

UTJECAJ KONZERVACIJSKIH SUSTAVA OBRADE TLA I KALCIZACIJE NA STATUS KOROVA U UZGOJU KUKURUZA, SOJE I PŠENICE

SAŽETAK

Poljoprivredna proizvodnja suočena je s rastućim izazovima klimatskih promjena i degradacije tla, što naglašava potrebu za primjenom održivih sustava gospodarenja tлом. Konzervacijska obrada i kalcizacija predstavljaju važne agrotehničke mjere koje mogu utjecati na razinu zakorovljenosti, sastav i bioraznolikost korovne flore te prinos usjeva. Cilj ovog istraživanja bio je utvrditi utjecaj različitih sustava obrade tla (glavni tretman) te primjene kalcizacije (podtretman) na zakorovljenost i prinos usjeva kukuruza (*Zea mays* L.), soje (*Glycine max* (L.) Merr.) i pšenice (*Triticum aestivum* L.) tijekom trogodišnjeg razdoblja (2021.– 2023.) na hipoglejnom tlu zapadne Panonske regije. Poljski pokus proveden je na pokušalištu Veleučilišta u Križevcima kao dvofaktorski pokus u tri ponavljanja. U okviru glavnog tretmana ispitivana su tri sustava obrade tla: (1) konvencionalna obrada tla (ST) – oranje do dubine od 30 cm; (2) duboka konzervacijska obrada tla (CTD) – rahljenje do 30 cm uz minimalno 30 % površine prekrivene biljnim ostacima; te (3) plitka konzervacijska obrada tla (CTS) – plitko rahljenje do 10 cm uz najmanje 50 % površine prekrivene biljnim ostacima. Podtretman je obuhvaćao dvije varijante kalcizacije: kalcizirani (CAL) i nekalcizirani (NCAL). U istraživanje su bile uključene tri strateške ratarske kulture: kukuruz (2021.), soja (2022.) i pšenica (2022./2023.). Zakorovljenost je određivana na površini od 1 m², određenoj pomoću nasumično postavljenog okvira površine 0,25 m² u četiri ponavljanja na svakoj istraživanoj parceli. Uzorkovanja korova obavljena su dvaput tijekom vegetacije svake istraživane kulture – u ranoj i kasnijoj fenofazi razvoja usjeva: V7 i R5 kod kukuruza, V3 i R7 kod soje te BBCH 25 i BBCH 85 kod pšenice. Utvrđeni su ukupan broj, broj vrsta, pokrovnost korova te nadzemna biomasa korova po jedinici površine. Korovi su determinirani i razvrstani po vrstama. Za određivanje biomase korovi su sušeni u laboratorijskoj sušionici na 65 °C do konstantne mase i vagani. Za procjenu raznolikosti korovne flore izračunati su Shannon–Wienerov indeks, indeks ujednačenosti i prosječna veličina populacije. Prinosi usjeva određeni su vaganjem ukupne količine zrna dobivenog na pokusnim parcelama nakon žetve, a rezultati su izraženi po hektaru. Rezultati su statistički obrađeni analizom varijance (ANOVA), a u slučaju značajnih razlika, test najmanje značajne razlike (LSD test) korišten je za usporedbu srednjih vrijednosti na razini značajnosti $p < 0,05$. Rezultati su pokazali da konzervacijski sustavi obrade tla, osobito plitka obrada, povećavaju brojnost, biomasu i pokrovnost korova u odnosu na konvencionalnu obradu. Istovremeno je kod konzervacijske obrade utvrđena veća bioraznolikost korovne flore, s izraženijom pojavom višegodišnjih širokolisnih vrsta. Kalcizacija je imala promjenjiv učinak na zakorovljenost, ali je u prosjeku povećala prinos usjeva za 4 – 6 %, pri čemu je najveći učinak zabilježen kod soje. Prosječni prinos kukuruza i pšenice bio je najveći kod konvencionalne obrade, dok je soja ostvarila najbolje rezultate u konzervacijskoj plitkoj obradi tla. Provedeno istraživanje potvrđuje da konzervacijska obrada tla doprinosi većoj zakorovljenosti i raznolikosti korovne flore, dok kalcizacija pozitivno utječe na prinose, ali nema dosljedan učinak na smanjenje zakorovljenosti. Rezultati istraživanja ukazuju da konzervacijski sustavi obrade tla, posebno kada se primjenjuju uz kalcizaciju, doprinose očuvanju i plodnosti tla, povećanju bioraznolikosti te održivosti proizvodnje, uz prinose koji ostaju na razini usporedivoj s konvencionalnim sustavima obrade.

Ključne riječi: konzervacijska obrada tla, kalcizacija, zakorovljenost, bioraznolikost, kukuruz (*Zea mays* L.), soja (*Glycine max* (L.) Merr.), pšenica (*Triticum aestivum* L.), prinos

INFLUENCE OF CONSERVATION TILLAGE AND LIMING ON WEED STATUS IN MAIZE, SOYBEN AND WHEAT CULTIVATION

EXTENDED ABSTRACT

Agricultural production today faces numerous challenges arising from accelerated climate change, increasing soil degradation, and the continuously growing global demand for food. These processes directly affect the sustainability of agroecosystems and yield stability, making it more difficult to plan and preserve agricultural potential in the long term. A particular concern is that the long-term use of conventional tillage systems greatly reduces soil fertility, increases erosion, depletes organic matter, and degrades biological activity. Such changes negatively influence not only productivity but also the resilience of agricultural systems to external stressors. Under these conditions, conservation agriculture, based on the principles of minimum soil disturbance, permanent soil cover, and diverse crop rotations, is gaining increasing importance. It represents one of the most effective solutions to the challenges of modern production, as it contributes to soil conservation, yield stability, and environmentally sustainable farming. However, although the positive effects of these technologies have been confirmed in numerous international studies, in Croatia there is a considerable lack of systematic data, especially on sensitive hypogley soils that predominate in northwestern Croatia. In addition, very few studies simultaneously consider liming as a measure for improving chemical properties and soil reaction, and its effects on weed infestation and crop yields. Weeds, as one of the key biotic factors, have a strong influence on the productivity of arable crop production. Their dynamics, abundance, composition, and competitiveness largely depend on the tillage system, nutrient availability, and chemical soil properties, particularly soil reaction (pH). Accordingly, the research problem of this dissertation is focused on assessing the relationship between conservation tillage and liming with changes in weed infestation, floristic diversity, and the final yields of three strategically important crops: maize, soybean, and wheat. The specific motivation arises from the need to find practical and scientifically based solutions that can ensure the long-term sustainability of agricultural production under the agroecological conditions of continental Croatia, where hypogley soils occupy a significant share of arable land and are highly sensitive to degradation processes. The research was conducted over three growing seasons (2021–2023) at the experimental field of the University of Applied Sciences in Križevci, located on hypogley soil in the western Pannonian region of Croatia. The field trial was established as a two-factor experiment with three replications. The main factor included three tillage systems: (1) conventional tillage (ST) – plowing to a depth of 30 cm; (2) deep conservation tillage (CTD) – subsoiling to 30 cm with approximately 30 % surface coverage with crop residues; and (3) shallow conservation tillage (CTS) – shallow loosening to 10 cm with at least 50 % surface coverage with crop residues. The sub-treatment involved two liming variants: limed (CAL) and unlimed (NCAL). Three strategically important field crops were included: maize (2021), soybean (2022), and wheat (2022/2023). Weed infestation was determined within a 1 m² area using a randomly placed 0.25 m² quadrat in four replications per plot. Sampling was performed twice during each growing season – in the early and later crop growth stages (V7 and R5 in maize, V3 and R7 in soybean, and BBCH 25 and BBCH 85 in wheat). The total number of weeds, species composition, cover, and aboveground biomass per unit area were recorded. All weed species were identified and classified. For biomass determination, weed samples were dried in a laboratory oven at 65 °C to constant weight and then weighed. Weed biodiversity was evaluated using the Shannon–

Wiener diversity index, evenness index and average population size. Crop yields were determined by weighing the total grain yield from each plot after harvest, and results were expressed per hectare. Data were statistically analyzed using analysis of variance (ANOVA),

and when significant differences were found, means were compared using the least significant difference (LSD) test at a significance level of $p < 0.05$.

The results indicated clear differences between tillage systems and the effects of liming. In maize, conventional tillage resulted in the highest weed density at the early growth stage (V7), while conservation systems, particularly shallow tillage, contributed to greater floristic diversity at the later stage (R5). Weed biomass was higher under conservation systems, but the community structure was more diverse and stable. The highest maize yield was obtained under conventional tillage, while conservation systems gave lower yields, with shallow tillage performing better than deep tillage. Liming increased maize yield by about 4% and reduced weed biomass at the early growth stage. In soybean, conservation systems led to higher floristic diversity and an increase in perennial broadleaf species, while conventional tillage favored annual broadleaf weeds. Liming reduced weed biomass at the early growth stage (V3), but no significant effects were recorded at later stages. The highest soybean yield was achieved under shallow conservation tillage, while the maximum yield was obtained under the ST – CAL variant. Liming increased yields by 4 – 6%, and the differences were statistically significant across all crops. In wheat, conservation systems increased the number of weed species and biodiversity indices compared with conventional tillage. The highest weed cover was recorded under shallow conservation tillage, while conventional tillage resulted in lower weed infestation but also lower weed community diversity. The highest wheat yield was achieved under conventional tillage, while liming had a positive but less pronounced effect.

The results confirm that conservation tillage systems, despite increasing weed biomass and cover, contribute to greater diversity and stability of weed communities, which is an essential element for the long-term sustainability of agroecosystems. Liming had a positive effect on soil chemical properties and yield, while its influence on weed infestation was limited. The scientific contribution of this dissertation lies in providing multi-year experimental evidence from hypogley soils of continental Croatia, where such comprehensive studies have so far been scarce. The findings expand the understanding of interactions between tillage, liming, and weed communities under specific agroecological conditions, and provide a scientific basis that can support the adoption of conservation tillage practices in similar environments. By maintaining yield stability while enhancing soil quality, biodiversity, and resource protection, the results contribute to food security and the reduction of soil degradation. In this way, the dissertation provides both a solid scientific foundation and recommendations for sustainable crop production systems under challenging climatic and pedological conditions.

Keywords: conservation tillage, liming, weed infestation, biodiversity, maize (*Zea mays* L.), soybean (*Glycine max* (L.) Merr.), wheat (*Triticum aestivum* L.), yield