line in which all evaluated traits improved significantly, suggesting a more complete restoration of normal physiological processes. The findings provide valuable information for breeding programs aimed at developing QPM genotypes with improved tolerance to early-season low-temperature stress.

Keywords: quality protein maize, early sowing, cold stress, seedling growth, morphological traits

Acknowledgement: This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040). This research is in line with Goal 2 – Zero Hunger of the United Nations 2030 Agenda for Sustainable Development.

GUSTINA USEVA I NJENA ULOGA U ADAPTACIJI POLJOPRIVREDNIH SISTEMA NA KLIMATSKE PROMENE

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Klimatske promene postale su jedan od glavnih izazova za održivost modernih poljoprivrednih sistema zbog sve učestalije suše, visokih temperatura i neredovnih padavina. U tom kontekstu, optimizacija gustine biljaka je važna agronomska praksa koja može poboljšati toleranciju useva na abiotiski stres i doprineti stabilnosti prinosa. Eksperiment je sproveden tokom dve vegetacione sezone koristeći šest hibrida kukuruza koji pripadaju grupi zrenja FAO 400, u tri gustine: D1 (40.000 biljaka ha⁻¹), D2 (69.000 biljaka ha⁻¹) i D3 (98.000 biljaka ha⁻¹). Uticaj gustine biljaka procenjen je u četiri faze razvoja zrna: 15, 25, 35 i 45 dana nakon oprašivanja (DAP). Rezultati ukazuju na jasne razlike između kombinacija gustine biljaka × faze razvoja (D × V) za sve analizirane osobine. Najviše srednje vrednosti sadržaja suve materije zrna (određene na 60°C, 105°C i 130°C) zabeležene su u tretmanu D3V4, dok su najniže vrednosti primećene u D2V4. Isto tako, najviše vrednosti morfoloških osobina, uključujući svežu i suhu masu lista ispod klipa (MLK, SMLK), površinu lista ispod klipa i komušine (LPK, LPŠ) i svežu i suhu masu komušine (MŠ, SMŠ), generalno su postignute u D3V4. Multivarijaciona analiza varijanse (MANOVA) potvrdila je veoma značajan uticaj gustine biljaka na analizirane osobine (Pilajev trag = 0,396; Vilksova lambda = 0,649; p < 0,001), dok efekti godine i interakcije gustina × godina nisu bili značajni (p > 0,05). Ovi nalazi ukazuju da optimizacija gustine biljaka može poboljšati performanse kukuruza i doprineti otpornosti sistema gajenja na promenljive klimatske uslove.

Ključne reči: kompeticija biljka, optimizacija resursa, prinos

Zahvalnica: Ovo istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije u okviru projekta br. 451-03-33/2026-03/200040, koji je realizovao Institut za kukuruz „Zemun Polje“ i Istraživačko razvojnog instituta "Tamiš" br. 451-03-33/2026-03/200116. Studija je usklađena sa Agendom Ujedinjenih nacija za održivi razvoj do 2030. godine i doprinosi ostvarivanju njenih Ciljeva održivog razvoja (CDG), posebno onih koji se odnose na održivu poljoprivredu, klimatske promene i odgovorno upravljanje prirodnim resursima.

PLANT DENSITY AND ITS ROLE IN THE ADAPTATION OF AGRICULTURAL SYSTEMS TO CLIMATE CHANGE

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Climate change has become one of the major challenges to the sustainability of modern agricultural systems due to the increasing frequency of drought, high temperatures, and irregular precipitation patterns. In this context, optimizing plant density is an important agronomic practice that can improve crop tolerance to abiotic stress and contribute to yield stability. A field experiment was conducted over two growing seasons using six maize hybrids belonging to the FAO 400 maturity group. Three plant densities were evaluated: D1 (40,000 plants ha⁻¹), D2 (69,000 plants ha⁻¹), and D3 (98,000 plants ha⁻¹). The effect of plant density was assessed at four grain development stages: 15, 25, 35, and 45 days after pollination (DAP). Results revealed clear differences among the plant density × developmental stage (D × V) combinations for all analyzed traits. The highest mean values of grain dry matter content (determined at 60°C, 105°C, and 130°C) were recorded in the D3V4 treatment, while the lowest values were observed in D2V4. Likewise, the highest values of morphological traits, including fresh and dry mass of the leaf below the ear (MLK, SMLK), leaf area of the leaf below the ear and husk (LPK, LPŠ), and fresh and dry husk mass (MŠ, SMŠ), were generally achieved in D3V4. Multivariate analysis of variance (MANOVA) confirmed a highly significant effect of plant density on the analyzed traits (Pillai's Trace = 0.396; Wilks' Lambda = 0.649; $p < 0.001$), whereas the effects of year and the density × year interaction were not significant ($p > 0.05$). These findings indicate that optimizing plant density can enhance maize performance and contribute to the resilience of cropping systems under changing climatic conditions.

Keyword: plant competition, resource optimization, yield

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GRAĐANSKA NAUKA KAO SREDSTVO ZA PROMOCIJU OČUVANJA POLJOPRIVREDNOG BIODIVERZITETA I ODRŽIVE POLJOPRIVREDE

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Klimatske promene i gubitak biodiverziteta predstavljaju velike izazove za održivu poljoprivredu i očuvanje tradicionalnih biljnih genetičkih resursa. Cilj ove studije bio je da se procene stavovi ispitanika o klimatskim promenama, biodiverzitetu i održivoj poljoprivredi, kao i njihova informisanost i spremnost za učešće u inicijativama građanske nauke. Istraživanje je obuhvatilo 91 ispitanika, koji se pretežno bave poljoprivredom (88,9%), pri čemu je većina angažovana u proizvodnji ratarskih kultura (78,9%). Većina ispitanika imala je završeno srednje obrazovanje (64,4%), a učesnici su predstavljali sve starosne grupe u rasponu od 20 do 70 godina. Visok procenat ispitanika (93,2%) prepoznao je klimatske promene kao problem, dok je 84,1% izrazilo interesovanje za teme vezane za klimatske promene. Zabrinutost zbog gubitka biodiverziteta takođe je bila izražena, pri čemu je 88,4% ispitanika izrazilo zabrinutost. Kada je reč o održivoj poljoprivredi, 62,0% ispitanika pokazalo je interesovanje za ovu temu, dok je 62,9% pokazalo da je upoznato sa pojmom biodiverziteta. Znanje o građanskoj nauci bilo je relativno ograničeno, s obzirom na to da je 73,0% odgovora ukazivalo na nedovoljno poznavanje tog pojma. Ipak, 80,9% ispitanika izrazilo je interesovanje za učešće u inicijativama građanske nauke. Prethodno iskustvo u volontiranju navelo je samo 1,2% ispitanika, što ukazuje na značajan jaz između prethodnog angažovanja i spremnosti za učešće. Sveukupno, rezultati ukazuju na visoku svest o ekološkim izazovima i značajan potencijal za učešće javnosti u građanskoj nauci. Ovi nalazi podržavaju razvoj aktivnosti građanske nauke prilagođenih lokalnim uslovima, usmerenih na promovisanje održive poljoprivrede, očuvanje tradicionalnih sorti biljaka i unapređenje poljoprivredne biodiverziteta.

Ključne reči: participativno istraživanje, autohtone sorte, tradicionalno znanje

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CITIZEN SCIENCE AS A TOOL FOR PROMOTING AGRICULTURAL BIODIVERSITY CONSERVATION AND SUSTAINABLE AGRICULTURE

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Climate change and biodiversity loss represent major challenges for sustainable agriculture and the conservation of traditional plant genetic resources. The aim of this study was to assess respondents' attitudes towards climate change, biodiversity, and sustainable agriculture, as well as their awareness of and willingness to participate in citizen science initiatives. The survey included 91 respondents, predominantly engaged in agriculture (88.9%), and the majority engaged in the production of field crops (78.9%). The majority of respondents had completed secondary education (64.4%), with participants representing all age groups within the 20–70-year age range. A high percentage of respondents (93.2%) recognized climate change as a problem, while 84.1% expressed interest in climate change issues. Concern about biodiversity loss was also high, with 88.4% of respondents expressing concern. Regarding sustainable agriculture, 62.0% reported interest in this topic, while 62.9% showed recognition of the concept of biodiversity. Knowledge of citizen science was relatively limited, with 73.0% of responses indicating insufficient recognition of the concept. However, 80.9% expressed interest in participating in citizen science initiatives. Previous volunteering experience was reported by only 1.2% of respondents, indicating a significant gap between previous engagement and willingness to participate. Overall, the results show a high awareness of environmental challenges and a significant potential for public participation in citizen science. These findings support the development of locally adapted citizen science activities aimed at promoting sustainable agriculture, preserving traditional plant varieties and enhancing agricultural biodiversity.

Keywords: participatory research, indigenous variety, traditional knowledge.

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FENOTIPIZACIJA I FIZIOLOŠKA OSNOVA FORMIRANJA PRINOSA PŠENICE

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Primena savremenih metoda fenotipizacije omogućava identifikaciju sekundarnih osobina koje se nalaze u bliskoj vezi sa prinosom pšenice i utiču na njegovo formiranje. Kontinuirana merenja različitih vegetacionih indeksa tokom sezone, poput NDVI vrednosti, omogućavaju izračunavanje brojnih stay-green (SG) osobina. Kako bi se procenila varijabilnost prinosa i SG osobina pšenice, kao i povezanost ovih osobina sa prinosom, skup genotipova ozime pšenice gajen je tokom dve vegetacione sezone. Primenom analize logističke krive za praćenje promene NDVI vrednosti od cvetanja do fiziološke zrelosti, izračunate su vrednosti ovog indeksa tokom različitih faza starenja useva, odnosno smanjenja "stay green" (Nmax, kao i N90 do N10), kao i dužina trajanja ovih faza (OnS, MidS i EndS). Prinos zrna pšenice bio je u najvećoj asocijaciji sa NDVI vrednostima u ranim fazama nakon cvetanja, dok se nastavkom vegetacije ova veza smanjuje. Kao visokoprinosni ideotip pšenice identifikovani su genotipovi sa odloženim početkom starenja (OnS), koji održavaju visoke NDVI vrednosti tokom cvetanja i početnih faza gubitka zelenila, a zatim pokazuju pad u kasnijim fazama u nastavku vegetacione sezone. Prema tome, primena savremenih alata za fenotipizaciju mogla bi olakšati implementaciju ove metodologije za bržu i lakšu ocenu linija u ranijim generacijama, čime se ubrzava razvoj visokoprinosnih genotipova pšenice.

Ključne reči: fenotipizacija, pšenica, NDVI vrednost, prinos

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PHENOTYPING AND THE PHYSIOLOGICAL BASIS OF WHEAT YIELD FORMATION

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The application of modern phenotyping methods enables the identification of secondary traits that are closely associated with wheat yield and contribute to its formation. Continuous measurements of various vegetation indices, such as NDVI, enable the calculation of numerous stay-green (SG) traits. To assess the variability of wheat yield and SG traits, as well as the relationships between these traits and yield, a set of winter wheat genotypes was grown over two growing seasons. By applying logistic curve analysis to monitor changes in NDVI values from flowering to physiological maturity, NDVI values were calculated for different stages of crop senescence, i.e. the decline in “stay-green” (Nmax, as well as N90 to N10), together with the duration of these stages (OnS, MidS, and EndS). Wheat grain yield was most strongly associated with NDVI values during the early stages after flowering, whereas this relationship decreased as the growing season progressed. Genotypes characterized by a delayed onset of senescence (OnS), which maintained high NDVI values during flowering and the initial stages of greenness loss, followed by a decline during the later stages of the growing season, were identified as high-yielding wheat ideotypes. Therefore, the application of modern phenotyping tools could facilitate the implementation of this methodology for faster and easier evaluation of breeding lines at earlier generations, thereby accelerating the development of high-yielding wheat genotypes.

Keywords: phenotyping, wheat, NDVI value, yield

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PHENO-DROP – New PHENO-ideotypes for DROught resilience in hexaPloid wheat (001739961 2025 13440 003 000 020 014 03 001)

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ISPITIVANJE INBRED LINIJA KUKURUZA POREKLOM IZ DVE SINTETIČKE POPULACIJE

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U procesu stvaranja samooplodnih linija kukuruza, pored dobrih osobina *per se*, izbor se zasniva i na dobrim kombinacionim sposobnostima odgovarajućih inbred linija kao roditelja u test ukrštanjima. Zbog toga je ispitivanje opštih (OKS) i posebnih (PKS) kombinacionih sposobnosti novostvorenih linija nezaobilazno u procesu hibridnog oplemenjivanja kukuruza. U ovom radu su prikazani rezultati ispitivanja inbred linija dobijenih iz različitih ciklusa selekcije, iz dve sintetičke populacije, BSSS i BSCB₁. Cilj je bio da se za osobinu dužina klipa ispituju kombinacione sposobnosti, heterozis kao i varijabilnost inbred linija i njihovih hibrida. Dobijeni hibridi su imali veće prosečne vrednosti za ispitivanu osobinu u odnosu na linije, što je i očekivano, obzirom da pri inbridingu dolazi do depresije osobina kod linija. Analizom varijanse kombinacionih sposobnosti ustanovljene su visoko značajne pozitivne vrednosti OKS i PKS za obe lokacije i obe godine. Rezultati test ukrštanja linije iz BSSS populacije i linije, roditelja elitnog hibrida, pokazali su da neaditivni efekti gena preovlađuju u nasleđivanju ove osobine, što se vidi iz odnosa OKS/PKS koji je manji od jedinice. Nasuprot tome, rezultati inbred linije iz sintetika BSCB₁ su ukazali na veći značaj aditivne varijanse. Utvrđeno je da su najbolji opšti kombinatori linije ZPL1 i ZPL2. Hibridi u kojima učestvuju ove linije su ispoljili visoko značajne vrednosti za ispitivanu osobinu u obe godine. Ovi hibridi uključuju oba roditelja sa dobrim OKS ili jednog roditelja sa dobrim OKS i drugog sa lošim OKS vrednostima.

Ključne reči: kukuruz, varijabilnost, kombinaciona sposobnost, dužina klipa

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EVALUATION OF MAIZE INBRED LINES DERIVED FROM TWO SYNTHETIC POPULATIONS

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In the process of developing maize inbred lines, selection is based not only on the *per se* performance of the lines but also on their combining ability as parents in test crosses. Therefore, the evaluation of the general combining ability (GCA) and specific combining ability (SCA) of newly developed lines is an essential component of hybrid maize breeding. This study presents the results of inbred lines derived from different cycles of selection from two synthetic populations, BSSS and BSCB1. The aim was to assess the combining abilities, heterosis, and variability of the inbred lines and their hybrids for ear length. The hybrids exhibited higher mean values for the evaluated trait than the parental inbred lines, as expected, since inbreeding depression generally reduces the expression of most morphological traits. ANOVA for combining ability revealed highly significant effects of both GCA and SCA at both locations and in both years. In the test crosses of line derived from the BSSS population and the tester, non-additive gene effects predominated in the inheritance of ear length, as indicated by the GCA/SCA ratio. In contrast, the results obtained for the inbred lines from the BSCB1 synthetic population indicated a greater contribution of additive genetic variance. The ZPL1 and ZPL2 inbred lines were identified as the best general combiners. Hybrids involving these lines exhibited highly significant values for ear length in both years of evaluation. These hybrids included either two parents with good GCA or one parent with good GCA and the other with poor GCA.

Key words: maize, variability, combining ability, ear length

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PROCENA SADRŽAJA INULINA U TUBERIMA RAZLIČITIH POPULACIJA *HELIANTHUS TUBEROSUS* L. PRI PROLEĆNOM VAĐENJU

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Jerusalimska artičoka (*Helianthus tuberosus* L.) je višegodišnja vrsta iz porodice Asteraceae, poznata po sposobnosti akumulacije rezervnih ugljenih hidrata u obliku fruktana inulinskog tipa u tuberima. U proleće, na početku novog vegetacionog perioda, rezerve inulina podležu metaboličkoj mobilizaciji i predstavljaju značajan izvor ugljenika i energije za rani vegetativni razvoj. Varijabilnost sadržaja inulina među populacijama može odražavati razlike u stanju rezervi ugljenih hidrata i njihovom potencijalu da podrže ponovni vegetativni rast. Cilj ovog istraživanja bio je da se ispita varijabilnost sadržaja inulina među pet divljih populacija *H. tuberosus*, čiji su tuberi uzorkovani u aprilu 2026. godine nakon prezimljavanja u poljskim uslovima. Sadržaj inulina u tuberima određen je tečnom hromatografijom visokih performansi uz primenu detektora indeksa prelamanja (HPLC-RID). Među ispitivanim populacijama uočena je izražena varijabilnost, pri čemu se sadržaj inulina kretao od 11,20 do 41,51 g/100 g suve materije (SM). Najviše vrednosti utvrđene su kod populacija *H. tuberosus* 6 (41,51 g/100 g SM) i *H. tub* 15 (32,34 g/100 g SM), što može ukazivati na bolje očuvanje rezervi ugljenih hidrata tokom zime i, posledično, veću raspoloživost ugljenika i energije za prolećno klijanje i rani vegetativni rast. Nasuprot tome, niže vrednosti utvrđene su kod populacija *H. tub* 1959 (22,70 g/100 g SM), *H. tub* 1704 (20,41 g/100 g SM) i *H. tub* 675 (11,20 g/100 g SM), što može ukazivati na veće korišćenje rezervi ugljenih hidrata tokom zimskog perioda. Dobijeni rezultati ukazuju na izraženu varijabilnost prolećnih rezervi inulina među divljim populacijama *H. tuberosus*, koja može odražavati populaciono specifične razlike u dinamici metabolizma rezervnih ugljenih hidrata tokom prezimljavanja. Veće rezerve inulina utvrđene kod populacija *H. tuberosus* 6 i *H. tuberosus* 15 mogu ukazivati na bolju prilagođenost uslovima prezimljavanja i veći potencijal za ponovni vegetativni rast u proleće, što ove populacije čini vrednim genetičkim resursima za dalja oplemenjivačka istraživanja i potencijalno gajenje.

Ključne reči: inulin, rezerve ugljenih hidrata, *H. tuberosus*, prezimljavanje

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ASSESSMENT OF INULIN CONTENT IN TUBERS OF DIFFERENT *HELIANTHUS TUBEROSUS* L. POPULATION AT SPRING HARVEST

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Jerusalem artichoke (*Helianthus tuberosus* L.) is a perennial species of the Asteraceae family known for its ability to accumulate carbohydrates in the form of inulin-type fructans in its tubers. In spring, at the beginning of a new growing season, inulin reserves undergo metabolic mobilization, serving as a major source of carbon and energy for early vegetative development. Variation in inulin content among populations may reflect differences in carbohydrate reserve status and their potential to support renewed growth. The aim of this study was to evaluate the variability in inulin content among five wild *H. tuberosus* populations harvested in April 2026 after overwintering under field conditions. Inulin content was determined using high-performance liquid chromatography coupled with a refractive index detector (HPLC-RID). Considerable variation was observed among populations, with values ranging from 11.20 to 41.51 g/100 g dry matter (DM). The highest inulin content was recorded for populations *H. tuberosus* 6 (41.51 g/100 g DM) and *H. tub* 15 (32.34 g/100 g DM), indicating better preservation of carbohydrate reserves during winter and, consequently, a greater availability of carbon and energy for spring sprouting and early vegetative growth. In contrast, lower values were found in *H. tub* 1959 (22.70 g/100 g DM), *H. tub* 1704 (20.41 g/100 g DM), and *H. tub* 675 (11.20 g/100 g DM) suggesting greater utilization of carbohydrate reserves during the winter period. These findings highlight substantial variability in spring inulin reserves among wild *H. tuberosus* populations, reflecting population-specific differences in carbohydrate dynamics during overwintering. The higher inulin reserves observed in *H. tuberosus* 6 and *H. tuberosus* 15 may indicate greater adaptability and a higher potential for spring regrowth, making them valuable genetic resources for further breeding and cultivation programs.

Keywords: inulin, carbohydrates reserves, *H. tuberosus*, overwintering

KARAKTERIZACIJA KAROTENOIDA U PLODOVIMA CUCURBITA BILJAKA: SADRŽAJ I SASTAV

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Istraživanje je sprovedeno sa ciljem utvrđivanja varijabilnosti sadržaja i sastava karotenoida u mesu zrelih plodova biljnih vrsta *Cucurbita maxima*, *Cucurbita moschata* i *Cucurbita pepo*. Karotenoidi se smatraju ključnom komponentom nutritivnog kvaliteta bundeva i tikava. Iz oplemenjivačke kolekcije je od svake biljne vrste odabrano po osam akcesija dobrih agronomskih karakteristika. Biljke su gajene u dvogodišnjem (2023, 2024) poljskom ogledu, uz primenu standardne agrotehničke mere. Nakon žetve je izvršeno uzorkovanje mesa plodova, a zatim liofilizacija uzoraka i ekstrakcija karotenoida. Ukupan sadržaj karotenoida određen je spektrofotometrijski, dok je njihov sastav analiziran primenom visokoefikasne tečne hromatografije (HPLC). Između ispitivanih biljnih vrsta, akcesija i vegetacionih sezona su zabeležene visoko značajne razlike u pogledu sadržaja ukupnih karotenoida. Najviše prosečne vrednosti su zabeležene kod *C. maxima* (10,15 mg/g suve materije), a najniže kod *C. pepo* (0,87 mg/g). Široka varijabilnost sadržaja karotenoida unutar sve tri vrste ukazuje na postojanje genetičkog potencijala za selekciju akcesija poboljšanog nutritivnog kvaliteta. Imajući u vidu da je u uzorcima iz druge vegetacione sezone utvrđen viši sadržaj ukupnih karotenoida (5,06 mg/g) u odnosu na prvu (3,62 mg/g), potrebno je detaljnije istražiti uticaj faktora sredine na njihovu akumulaciju. Što se sastava karotenoida tiče; detektovani su α - i β -karoten, violaksantin, zeaksantin, lutein i β -kriptoksantin u različitim odnosima, kao i veći broj njima srodnih jedinjenja. Iako su ovi karotenoidi identifikovani kod sve tri biljne vrste, postoji varijabilnost među akcesijama. Rezultati će poslužiti kao osnova za dalja istraživanja i unapređenje oplemenjivanja biljaka roda *Cucurbita* u cilju poboljšanja njegovog nutritivnog kvaliteta.

Ključne reči: nutritivni kvalitet, karotenoidi, tikve i bundeve, spektrofotometrija, HPLC

Zahvalnica: Istraživanje sprovedeno uz podršku Fonda za nauku Republike Srbije, 6680, Oplemenjivanje Cucurbita biljaka na nutritivni kvalitet – NutSens_PumpBreed.

CHARACTERIZATION OF CAROTENOIDS IN CUCURBITA FRUITS: CONTENT AND COMPOSITION

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This study investigated the variability of carotenoid content and composition in the ripe fruit flesh of *Cucurbita maxima*, *Cucurbita moschata*, and *Cucurbita pepo*. Carotenoids represent a critical component of the nutritional quality of pumpkins and squashes. From breeding collection, eight accessions exhibiting favorable agronomic characteristics were selected per species. The plants were cultivated over a two-year period (2023, 2024) in a field trial, using standard agricultural practices. Following harvest, the fruit flesh was sampled, lyophilized, and the carotenoids were extracted. Total carotenoid content was determined spectrophotometrically, whereas carotenoid composition was analyzed by high-performance liquid chromatography (HPLC). Significant variations in total carotenoid content were observed among the studied *Cucurbita* species, accessions, and growing seasons. *Cucurbita maxima* exhibited the highest mean concentration, whereas *Cucurbita pepo* displayed the lowest (10.15 and 0.87 mg/g dry matter, respectively). The broad within-species variation indicates useful genetic potential for selecting accessions with improved nutritional quality. Because total carotenoid content differed substantially between the seasons of 2024 and 2023 (5.06 and 3.62 mg/g, respectively), further investigation into the effects of environmental factors on carotenoid accumulation is required. Regarding carotenoid composition; α -carotene, β -carotene, violaxanthin, zeaxanthin, lutein, and β -cryptoxanthin were detected in varying ratios, alongside several related compounds. Although these carotenoids were present across all three species, considerable variability was noted among individual accessions. The findings will be utilized in future research aimed at breeding *Cucurbita* crops for enhanced nutritional quality.

Keywords: nutritional quality, carotenoids, pumpkins and squashes, spectrophotometry, HPLC

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OPLEMENJIVANJE KUKURUZA U KONTEKSTU GLOBALNIH KLIMATSKIH PROMENA

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Oplemenjivanje biljaka je imalo izuzetno važnu ulogu u rešavanju problema nestašice hrane za rastuću ljudsku populaciju. Taj zadatak će svakako biti još zahtevniji u budućnosti, s obzirom na posledice globalnih klimatskih promena, rast broja stanovnika i smanjenje površina obradivog zemljišta. Oplemenjivanje biljaka ostaje ključno za suočavanje sa uticajima klimatskih promena, dopunjujući mere upravljanja usevima i političke intervencije u cilju obezbeđivanja globalne sigurnosti hrane. Međutim, promene faktora životne sredine takođe utiču na ciljeve, efikasnost i genetsku dobit u okviru savremenog sistema oplemenjivanja kukuruza (biljaka). Uprkos boljem poznavanju funkcije gena i razvoju tehnologija poput uređivanja genoma, oplemenjivači se i dalje suočavaju sa izazovima proisteklim iz sužene genetske osnove i neizvesnih klimatskih uslova širom sveta. Nedovoljno razumevanje interakcije genotipa i sredine (GxE) ostaje glavni ograničavajući faktor u kreiranju efikasnijih sistema oplemenjivanja. Savremeno oplemenjivanje kukuruza, uz očuvanje i korišćenje genetičke raznovrsnosti i kombinovanje klasičnog oplemenjivanja i savremenih alata (molekularni markeri, genomna selekcija, fenotipizacija dronovima, multispektralno snimanje i VI), treba da ide u pravcu stvaranja hibrida koji: održavaju prinos i stabilnost proizvodnje u uslovima nedostatka vode i toplotnog stresa; poseduju veću efikasnost korišćenja vode i azota; imaju kraću vegetaciju i time izbegavaju najnepovoljnije periode tokom kritičnih faza razvoja. Odnosno, oplemenjivanje kukuruza treba da, pored selekcije na visok potencijal prinosa, fokus usmeri posebno ka selekciji adaptabilnih, stabilnih i resursno efikasnih genotipova, sposobnih da daju visok prinos i kvalitet u uslovima sve izraženije klimatske varijabilnosti i novih kombinacija abiotičkih i biotičkih stresova.

Ključne reči: Oplemenjivanje, klimatske promene, GxE interakcija, suša

MAIZE BREEDING IN CONTEXT OF GLOBAL CLIMATE CHANGE

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Plant breeding played an extremely important role in solving the problem of food shortages for the growing human population. That task will certainly be even more demanding in the future, having in mind the consequences of global climate change, population growth and the reduction of arable land. Plant breeding remains key to addressing the impacts of climate change, complementing crop management measures and policy interventions to ensure global food security. However, changes in environmental factors also affect the objectives, efficiency and genetic gain in the modern maize (plant) breeding system. Despite better knowledge of gene function and the development of technologies such as genome editing, breeders still face challenges originating from a narrow genetic base and uncertain climates around the world. Insufficient understanding of genotype-environment (GxE) interactions remains a major limiting factor in creating more efficient breeding systems. Modern maize breeding, while preserving and using genetic diversity and combining classical breeding and modern tools (molecular markers, genomic selection, phenotyping, multispectral imaging and AI), should go in the direction of creating hybrids that: maintain yield and stability of production in conditions of water shortage and heat stress; have a higher efficiency of water and nitrogen use; have a shorter growing season and thus avoid the most unfavorable periods during the critical stages of development. That is, maize breeding should, in addition to selection for high yield potential, direct strong focus on the selection of adaptable, stable and resource-efficient genotypes, capable of giving high yield and quality in conditions of increasingly present climate variability and new combinations of abiotic and biotic stresses.

Keywords: Breeding, climate changes, GxE interaction, drought

PROCENA STABILNOSTI INDEKSA KLASA KOD GENOTIPOVA PŠENICE GAJENIH U RAZLIČITIM AGROEKOLOŠKIM USLOVIMA

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Procena stabilnosti genotipova ima važnu ulogu u oplemenjivačkim programima, posebno u uslovima promenljive klime. Izveden je ogled sa 15 genotipova pšenice (10 KG linija hlebne pšenice, tri sorte hlebne pšenice korišćene kao standardi i dve KG linije spelte) po potpuno slučajnom blok sistemu u tri ponavljanja, na tri lokaliteta (Pančevo, Kragujevac i Kruševac), tokom dve vegetacione sezone (2022/2023 i 2023/2024). Cilj istraživanja je bio da se procene stabilnost i adaptabilnost genotipova pšenice za indeks klasa, kao i da se identifikuju najpogodnije sredine za testiranje genotipova. Analizom GGE biplot prikazani su efekti genotipa i interakcije genotip $\times$ sredina, gde su PC1 i PC2 zajedno objasnili 87,13% ukupne varijabilnosti. Indeks klasa je izračunat kao odnos mase zrna po klasu i mase klasa i predstavlja pokazatelj efikasnosti formiranja zrna u klasu. Najveće prosečne vrednosti indeksa klasa zabeležene su kod genotipova KG-4/1 (0,79), KG-11/1 (0,79), Renesansa (0,79) i Pobjeda (0,78), dok je namanju vrednost imao genotip KG-33/1 (0,65). Linije spelte su imale vrednost indeksa klasa 0,71 i dobru stabilnost. Sorta Pobjeda je prema GGE biplotu „Ranking genotypes“ rangirana kao „idealni genotip“ po postignutoj stabilnosti i visokoj vrednosti osobine. Na biplotu „Which-won-where“ lokaliteti Pančevo i Kruševac u 2022/2023 sezoni su grupisani u isti sektor, u kojem su se kao pobednički genotipovi izdvojili KG-4/1 i KG-11/1. Sredina Kragujevac 2023/2024 je najpogodnija za diferencijaciju genotipova, s obzirom da se istovremeno odlikuje dobrom diskriminativnošću i reprezentativnošću. Ovi rezultati pružaju osnovu za odabir stabilnih i dobro adaptiranih genotipova, koji imaju potencijal da se koriste u budućim programima oplemenjivanja pšenice.

Ključne reči: adaptabilnost, stabilnost, indeks klasa, GGE-biplot analiza, interakcija genotip $\times$ spoljašnja sredina

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ASSESSMENT OF SPIKE INDEX STABILITY IN WHEAT GENOTYPES GROWN UNDER DIFFERENT AGROECOLOGICAL CONDITIONS

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Assessment of the genotypes stability has an important role in breeding programs, especially under changing climatic conditions. An experiment was conducted with 15 wheat genotypes (10 KG bread wheat lines, three bread wheat cultivars used as standards, and two KG spelt wheat lines) according to a randomized complete block design with three replications at three localities (Pančevo, Kragujevac, and Kruševac) during two growing seasons (2022/2023 and 2023/2024). The aim of this study was to evaluate the stability and adaptability of wheat genotypes for the spike index, as well as to identify the most suitable environments for genotype testing. The GGE biplot presented the combined genotype and genotype $\times$ environment (GE) effects, where PC1 and PC2 together explained 87.13% of the total variation. The spike index was calculated as the ratio of grain weight per spike to spike weight and represents an indicator of grain formation efficiency within the spike. The highest average spike index values were recorded for the genotypes KG-4/1 (0.79), KG-11/1 (0.79), Renesansa (0.79) and Pobeda (0.78), while genotype KG-33/1 had the lowest value (0.65). The spelt lines had a spike index value of 0.71 and good stability. According to the GGE biplot "Ranking Genotypes", the variety Pobeda was ranked as an "ideal genotype" based on the achieved stability and high trait value. In the "Which-won-where" biplot, Pančevo and Kruševac localities in the 2022/2023 growing season were grouped in the same sector, in which the lines KG-4/1 and KG-11/1 stood out as the winning genotypes. Kragujevac 2023/2024 was identified as the most suitable environment for genotype differentiation, as it showed both good discriminativeness and representativeness. These results provide a basis for selecting stable and well-adapted genotypes with potential for use in future wheat breeding programs.

Keywords: adaptability, stability, spike index, GGE biplot analysis, genotype $\times$ environment interaction

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UTICAJ NISKIH TEMPERATURA NA GERMINACIJU ADAPTIRANIH LINIJA KUKURUZA POVEĆANOG KVALITETA PROTEINA

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Kukuruz je izuzetno osetljiv na sušu i visoke temperature u periodu cvetanja i nalivanja zrna. Iako rana setva predstavlja strategiju za održivost prinosa i kvaliteta zrna, niske temperature u rano proleće mogu negativno uticati na germinaciju. U ovom radu ispitivani su efekti niskih temperatura na parametre germinacije, uključujući procenat germinacije (GP), indeks germinacije (GI), energiju germinacije (GE), srednje vreme germinacije (MGT), indeks brzine germinacije (GRI) i vigor (VI1 i VI2). Klijanci četiri linije kukuruza povećanog kvaliteta proteina (L1-L4) gajeni su 11 dana u fitotronske komori (vlažnost vazduha 60%, fotoperiod 12/12h, intenzitet svetlosti 700 $\mu\text{mol m}^{-2} \text{s}^{-1}$) na optimalnim (19 °C/11 °C) i niskim temperaturama (19 °C/11 °C u trajanju od 2 dana, zatim 20 °C/13.7 °C, 9.4 °C/6.3 °C i 6.5 °C/3.5 °C, po 3 dana) karakterističnim za rano proleće. Iako su niske temperature negativno uticale na germinaciju, razlike u odnosu na kontrolu nisu bile statistički značajne. Međutim, statistički značajne razlike ($p < 0.001$) uočene su između kontrole i tretmana kod sve četiri linije za VI1 i kod L1, L2 i L4 za VI2 ukazujući da niske temperature utiču i na germinaciju i na morfologiju. Značajne korelacije ($p < 0.001$) dobijene su između GI, GE, MGT, GRI, i VI1, što sugerše da niske temperature produžavaju germinaciju, smanjuju njene performanse i smanjuju dužinu klijanaca. Ispitivanje germinacije je samo prvi korak eksperimenta, koji će zajedno sa morfološkim, biohemijskim i fiziološkim analizama dati sveobuhvatniji odgovor kukuruza na niske temperature i omogućiti odabir linija pogodnih za ranu setvu.

Ključne reči: kukuruz povećanog kvaliteta proteina; rana setva; stres niskim temperaturama; germinacija;

Zahvalnica: Ovaj rad je podržan od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (Ugovor No. 451-03-33/2026-03/200040). Istraživanje je u skladu sa ciljem 2 – Svet bez gladi Ujedinjenih Nacija 2030 Agende o Održivom Razvoju.

EFFECTS OF COLD STRESS ON GERMINATION OF ADAPTED QUALITY PROTEIN MAIZE LINES

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Maize is highly sensitive to the combined effects of high-temperature stress and drought during the flowering and grain-filling stages. Although early sowing may negatively affect germination due to low temperatures in early spring, it can mitigate reductions in grain quality and yield. This study investigated the cold stress effects on germination parameters, including germination percentage (GP), germination index (GI), germination energy (GE), mean germination time (MGT), germination rate index (GRI), and vigor indices (VI1 and VI2). Seedlings of four quality protein maize lines (L1-L4) were grown in a growth chamber (humidity 60%, photoperiod 12/12 h, light intensity 700 $\mu\text{mol m}^{-2} \text{s}^{-1}$) under early spring optimal (19 °C/11 °C) and stress conditions (19 °C/11 °C for two days, followed by 20 °C/13.7 °C, 9.4 °C/6.3 °C, and 6.5 °C/3.5 °C, three days each) for 11 days. Although all germination parameters decreased under cold stress, the differences were not significant. However, statistically significant differences ($p < 0.001$) were observed between control and treatment for VI1 in all four lines and for VI2 in L1, L2, and L4, suggesting that cold stress affected both germination and morphological parameters. Significant correlations ($p < 0.001$) were identified among GI, GE, MGT, GRI, and VI1, indicating that cold stress prolonged germination, reduced germination performance and seedling length. Germination was only the initial stage of our experiment, and combined with morphological, biochemical and physiological analyses, it will provide a more comprehensive understanding of maize response to cold stress and facilitate the identification of promising lines for early sowing.

Keywords: quality protein maize; early sowing; cold stress; germination;

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ISPITIVANJE UTICAJA PRIMENE PANAMINA NA RAZVOJ BILJAKA I OTPORNOST NA SUŠU KOD KONZUMNOG SUNCOKRETA

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Intezivne klimatske promene koje prate sve toplija leta i sve duži periodi suše sve više utiču na proizvodnju konzumnog suncokreta. Da bi se poboljšala proizvodnja suncokreta u ekstremnim uslovima, važno je naći način da se nadoknadi šteta koju ti uslovi nanose. PANAMIN® je biostimulator proizveden kao fino mleveno kameno brašno od austrijskih stena vulkanskog porekla. Primenuje se preko lista, i obiluje mikro i makro elementima za ishranu biljaka koji se efektno usvajaju usled inovativne tehnike mlevenja. Potencijal ovog tretmana je visok, ali je ključno ustanoviti da li je folijarna primena . PANAMINA® zaista efikasna kada se primeni na konzumni suncokret, naročito u uslovima suše. Postavljen je dvogodišnji ogled u tri ponavljanja sa šest NS komercijalnih konzumnih hibrida. Bile su dve eksperimentalne grupe: tretman, gde je usev tretiran PANAMINOM®, i kontrola bez tretmana. Tretman je rađen u fazi 3 do 5 listova, u fazi butonizacije, i u fazi početka cvetanja, sa dozom od 15 g na 100 m². U fazi berbe je odabrano 10 nasumičnih biljaka iz svake kombinacije eksperimentalnih faktora. Za svaku biljku je merena visina biljke, prečnik glave, broj semena po glavi, masa 1000 semena, sadržaj ulja sadržaj i proteina u semenu, i prinos po biljci. Podaci su analizirani korišćenjem dva statistička protokola. Prvo su agregatni podaci po eksperimentalnim kombinacijama analizirani korišćenjem permutacione analize varijacija (PERMANOVA metod). Time je ustanovljeno da postoje značajne razlike između godina ispitivanja, i hibrida, ali ne i između tretmana i kontrole. Imajući u vidu statističku moć eksperimenta, izvršen je dvostruki jednostrani test (TOST) da bi se procenile maksimalne dimenzije efekta PANAMINA®. Dobijeni rezultati ukazuju na potrebu za daljim ispitivanjem različitih doza i modaliteta primene PANAMINA® u različitim agroekološkim uslovima i sistemima proizvodnje, u uslovima abiotičkog stresa, uključujući i marginalna zemljišta.

Ključne reči: konzumni suncokret, PANAMIN®, stistički protokol, svojstva

Zahvalnica: Ovaj rad je podržan od strane Horizon Europe projekta CARINA (broj ugovora 101081839), Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (broj ugovora 451-03-33/2026-03/200032), kao i Centra izuzetnih vrednosti za oplemenjivanje biljaka tolerantnih na promene klime - Climate Crops, Institute of Field and Vegetable Crops, Novi Sad. VBP je finansiran od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije (broj ugovora 451-03-34/2026-03/200156) i Fakulteta tehničkih nauka, Univerziteta u Novom Sadu kroz projekat "Scientific and Artistic Research Work of Researchers in Teaching and Associate Positions at the Faculty of Technical Sciences, University of Novi Sad 2026" (ugovor broj 01-3609/1).

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EXAMINING THE EFFECT OF PANAMINE ON PLANT DEVELOPMENT AND DROUGHT RESISTANCE IN CONFECTIONARY SUNFLOWER

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Intensive climate change which leads to warmer summers and longer periods of drought influence more and more the production of confectionary sunflower. To improve sunflower production in these extreme circumstances, it is important to find ways to counteract the damage these circumstances do. PANAMIN[®] is a biostimulator manufactured as finely ground stone flour, made out of Austrian igneous rock. PANAMINE[®] is used through foliar application, and is rich in both micro- and macro- plant nutrients, which are absorbed effectively because of the innovative technique of fine milling of the flour. The potential of this treatment is high, but it is crucially important to first establish if the foliar application of PANAMIN[®] is truly effective when applied to confectionary sunflower, especially in drought conditions. A two year experiment was conducted, with three repetitions and six NS commercial confectionary hybrids under observation. There were two experimental groups: the treatment which was treated with PANAMIN[®], and a control which was not. Treatment was applied first between the three-leaf and five-leaf phase, then between the miniature bud and bud elevation phases and lastly in the flowering phase. The treatment used a dose of 15g per 100m² of PANAMIN[®]. At harvest-time ten plants were randomly selected from each experimental factor combination. Each plant was evaluated according to head diameter, number of seeds per head, one thousand seed weight, seed oil and protein content and yield per plant. Data were analyzed using two statistical protocols. First, aggregate data according to experimental combinations were analyzed using permutation analysis of variation (PERMANOVA method). It was established that there were significant differences between years that were studied, and between the hybrids, but not between the treatment and control groups. Given the statistical power of the experiment, a two one-sided test (TOST) was conducted to estimate the maximal effect size that is expected from PANAMIN[®]. The results indicate the need to further evaluate different application rates and methods across PANAMIN[®] range of agroecological conditions and production systems, particularly under abiotic stress, including on marginal lands.

Keywords: confectionery sunflower, PANAMIN[®], statistical protocol, traits

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UTICAJ DINAMIKE BIOHEMIJSKIH PROMENA NA POTENCIJAL KLIJAVOSTI SEMENA KUKURUZA U SREDNJOROČNIM USLOVIMA EX SITU KONZERVACIJE

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Dugoročno čuvanje genetičkih resursa u bankama gena zahteva dublje razumevanje fizioloških i biohemijskih procesa koji prate starenje semena tokom decenijskog čuvanja uzoraka. Cilj ovog rada bio je da se sagleda uticaj višedecenijskog starenja na dinamiku biohemijskih promena i njihov odnos sa potencijalom klijavosti introdukovanih populacija kukuruza (*Zea mays* L.) kroz poređenje sa sveže regenerisanim uzorcima. Integrisanom multivarijantnom analizom evaluirani su ključni parametri oksidativnog statusa indukovanog prirodnim starenjem, status proteina, ugljenih hidrata i antioksidativnog sistema (ukupna fenolna jedinjenja i fenolne kiseline u slobodnoj i vezanoj formi, β-karoten, lutein i zeaksantin, tokoferolni izomeri i ukupni antioksidativni kapacitet). Rezultati pokazuju da tokom starenja dolazi do sistemskog razdvajanja mreža zaštitnih molekula i gubitka metaboličke koordinacije, što definiše kritične pragove stabilnosti ćelijske matrice. Identifikovane promene u statusu i organizaciji biohemijskih markera pružaju posredne pokazatelje relaksacije i strukturnih modifikacija staklaste matrice, udružene sa efektima molekularne zbijenosti. Ovakav mehanistički uvid pruža pouzdan osnov za unapređenje standardnih protokola praćenja klijavosti i ocenu viabilnosti semena u ex situ uslovima, čime se direktno doprinosi efikasnijem upravljanju biljnim genetičkim resursima.

Ključne reči: unutarćelijska staklasta matrica, metabolička mreža, prirodno starenje semena, redoks homeostaza, *Zea mays* L.

Zahvalnica: Ovaj rad je finansiran od strane Ministarstva nauke, tehnološkog razvoja i inovacija (Grant No. 451-03-33/2026-03/200040; Ciljevi održivog razvoja—*zero hunger, climate action, life on land*).

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IMPACT OF BIOCHEMICAL SHIFT DYNAMICS ON THE GERMINATION POTENTIAL OF MAIZE SEEDS UNDER MEDIUM-TERM EX SITU CONSERVATION

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Long-term conservation of plant genetic resources in gene banks requires a comprehensive understanding of the physiological and biochemical processes accompanying seed ageing over decades of preservation. This study aimed to evaluate the impact of multi-decadal ageing on the dynamics of biochemical shifts and their relationship with the germination potential of introduced maize (*Zea mays* L.) populations through comparison with freshly regenerated accessions. Using integrated multivariate analysis, key parameters of oxidative status induced by natural ageing were evaluated, including protein status, carbohydrates, and the antioxidant system (total phenolic compounds and phenolic acids in free and bound forms, β -carotene, lutein, and zeaxanthin, tocopherol isomers, and total antioxidant capacity). The results demonstrate that ageing triggers a systemic uncoupling of protective molecular networks and a loss of metabolic coordination, thereby defining critical thresholds of cellular matrix stability. The identified alterations in the status and organisation of biochemical markers provide indirect evidence of glassy matrix relaxation and structural modifications, coupled with molecular crowding effects. Such mechanistic insights establish a robust foundation for improving standard germination-monitoring protocols and assessing seed viability under ex situ conditions, directly contributing to the more efficient management of plant genetic resources.

Keywords: intracellular glassy matrix, metabolic network, natural seed ageing, redox homeostasis, *Zea mays* L.

Acknowledgments: This study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040; Sustainable Development Goals—zero hunger, climate action, life on land).

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ANALIZA OTPORNOSTI SUNCOKRETA PREMA UGLJENASTOJ TRULEŽI I AGRONOMSKIH SVOJSTAVA NAKON PRIRODNE I VEŠTAČKE INOKULACIJE

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Ugljenasta trulež, koju prouzrokuje *Macrophomina phaseolina*, jedna je od najznačajnijih bolesti koja ograničava proizvodnju suncokreta u uslovima suše i visokih temperatura. U ovom istraživanju ispitano je deset samooplodnih linija suncokreta primenom dve metode veštačke inokulacije, sa ciljem poređenja intenziteta bolesti i njegove povezanosti sa agronomskim performansama. Intenzitet bolesti, kvantifikovan na osnovu dužine inficiranog tkiva stabla, kretao se od 0 do 65,5, dok su prinosi i masa 1000 semena određeni za svaku metodu inokulacije. Analiza varijanse pokazala je značajne genotipske razlike za sva ispitivana svojstva. Analiza glavnih komponenti pokazala je da je intenzitet bolesti utvrđen primenom dve metode inokulacije bio blisko povezan, što ukazuje na sličnu sposobnost obe metode da razlikuju genotipove. Nasuprot tome, prinosi i masa 1000 semena formirali su zasebnu grupu međusobno pozitivno povezanih svojstava. Vektori intenziteta bolesti bili su usmereni suprotno od varijabli povezanih sa prinosom, što ukazuje na slabu negativnu povezanost između nivoa infekcije i agronomskih performansi. Ovi rezultati pokazuju da povećanje intenziteta bolesti nije bilo dosledno praćeno smanjenjem prinosa ili mase 1000 semena kod ispitivanih genotipova. Rezultati pokazuju da obe metode inokulacije pružaju slične informacije o reakciji suncokreta na ugljenastu trulež i da mogu biti korisne za skrining oplemenjivačkog materijala suncokreta, dok multivarijaciona analiza olakšava tumačenje odnosa između otpornosti prema bolesti i agronomskih svojstava.

Ključne reči: *Macrophomina phaseolina*, biljna bolest, biljna patologija, prinos semena, masa 1000 semena.

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ANALYSIS CHARCOAL ROT RESISTANCE AND AGRONOMIC TRAITS IN SUNFLOWER FOLLOWING NATURAL AND ARTIFICIAL INOCULATION METHODS

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The aim of this study was to characterize variation in seed protein content and its association Charcoal rot, caused by *Macrophomina phaseolina*, is one of the most important diseases limiting sunflower production under drought and high-temperature conditions. This study evaluated ten sunflower inbred lines using two artificial inoculation methods to compare disease severity and its relationship with agronomic performance. Disease severity, quantified based on infected stem tissue length, ranged from 0 to 65.5, while yield and thousand-seed weight were recorded for each inoculation method. Analysis of variance revealed significant genotypic differences for all evaluated traits. Principal component analysis showed that disease severity measured by the two inoculation methods was closely associated, indicating comparable discrimination among genotypes. In contrast, yield and thousand-seed weight formed a separate group of positively associated traits. Disease severity vectors were oriented opposite to yield-related variables, suggesting only a weak negative relationship between infection level and agronomic performance. These findings indicate that increased disease severity was not consistently accompanied by reduced yield or thousand-seed weight across the evaluated genotypes. The results demonstrate that both inoculation methods provide similar information on charcoal rot response and may be useful for screening sunflower breeding material, while multivariate analysis facilitates the interpretation of relationships among disease resistance and agronomic traits.

Keywords: *M.phaseolina*, plant disease, plant pathology, seed yield, 1000 seed mass,

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SADRŽAJ PROTEINA I POVEZANA SVOJSTVA KVALITETA SEMENA U OPLEMENJIVAČKOM MATERIJALU SUNCOKRETA

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Povećanje sadržaja proteina u semenu uz očuvanje povoljnih svojstava kvaliteta semena predstavlja potencijalno značajan cilj u oplemenjivanju suncokreta. Cilj ovog istraživanja bio je da se utvrdi varijabilnost sadržaja proteina u semenu i njegova povezanost sa drugim svojstvima kvaliteta semena u oplemenjivačkom materijalu suncokreta. Ispitano je 100 genotipova poreklom iz programa oplemenjivanja suncokreta Instituta za ratarstvo i povrtarstvo, Novi Sad (IFVCNS), Srbija. Biljni materijal obuhvatao je samooplodne linije majčinske komponente, linije restorere, eksperimentalne hibride i priznati hibrid NS Oliva. Određeni su sadržaj proteina, sadržaj vlage, sadržaj ulja, udeo ljuske i masa 1000 semena, dok je varijabilnost analizirana primenom analize glavnih komponenti (PCA) na osnovu standardizovanih varijabli. Kod ispitivanih genotipova utvrđena je varijabilnost sadržaja proteina, koji se kretao od 15,08 do 27,37%. NS Oliva imala je najveći sadržaj proteina (27,37%), a zatim eksperimentalni hibridi k18/2021 (24,97%) i k17/2021 (24,38%), kao i samooplodne linije Ha-26-OL-IMI (24,43%), Ha-74 (24,41%), AB-OR-12 (24,15%) i IMI-AB 12-PR (24,08%). Značajna varijabilnost utvrđena je i za ostala ispitivana svojstva semena, pri čemu se sadržaj ulja kretao od 26,61 do 52,51%, udeo ljuske od 18,2 do 41,2%, a masa 1000 semena od 26,5 do 71,72 g. Prve dve glavne komponente objasnile su 78,62% ukupne varijabilnosti. Prva glavna komponenta (PC1) objasnila je 54,57% varijabilnosti i uglavnom je bila određena suprotnim doprinosima sadržaja ulja i ostalih svojstava semena, dok je druga glavna komponenta (PC2) objasnila 24,05% varijabilnosti i prvenstveno je bila povezana sa većim sadržajem proteina i masom 1000 semena, nasuprot udelu ljuske. PCA analiza pokazala je značajnu diferencijaciju među ispitivanim oplemenjivačkim materijalom i omogućila identifikaciju genotipova koji kombinuju visok sadržaj proteina sa povoljnim vrednostima drugih svojstava kvaliteta semena. Posebno se izdvojila NS Oliva, kombinacijom najvećeg sadržaja proteina, velike mase 1000 semena i malog udela ljuske. Utvrđena varijabilnost i identifikovani genotipovi sa visokim sadržajem proteina predstavljaju vredne genetičke resurse za oplemenjivanje suncokreta u cilju povećanja sadržaja proteina i poboljšanja kvaliteta semena.

Ključne reči: hibrid, samooplodna linija, sadržaj ulja, sadržaj proteina, masa 1000 semena

Zahvalnica: Ovo istraživanje podržano je u okviru Inovativnog projekta AP Vojvodine „Oliva Plus – Inovativni hibrid suncokreta za unapređenje poljoprivredne konkurentnosti AP Vojvodine“, broj projekta 003793802 2025 09418 003 000 000 001/2, kao i od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, broj ugovora 451-03-33/2026-03/200032. Istraživanje je realizovano u okviru aktivnosti Centra izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na promene klime – Climate Crops, Institut za ratarstvo i povrtarstvo, Institut od nacionalnog značaja za Republiku Srbiju, Novi Sad, Srbija.

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PROTEIN CONTENT AND ASSOCIATED SEED QUALITY TRAITS IN SUNFLOWER BREEDING GERMPLASM

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The aim of this study was to characterize variation in seed protein content and its association with seed quality traits in sunflower germplasm. Total 100 genotypes from the sunflower breeding program of the Institute of Field and Vegetable Crops, Novi Sad (IFVCNS), were evaluated. The material comprised inbred lines, restorer lines, experimental hybrids, and the registered hybrid NS Oliva. Protein content, moisture content, oil content, hull percentage, and thousand-seed weight were determined, and variation was assessed by PCA analysis based on standardized variables. Variation in protein content was observed among the genotypes, ranging 15.08-27.37%. NS Oliva exhibited the highest protein content (27.37%), followed by the experimental hybrids k18/2021 (24.97%) and k17/2021 (24.38%), and the inbred lines Ha-26-OL-IMI (24.43%), Ha-74 (24.41%), AB-OR-12 (24.15%), and IMI-AB 12-PR (24.08%). Variability was also observed for the associated seed traits, with oil content ranging from 26.61-52.51%, hull percentage ranging 18.2-41.2%, and thousand-seed weight, 26.5-71.72 g. The first two principal components explained 78.62% of variation. PC1 (54.57%) was mainly characterized by the opposing contributions of oil content and other seed traits, whereas PC2 (24.05%) was primarily associated with higher protein content and thousand-seed weight in contrast to hull percentage. The PCA revealed differentiation among the evaluated germplasm, enabled the identification of genotypes combining high protein content with favorable values of other seed quality traits. In particular, NS Oliva was distinguished by the combination of the highest protein content, high thousand-seed weight, and low hull percentage. The identified variability and high-protein genotypes represent valuable resources for breeding sunflower with improved protein and seed quality.

Keywords: hybrid, inbred line, oil content, protein content, 1000 seed mass

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EVOLUTIVNO-PARTICIPATIVNO OPLEMENJIVANJE GAJENIH BILJAKA

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Evolutivno-participativno oplemenjivanje gajenih biljaka predstavlja pristup stvaranju i unapređenju sorti koje kombinuju principe evolutivnog oplemenjivanja i aktivno učešće poljoprivrednika u procesu selekcije. Ovaj pristup se zasniva na stvaranju genetički raznovrsnih populacija (najčešće mješavina potomstva različitih ukrštanja), koje se zatim uzgajaju u različitim agroekološkim uslovima gdje djeluju prirodna i vještačka selekcija. Tokom više generacija populacije se evolutivno prilagođavaju lokalnim uslovima sredine – klimi, zemljištu, biotičim faktorima i agrotehnici. Participativnu komponentu predstavljaju poljoprivrednici koji, zajedno sa oplemenjivačima, učestvuju u izboru genotipova koji najbolje odgovaraju lokalnim proizvodnim uslovima i potrebama tržišta. Na taj način se ubrzava proces prilagođavanja biljnih populacija specifičnim uslovima gajenja i povećava prihvatanje novih sorti u praksi. Evolutivno-participativno oplemenjivanje posebno je značajno u uslovima promjenljive klime, heterogenih proizvodnih sistema i ekološke poljoprivrede, gdje uniformne sorte često ne postižu optimalne rezultate. Genetički heterogene populacije imaju veću sposobnost adaptacije i stabilnosti prinosa u različitim uslovima sredine. Ovaj pristup doprinosi očuvanju i održivom korišćenju genetičkih resursa biljaka i jačanju saradnje između nauke i poljoprivredne prakse. Zahvaljujući svojoj fleksibilnosti i sposobnosti kontinuirane adaptacije, evolutivno-participativno oplemenjivanje predstavlja važan model razvoja održive poljoprivrede i efikasnog odgovora na izazove savremene proizvodnje hrane.

Ključne reči: balk metod, evolutivne populacije, kompozitne ukrštene populacije, prirodna selekcija, adaptabilnost, stabilnost

EVOLUTIONARY-PARTICIPATORY BREEDING OF CROPS

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Evolutionary-participatory breeding of crops represents an approach to the development and improvement of cultivars that integrates the principles of evolutionary breeding with the active participation of farmers in the selection process. This approach is based on the development of genetically diverse populations, most commonly mixtures of progenies derived from different crosses, which are subsequently grown under diverse agroecological conditions where both natural and artificial selection operate. Over successive generations, these populations undergo evolutionary adaptation to local environmental conditions, including climate, soil, biotic factors, and agronomic practices. The participatory component involves farmers working together with plant breeders to select genotypes that are best suited to local production conditions and market requirements. In this way, the adaptation of plant populations to specific growing environments can be accelerated, while the adoption of newly developed cultivars in agricultural practice can be enhanced. Evolutionary-participatory breeding is particularly relevant under conditions of climate variability, heterogeneous production systems, and organic farming, where genetically uniform cultivars often fail to achieve optimal performance across diverse environments. Genetically heterogeneous populations possess greater adaptive capacity and yield stability under variable environmental conditions. This approach also contributes to the conservation and sustainable utilization of plant genetic resources and strengthens collaboration between scientific research and agricultural practice. Owing to its flexibility and capacity for continuous adaptation, evolutionary-participatory breeding represents an important model for the development of sustainable agriculture and an effective response to the challenges of modern food production.

Keywords: bulk method, evolutionary populations, composite cross populations, natural selection, adaptability, yield stability

ALTERNATIVE HEMIJSKIM TRETMANIMA SEMENA

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U tretmanima semena, najzastupljeniji su hemijski tretmani koji se odlikuju velikom efikasnošću, lakoćom primene i niskom do umerenom cenom. Porastom ekološke svesti raste i potražnja za sirovinama iz organske proizvodnje u kojoj je upotreba sintetisanih hemijskih sredstava, pa i za tretman semena, zabranjena. Kao alternativu, imamo na raspolaganju biološke i fizičke tretmane semena. Biološki tretmani su najčešće formulisani tako da mogu naneti na seme pomoću standardnih uređaja za tretiranje semena. Pošto ovi preparati sadrže žive organizme (najčešće bakterije ili gljive), izazov je očuvati njihovu vitalnosti do setve semena. Zato je preporuka da se primenjuju neposredno pred setvu. Fizički tretmani semena se primenjuju kako za razbijanje dormancije, tako i za uništavanje patogena na semenu. Zahtevaju posebnu opremu koja već dostiže industrijske kapacitete. Već više godina poznat je tretman ubrzanim elektronima koji sterilise seme. Ovde se precizno dozira dubina prodiranja elektrona kako bi uništili patogene na i u semenjači a ne bi oštetili klicu. Sličan efekat ima i tretman vodenom parom koji se izvodi u specijalizovanim uređajima. Pri ovom tretmanu precizno se reguliše temperatura pare i dužina ekspozicije semena sa ciljem uništavanja patogena na i u semenjači a da se pri tom ne ošteti klica. Fizičkim tretmanima se mogu efikasno suzbiti bolesti koje se prenose semenom međutim oni ne pružaju dugotrajniju zaštitu kao hemijski tretmani. Zbog ovoga treba razmisliti o kombinovanju fizičkih tretmana za sterilizaciju semena i bioloških za sprečavanje sekundarne infekcije i dugotrajniju zaštitu.

Ključne reči: tretman semena, ubrzani elektroni, vodena para, biološki tretman.

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ALTERNATIVES TO CHEMICAL SEED TREATMENTS

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Chemical treatments are the most widely used methods for seed treatment due to their high efficacy, ease of application, and relatively low cost. However, increasing environmental awareness and the growing demand for organically produced raw materials have increased the need for alternatives to synthetic chemical agents, whose use is prohibited in organic production. Biological and physical treatments represent important alternatives. Biological treatments are generally formulated for application using standard seed-treatment equipment. However, because they contain living organisms, most commonly bacteria or fungi, maintaining their viability until sowing is a major challenge. Therefore, they are recommended for application immediately before sowing. Physical treatments are used both to break seed dormancy and to eliminate seed-borne pathogens. They require specialized equipment and can be applied on an industrial scale. Accelerated electron treatment can sterilize seeds by precisely controlling electron penetration to destroy pathogens on and within the seed coat while avoiding damage to the embryo. Steam treatment provides a similar effect, with steam temperature and exposure time carefully controlled to eliminate pathogens without impairing seed viability. Although physical treatments can effectively control seed-borne diseases, they generally do not provide the long-term protection associated with chemical treatments. Therefore, combining physical seed sterilization with biological treatments may provide an effective strategy by preventing secondary infections and extending protection after treatment.

Keywords: seed treatment, accelerated electrons, steam, biological treatment.

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OLIVA PLUS: DVONAMENSKI VISOKOOLEINSKI HIBRID SUNCOKRETA SA POVEĆANIM SADRŽAJEM PROTEINA

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Rastuća potražnja za održivim prehrambenim proizvodima biljnog porekla nameće potrebu za stvaranjem sorti i hibrida unapređene nutritivne i upotrebne vrednosti. Većina postojećih visokooleinskih hibrida suncokreta (*Helianthus annuus* L.) prvenstveno je namenjena proizvodnji ulja, dok potencijal proteinski bogatog ostatka nakon prerade nije dovoljno iskorišćen. Oliva Plus je razvijen kao dvonamenski hibrid suncokreta, namenjen istovremenoj proizvodnji visokokvalitetnog ulja i proteinski bogate sačme. U preliminarnim ispitivanjima analizirani su prinos semena, sadržaj ulja, oleinske kiseline i proteina, otpornost na prouzrokovaoče bolesti i štetočina. Stabilnost prinosa, kvalitet ulja, sadržaj proteina i prilagodljivost hibrida dodatno su procenjeni u mreži višelokacijskih ogleda u različitim agroekološkim uslovima. Oliva Plus odlikuje se sadržajem ulja od oko 50% u semenu, od toga je sadržaj oleinske kiseline preko 80%, a sadržajem proteina u semenu veći od 30%. Preliminarni rezultati ukazuju na prinos semena veći od 4,5 t ha⁻¹, genetičku otpornost na prouzrokovaoče plamenjače i rđe, kao i visoku produkciju nektara i polena značajnu za oparašivače. Ovakva kombinacija svojstava omogućava proizvodnju jestivog ulja visoke oksidativne stabilnosti i proteinski bogate sačme pogodne za ishranu ljudi i životinja, kao i za razvoj različitih proizvoda na bazi biljnih proteina. Objedinjavanjem visokog prinosa, vrhunskog kvaliteta ulja i povećanog sadržaja proteina, Oliva Plus predstavlja značajno oplemenjivačko dostignuće i perspektivan dvonamenski hibrid, čija proizvodnja može doprineti efikasnijem korišćenju sirovine, razvoju cirkularne bioekonomije i održivoj proizvodnji visokovrednih proizvoda od suncokreta.

Ključne reči: suncokret, dvonamenski hibrid, oleinska kiselina, ulje, proteini.

Zahvalnica: Ovaj rad je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (broj ugovora 451-03-136/2025-03/20032), kao i Autonomna Pokrajina Vojvodina kroz finansiranje inovacionog projekta „Inovativni hibridi suncokreta za unapređenje konkurentnosti poljoprivrede AP Vojvodine“ (broj projekta 003793802 2025 09418 003 000 000 001). Podršku realizaciji istraživanja pružio je i Centar izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na klimatske promene – Climate Crops, Institut za ratarstvo i povrtarstvo, Novi Sad, Srbija.

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OLIVA PLUS: A DUAL-PURPOSE HIGH-OLEIC, HIGH-PROTEIN SUNFLOWER HYBRID

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The growing demand for sustainable plant-based food products highlights the need to develop cultivars and hybrids with improved nutritional value and wider end-use potential. Most existing high-oleic sunflower (*Helianthus annuus* L.) hybrids are primarily intended for oil production, while the potential of the protein-rich by-product remaining after processing remains insufficiently exploited. Oliva Plus was developed as a dual-purpose sunflower hybrid intended for the simultaneous production of high-quality oil and protein-rich meal. Preliminary evaluations included seed yield, oil, oleic acid and protein contents, as well as resistance to major pathogens and pests. Yield stability, oil quality, protein content and hybrid adaptability were further assessed in a network of multi-location trials conducted under diverse agroecological conditions. Oliva Plus is characterized by a seed oil content of approximately 50%, with oleic acid accounting for more than 80% of the total fatty acid composition, and a seed protein content exceeding 30%. Preliminary results indicate a seed yield above 4.5 t ha⁻¹, genetic resistance to the causal agents of downy mildew and rust, and high nectar and pollen production beneficial to pollinators. This combination of traits enables the production of edible oil with high oxidative stability and protein-rich meal suitable for human and animal nutrition, as well as for the development of various plant-based protein products. By combining high yield, superior oil quality and increased protein content, Oliva Plus represents a significant breeding achievement and a promising dual-purpose hybrid. Its cultivation could contribute to more efficient use of raw materials, the development of a circular bioeconomy and the sustainable production of high-value sunflower products.

Keywords: sunflower, dual-purpose hybrid, oleic acid, oil, proteins.

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VISOKOPROPUSNA FENOTIPIZACIJA U PREDIKCIJI VLAGE ZRNA I SELEKCIJI HIBRIDA KUKURUZA

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Pored vremena cvetanja i prinosa zrna, sadržaj vlage u zrnu u berbi predstavlja agronomski i ekonomski važnu osobinu kukuruza, jer direktno utiče na optimalno vreme berbe, potrebu za naknadnim sušenjem, kvalitet i stabilnost zrna tokom skladištenja, kao i na ukupne troškove proizvodnje. Dinamika promene vlage u zrnu tokom sazrevanja povezana je sa fiziološkim procesima u biljci, zbog čega se pretpostavlja da se njena varijabilnost može indirektno proceniti na osnovu fenotipskih karakteristika biljaka registrovanih primenom bespilotnih letelica (UAV). Cilj istraživanja je da se na osnovu RGB ortomozaika snimljenih uz pomoć UAV razvije model za procenu i predviđanje vlage u zrnu. Za istraživanje je korišćeno 200 hibrida, a ogled je sejan na dve lokacije (Zemun Polje i Školsko Dobro) tokom 2025. godine. UAV snimanje je vršeno jednom nedeljno, odnosno dva puta nedeljno u fazi cvetanja. Ogled je na svakoj lokaciji snimljen u oko 20 vremenskih tačaka. Na osnovu UAV snimaka izrađeni su ortomozaici koji su dalje korišćeni za izdvajanje podataka potrebnih za predikciju vlage zrna. Radi pružanja specifičnih informacija o primenljivosti i robusnosti modela za mašinsko učenje korišćeni su Hold-One-Out i Group K-fold strategije validacije. Model Random Forest (RF) je pokazao najveću tačnost predviđanja. Validacionom metodom Hold-One-Out postignut je rezultat za koeficijent determinacije (R^2) od 0,839 i koren srednje kvadratne greške (RMSE) od 0,531, dok je primenom Group K-fold validacije ostvarena podjednako visoka tačnost predikcije, sa vrednostima R^2 od 0,814 i RMSE od 0,566. Dobijeni rezultati pokazuju da se vlaga zrna u trenutku berbe može pouzdano predvideti, što ukazuje na potencijal primene UAV tehnologije u fenotipizaciji i selekciji kukuruza.

Ključne reči: visokopropusna fenotipizacija, bespilotne letelice (UAV), oplemenjivanje kukuruza, RGB snimanje, sadržaj vlage u zrnu

Zahvalnica: Ovo istraživanje podržali su Ministarstvo nauke, tehnološkog razvoja i inovacija, na osnovu Ugovora broj 451-03-33/2026-03/200040, i Fond za nauku Republike Srbije, u okviru projekta broj 6672, „Visokopropusna fenotipizacija u poljskim uslovima u oplemenjivanju hibrida kukuruza u umerenom klimatu: kako fenomika može unaprediti brzinu i preciznost selekcije?“ – PHENO_MaizE. Ovo istraživanje je u skladu sa Ciljem 2 – Iskorenjivanje gladi Agende Ujedinjenih nacija za održivi razvoj do 2030. godine.

Perić, S. (0009-0001-1966-1808), Pavlov, J. (0000-0002-0310-1902), Grčić, N. (0000-0002-3736-0208), Vančetović, J. (0000-0002-8743-0454), Mladenović, M. (0000-0002-3991-5414), Kovačević, A. (0000-0001-5661-2071), Božinović, S. (0000-0002-1966-1656), Galić, V. (0000-0002-5191-2953)

HIGH-THROUGHPUT PHENOTYPING IN THE PREDICTION OF GRAIN MOISTURE AND SELECTION OF MAIZE HYBRIDS

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In addition to flowering time and grain yield, grain moisture content at harvest represents an agronomically and economically important trait in maize, as it directly affects the optimal harvest time, the need for post-harvest drying, grain quality and storage stability, as well as overall production costs. The dynamics of changes in grain moisture during maturation are associated with physiological processes in the plant, which suggests that its variability can be indirectly assessed based on plant phenotypic characteristics recorded using unmanned aerial vehicles (UAVs). The aim of this study was to develop a model for estimating and predicting grain moisture content based on RGB orthomosaics acquired using UAVs. The study included 200 maize hybrids and was conducted at two locations (Zemun Polje and Školsko Dobro) during 2025. UAV imaging was performed once a week, and twice a week during the flowering stage. At each location, the trial was imaged at approximately 20 time points. Based on the UAV imagery, orthomosaics were generated and subsequently used to extract the data required for grain moisture prediction. To provide specific insights into the applicability and robustness of the machine-learning models, Hold-One-Out and Group K-fold validation strategies were employed. The Random Forest (RF) model demonstrated the highest prediction accuracy. Using the Hold-One-Out validation method, a coefficient of determination (R^2) of 0.839 and a root mean square error (RMSE) of 0.531 were achieved, while the Group K-fold validation resulted in similarly high prediction accuracy, with an R^2 of 0.814 and an RMSE of 0.566. The obtained results demonstrate that grain moisture content at harvest can be reliably predicted, indicating the potential of UAV-based technology for high-throughput phenotyping and maize breeding.

Keywords: high-throughput phenotyping, UAV, maize breeding, RGB imaging, grain moisture content

Acknowledgments: This research was supported by the Ministry of Science, Technological Development and Innovation, Agreement No. 451-03-33/2026- 03/200040 and the Science Fund of the Republic of Serbia, Grant No 6672, High-throughput field phenotyping in temperate maize hybrid breeding: how can phenomics improve speed and accuracy of selection? – PHENO_MaizE. This research is in line with Goal 2 – Zero Hunger of the United Nations 2030 Agenda for Sustainable Development.

Perić, S. (0009-0001-1966-1808), Pavlov, J. (0000-0002-0310-1902), Grčić, N. (0000-0002-3736-0208), Vančetović, J. (0000-0002-8743-0454), Mladenović, M. (0000-0002-3991-5414), Kovačević, A. (0000-0001-5661-2071), Božinović, S. (0000-0002-1966-1656), Galić, V. (0000-0002-5191-2953)

UTICAJ GENOTIPA NA PRODUKCIJU I KVALITET SEMENA JEŽEVICE

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Ježevica (*Dactylis glomerata* L.) jedna je od najvažnijih višegodišnjih krmnih trava u Srbiji. Odlikuje se velikom prilagodljivošću različitim agro-ekološkim uslovima kao i visokim i stabilnim prinosom u smešama sa leguminozama, posebno sa lucerkom i drugim travama. Tolerantna je na mraz, zasenu, toplotu i sušu, sa dobrom sposobnošću ponovnog rasta. Primarni cilj u oplemenjivanju ježevice je stvaranje sorti sa visokim prinosom i kvalitetom krme. Pored toga, jedna od veoma bitnih osobina svake sorte jeste produkcija dovoljnih količina semena dobrog kvaliteta. U ovom istraživanju je testiran odgovor tri sorte ježevice (K-40, K-24 i Amba) na različite količine azotnog i fosforno-kalijumovog đubriva, praćenjem osobina: broj generativnih izdanaka po m², prinos semena po parceli i masa 1000 zrna. Ogled je izveden po slučajnom blok sistemu, u tri ponavljanja. Veličina osnovne parcele je bila 8m². Azot je primenjen u obliku KAN-a (N0, N45, N90 kg/ha) a fosfor i kalijum u obliku MKP đubriva sa 52% P₂O₅ i 34% K₂O, u količini PK0, PK75 i PK150 kg/ha. Najveći broj generativnih izdanaka po m² (308) je utvrđen kod sorte K-40 pri najvećim normama đubrenja. Najveći prinos semena po parceli (97,1g) je imala sorta K-24 kada je primenjena maksimalna količina azota i niža količina PK đubriva. Najveća masa 1000 zrna (0,58g) je utvrđena kod sorte K-40 pri maksimalnim količinama đubriva. Za sve osobine je zabeležen bolji odgovor domaćih sorti u svim tretmanima u poređenju sa introdukovanom sortom Amba. Ovakav odnos je očekivan imajući u vidu bolju prilagođenost domaćih sorti lokalnim agro-ekološkim uslovima.

Ključne reči: ježevica, sorta, prinos semena, kvalitet semena

Zahvalnica: Istraživanja je finansiralo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije (451-03-33/2026-03/200217).

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INFLUENCE OF GENOTYPE ON COCKSFOOT SEED PRODUCTION AND QUALITY

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Cocksfoot (*Dactylis glomerata* L.) is one of the most important forage perennial grasses in Serbia. It has great adaptability, and very high and stabile yield in mixtures with legumes, especially with alfalfa, and other grasses. Cocksfoot shows large tolerance to frost, shade, heat and drought with good regrowth ability. Primary aim in cocksfoot forage breeding is obtaining of cultivars with high yield and dry matter quality as well as production of sufficient quantities of good quality seeds. In this research, the response of three cultivars (K-40, K-24 and Amba) to different amounts of nitrogen and phosphorus-potassium fertilizers was tested, by monitoring the characteristics: number of generative tillers per m² (NGT), seed yield per plot (SY) and 1000 seed weight (1000SW). The experiment was performed according to a random block design, in three replications, with basic plot size of 8m². Nitrogen was applied in the form of KAN (N0, N45, N90 kg/ha) and phosphorus and potassium in the form of MKP fertilizer with 52% P2O5 and 34% K2O, in the amount of PK0, PK75 and PK150 kg/ha. The highest NGT (308) was found in K-40 at the highest fertilization rates. The K-24 had the highest SY (97.1g) when used maximum nitrogen and a lower PK fertilizer. The highest 1000SW (0.58g) was in K-40 with maximum amounts fertilizers. For all traits, a better response of domestic cultivars was recorded in all treatments compared to the introduced Amba cultivar, which is expected considering the better adaptability of domestic cultivars to local agro-ecological conditions.

Keywords: cocksfoot, cultivar, seed yield, seed quality

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PRIMENA SNP MARKERA VISOKE PROPUSNOSTI ZA KARAKTERIZACIJU GENETSKE VARIJABILNOSTI GERMOPLAZME KUKURUZA IZ BANKE GENA

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Analiza genetskog diverziteta i klasifikacija germoplazme kukuruza od suštinskog su značaja za efikasno planiranje programa oplemenjivanja i upravljanje resursima. U ovoj studiji ispitivani su genetski diverzitet i populaciona struktura 94 inbred linije kukuruza iz banke gena, koje predstavljaju različite tipove zrna (standardni, voštani, šećerac i kokičar). Genotipizacija je izvršena pomoću 25k Illumina SNP čipa, pri čemu je, nakon rigoroznog filtriranja u softveru TASSEL, dobijeno 14.588 visokokvalitetnih polimorfizama pojedinačnih nukleotida (SNP-ova). Procene genetske udaljenosti ukazale su na značajnu varijabilnost u okviru kolekcije, pri čemu je minimalna udaljenost zabeležena između linija L4 i L36, a maksimalna između linija L7 i L69. Zbirni statistički pokazatelji genetskog diverziteta ukazali su na prosečnu opaženu heterozigotnost (H_o) od 0,045 (u rasponu od 0,000 do 0,100) i prosečnu očekivanu heterozigotnost (H_e) od 0,445 (u rasponu od 0,320 do 0,500). Prosečna vrednost informativnosti polimorfizma (PIC) iznosila je 0,244 (u rasponu od 0,218 do 0,250), što potvrđuje zadovoljavajući nivo informativnosti markera. Pored toga, grupisanje na osnovu dendrograma i analiza glavnih komponenti (PCA) uspešno su okarakterisali genetske odnose i obrasce grupisanja među različitim inbred linijama. Ovi rezultati pružaju čvrstu genetsku osnovu za buduću selekciju potpomognute markerima, konzervativne strategije i napredne inicijative u oplemenjivanju kukuruza.

Ključne reči: kukuruz, SNP-ovi visoke propusnosti, genetski diverzitet

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HARNESSING HIGH-THROUGHPUT SNP MARKERS TO CHARACTERIZE GENETIC VARIABILITY IN GENE BANK MAIZE GERMPLASM

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Analysis of genetic diversity and classification of maize germplasm is fundamental for effective breeding program planning and resource management. This study investigated the genetic diversity and population structure of 94 maize inbred lines sourced from a gene bank, representing diverse kernel types (standard, waxy, sweet, and popcorn). Genotyping was performed using the 25k Illumina SNP chip, yielding 14,588 high-quality single nucleotide polymorphisms (SNPs) after rigorous filtering in TASSEL software. Genetic distance estimates revealed significant variability across the collection, with the minimum distance observed between lines L4 and L36, and the maximum distance recorded between lines L7 and L69. Summary statistics for genetic diversity indicated an average Observed Heterozygosity (Ho) of 0.045 (ranging from 0.000 to 0.100) and an average Expected Heterozygosity (He) of 0.445 (ranging from 0.320 to 0.500). The mean Polymorphic Information Content (PIC) value was 0.244 (ranging from 0.218 to 0.250), confirming a satisfactory level of marker informativeness. Furthermore, dendrogram clustering and Principal Component Analysis (PCA) effectively characterized the genetic relationships and grouping patterns among the diverse inbred lines. These findings provide a robust genetic foundation for future marker-assisted selection, conservation strategies, and advanced maize breeding initiatives.

Keywords: maize, high-throughput SNPs, genetic diversity

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MORFOLOŠKI POKAZATELJI OPORAVKA SUNCOKRETA NAKON STRESA SUŠOM

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Morfologija korena ima važnu ulogu u odgovoru biljaka na vodni deficit u zemljištu i naknadni oporavak nakon ponovnog zalivanja. Cilj ovog istraživanja bio je da se ispituju promene morfologije korena i raspodela biomase kod tri inbred linije suncokreta (AB OR 8, DF AB 2 i FE 54), odabrane na osnovu različite osetljivosti na sušu. Biljke su gajene u saksijama zapremine 6 l u tri tretmana vlažnosti: kontrola (70% gravimetrijskog sadržaja vode, GWC), vodni deficit (50% GWC) i oporavak (50% GWC tokom 5 dana, nakon čega je sadržaj vode vraćen na 70% GWC do kraja ogleda). Indeks oporavka korišćen je za poređenje vrednosti nakon oporavka sa kontrolom. Vodni deficit je značajno uticao na osobine korena, pri čemu su razlike između linija uočene za dužinu, površinu i zapreminu korena. U uslovima vodnog deficita, linija AB OR 8 pokazala je visoku stabilnost i zadržala većinu parametara korena, dok je kod DF AB 2 zabeleženo izraženo smanjenje površine i zapremine korena. Nakon zalivanja, DF AB 2 je pokazala najveći indeks oporavka za suhu masu izdanka (125,67%) i suhu masu korena (232,71%). Linija AB OR 8 zadržala je relativno stabilnu biomasu između tretmana, dok se FE 54 slabije oporavila, sa niskim indeksom oporavka suve mase izdanka (60,98%) i ograničenim razvojem korena. Univarijantne i multivarijantne analize podržale su ove odgovore specifične za pojedinačne linije. Sagledavanje oporavka nakon suše zajedno sa promenama morfologije korena omogućava potpuniju procenu tolerantnosti na sušu. Među ispitivanim linijama, DF AB 2 je pokazala izraženu sposobnost oporavka, što ukazuje na njen potencijalni značaj u oplemenjivanju suncokreta na povećanu tolerantnost na sušu.

Ključne reči: *Helianthus annuus* L., morfologija korena, vodni stres, oporavak

Zahvalnica: Ovo istraživanje je podržano od strane Ministarstva nauke, tehnološkog razvoja i inovacija Republike Srbije, brojevi ugovora: 451-03-33/2026-03/200032, 451-03-33/2026-03/200125 i 451-03-34/2026-03/200125. Istraživanje je realizovano u okviru aktivnosti Centra izuzetnih vrednosti za inovacije u oplemenjivanju biljaka tolerantnih na promene klime – CLIMATE CROPS, Instituta za ratarstvo i povrstarstvo iz Novog Sada.

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MORPHOLOGICAL INDICATORS OF SUNFLOWER RECOVERY FROM DROUGHT STRESS

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Root morphology plays an important role in crop responses to soil water deficit and subsequent recovery after rewatering. This study examined changes in root morphology and biomass partitioning of three sunflower inbred lines (AB OR 8, DF AB 2, and FE 54) selected for contrasting drought sensitivity and subjected to drought. Plants were grown in 6 l pots under three water regimes: control (70% gravimetric water content, GWC), water deficit (50% GWC), and recovery (50% GWC for 5 days followed by rewatering to 70% GWC until the end of the experiment). The recovery index compared recovery values with the control group. Water deficit significantly affected root traits, with genotypic variations observed in root length, root surface area, and root volume. Under water deficit, line AB OR 8 showed high stability, maintaining most root parameters, whereas DF AB 2 showed strong declines in root surface area and root volume. After rewatering, DF AB 2 demonstrated the highest recovery index for shoot dry mass (125.67%) and root dry mass (232.71%). Line AB OR 8 maintained relatively stable biomass across treatments, while FE 54 failed to recover effectively, showing a low shoot dry mass recovery index (60.98%) and restricted root development. Univariate and multivariate analyses supported these line-specific responses. Considering post-drought recovery together with root morphological changes provides a more complete assessment of drought resilience. Among the lines examined, DF AB 2 showed a pronounced capacity for post-drought recovery, suggesting its potential value for breeding sunflower genotypes with improved drought resilience.

Keywords: *Helianthus annuus* L., root morphology, water stress, recovery

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KLIJAVOST I DUGOVEČNOST TOKOM ČUVANJA GENERATIVNOG MATERIJALA PLANINSKE ARNIKE (ARNICA MONTANA L.) DOBIJENOG SA BILJAKA GAJENIH SA MALČEM I BEZ MALČA

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Planinska arnika (*Arnica montana* L.) predstavlja ugroženu vrstu lekovite biljke značajne farmaceutske i komercijalne vrednosti. Zbog ograničenja sakupljanja materijala iz prirodnih populacija, njeno plantažno gajenje i proizvodnja kvalitetnog generativnog materijala dobijaju još veći značaj. Cilj ovog istraživanja bio je da se procene prinos semena i promene klijavosti tokom trogodišnjeg perioda čuvanja. Poljski ogled postavljen je na distričnom kambisolu na planini Tari i obuhvatio je tretmane sa agrotekstilnim malčem i bez njega. Prethodno istraživanje sprovedeno na istim biljkama pokazalo je da je primena agrotekstilnog malča povećala prinos cveta zahvaljujući većem broju cvetnih glavica. Tokom 2023. godine zrele cvetne glavice ručno su sakupljene iz oba tretmana. Između tretmana nije utvrđena razlika u prinosu semena po biljci. Međutim, zbog većeg broja cvetnih glavica na biljkama gajenim na agrotekstilu, ukupan prinos semena po jedinici površine bio je veći. Nakon sakupljanja i sušenja, generativni materijal doraden je uklanjanjem papusa, nedovoljno razvijenih jedinica i drugih primesa. Očišćeni materijal čuvan je u papirnim kesama pri relativnoj vlažnosti vazduha od 48 do 62% i temperaturi od 12 do 15 °C. Klijavost je ispitivana tokom 2024, 2025. i 2026. godine u četiri ponavljanja sa po 100 jedinica postavljenih na vlažan filter-papir u Petrijevim posudama. Ispitivanje je trajalo 21 dan, pri temperaturi od 22 ± 1 °C i fotoperiodu od 12 časova svetlosti i 12 časova tame. Klijavost se u 2024. godini kretala od 75 do 84%, u 2025. od 52 do 63%, a u 2026. godini od 28 do 35%. Vreme čuvanja značajno je smanjilo klijavost, dok je primena agrotekstila povećala ukupan prinos semena, prvenstveno zahvaljujući većem broju cvetnih glavica.

Ključne reči: reproduktivni materijal, lekovita vrsta, dorada semena, dugovečnost

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MOUNTAIN ARNICA (*ARNICA MONTANA* L.) GERMINATION AND STORAGE LONGEVITY OF GENERATIVE MATERIAL OBTAINED FROM MULCHED AND NON-MULCHED PLANTS

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An endangered species of medicinal plant with significant pharmaceutical and commercial value is mountain arnica (*Arnica montana* L.). Field culture and the generation of high-quality generative material are even more important due to restrictions on harvesting from wild populations. The purpose of this study was to evaluate seed yield and germination variations throughout a three-year storage period. The Dystric Cambisol on Tara Mountain was the site of the field experiment, which included treatments with and without agrotexile mulch. Agrotexile mulch boosted flower yield by increasing the number of bloom heads, according to a prior study done on the same plants. In 2023, mature flower heads were gathered by hand from both treatments. There was no difference in seed output per plant between the treatments. However, because the plants in the agrotexile treatment produced more flower heads, the total seed production per unit area was higher. The generating material was treated by eliminating the pappus, underdeveloped units, and other contaminants after collection and drying. The cleansed material was kept in paper bags between 48–62% relative air humidity and 12–15 °C. Four replicates of 100 units placed on wet filter paper in Petri dishes were used to assess germination in 2024, 2025, and 2026. For 21 days, tests were carried out at 22 ± 1 °C with a 12-hour light/12-hour dark photoperiod. In 2024, germination was between 75 and 84%; in 2025, it was between 52 and 63%; and in 2026, it was between 28 and 35%. While storage time significantly decreased germination, agrotexile boosted overall seed production mainly through a greater number of blossom heads.

Keywords: reproductive material, medicinal species, seed processing, longevity

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FENOLOŠKA VARIJABILNOST POČETKA VEGETACIJE PITOMOG KESTENA (*CASTANEA SATIVA* MILL.) KAO OSNOVA ZA SELEKCIJU ADAPTIVNO VREDNIH GENOTIPOVA

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Početak vegetacije predstavlja jednu od ključnih adaptivnih osobina šumskog drveća, jer određuje izloženost biljaka kasnim prolećnim mrazovima. Identifikacija genotipova sa različitom dinamikom razvoja pupoljaka predstavlja važan segment oplemenjivanja i očuvanja genetičkih resursa pitomog kestena (*Castanea sativa* Mill.). Cilj istraživanja bio je utvrditi fenološku varijabilnost početka vegetacije odabranih stabala pitomog kestena na osnovu dinamike razvoja pupoljaka i akumulacije efektivnih temperatura. Istraživanje je obuhvatilo deset odabranih stabala sa po dvadeset zimskih grančica. U kontrolisanim laboratorijskim uslovima praćene su fenofaze bubrenja pupoljaka, pucanja pupoljaka i listanja. Na osnovu četiri dnevna merenja temperature izračunate su srednje dnevne temperature i kumulativna suma efektivnih temperatura (Growing Degree Days – GDD; $T_{base} = 5\text{ }^{\circ}\text{C}$). Podaci su analizirani primenom deskriptivne statistike, jednofaktorske analize varijanse (ANOVA) i Tukey HSD testa. Utvrđene su statistički značajne razlike među ispitivanim stablima za sve analizirane fenološke parametre ($p < 0,001$), što potvrđuje izraženu fenološku varijabilnost unutar ispitivanog materijala. Od ukupno 200 analiziranih grančica, listanje je registrovano kod 137 (68,5%), dok 63 grančice (31,5%) nisu dostigle ovu fenofazu. Posebno se izdvajaju dva stabla kod kojih nije zabeleženo listanje ni na jednoj grančici, uprkos prethodno registrovanom bubrenju i pucanju pupoljaka. Dobijeni rezultati ukazuju da fenološke osobine početka vegetacije mogu predstavljati selekzione kriterijume za identifikaciju genotipova sa različitim adaptivnim potencijalom i poslužiti kao osnova za programe oplemenjivanja i očuvanja genetičkih resursa pitomog kestena. Za potvrdu njihovog adaptivnog značaja neophodna su dalja višegodišnja terenska istraživanja.

Ključne riječi: *Castanea sativa*, fenologija, početak vegetacije, Growing Degree Days (GDD), oplemenjivanje

PHENOLOGICAL VARIABILITY OF VEGETATION ONSET IN SWEET CHESTNUT (*CASTANEA SATIVA* MILL.) AS A BASIS FOR THE SELECTION OF ADAPTIVELY VALUABLE GENOTYPES

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The onset of vegetation is one of the key adaptive traits of forest trees, as it determines plant exposure to late spring frosts. Identifying genotypes with different bud development dynamics represents an important component of breeding programs and the conservation of sweet chestnut (*Castanea sativa* Mill.) genetic resources. The aim of this study was to assess the phenological variability of the onset of vegetation among selected sweet chestnut trees based on bud development dynamics and the accumulation of effective temperatures. The study included ten selected trees, with twenty dormant shoots collected from each tree. Under controlled laboratory conditions, the phenological stages of bud swelling, bud burst, and leaf emergence were monitored. Based on four daily air temperature measurements, mean daily temperatures and cumulative Growing Degree Days (GDD; T base = 5 °C) were calculated. The data were analyzed using descriptive statistics, one-way analysis of variance (ANOVA), and Tukey's HSD test. Statistically significant differences were found among the studied trees for all analyzed phenological parameters ($p < 0.001$), confirming pronounced phenological variability within the examined material. Out of 200 analyzed shoots, leaf emergence was recorded in 137 (68.5%), whereas 63 shoots (31.5%) did not reach this phenological stage. Two trees were particularly distinguished by the complete absence of leaf emergence on all analyzed shoots, despite the successful completion of the preceding stages of bud swelling and bud burst. The obtained results indicate that phenological traits related to the onset of vegetation may serve as selection criteria for identifying genotypes with different adaptive potential and provide a basis for breeding programs and the conservation of sweet chestnut genetic resources. However, further multi-year field studies are required to confirm their adaptive significance.

Keywords: *Castanea sativa*, phenology, onset of vegetation, Growing Degree Days (GDD), tree breeding.

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