

PROMJENE FIZIKALNO KEMIJSKIH ZNAČAJKI TLA I PRINOSI JARINA POD UTJECajem UGARA I ZELENE GNOJIDBE

SAŽETAK

Usljed korištenja velikih količina različitih kemijskih sredstava, zapostavljanja stočarstva, usko specijaliziranoj proizvodnji, konvencionalna poljoprivreda uzrokovala je smanjenje plodnosti tla, odnosno degradaciju fizikalnih i kemijskih osobina tla. Poznato je da ugar kao najstarija agrotehnička mjera za poboljšanje plodnosti tla, pozitivno utječe na mikrobiološku aktivnost tla, a samim time i na fizikalna i kemijska svojstva tla. Zelena gnojidba, odnosno sijanje siderata kratke vegetacije između glavnih kultura također pozitivno utječe na poboljšanje navedenih karakteristika tla. Budući da se organska tvar unosi u tlo, a korijenov sistem sustav rahli tlo, a kod mahunarki (*Fabaceae* ili *Leguminosae*) koje koristimo kao siderat usvaja se dušik iz atmosfere pa se njihovim unošenjem u tlo povećava sadržaj ovog hranjiva. Ovim trogodišnjim istraživanjem koje se provodilo na OPG-u Dalibor Jurina u Velikim Zdencima, u razdoblju 2020. - 2023. godina, uključen je tzv. pravi ugar (tlo ostavljeno bez sijanja usjeva), zeleni ugar (tlo ostavljeno bez glavnog usjeva ali sa sjetvom siderata) i sjetva glavnih kultura (kukuruz, soja, krumpir) sa i bez siderata. U radu su promatrane slijedeće fizikalne i kemijske značajke tla i prinos tih kultura. Nulti početni uzorci tla uzeti su u listopadu 2020. godine, te su za svaku vegetacijsku godinu uzeti prosječni uzorci tla u proljeće i jesen, dakle 2021, 2022. i 2023. godine, ukupno 7 uzorkovanja tla. Od fizikalnih značajki tla istraživala se volumna gustoća tla (Stv) i gustoća čvrste faze tla (Stp), a od kemijskih osobina tla promatrala se kiselost tla (pH u KCl-u), sadržaj organske tvari (%), ukupni ugljik (TC), ukupni dušik (TN), odnos ugljika i dušika (C/N), fiziološki aktivni fosfor (P₂O₅) i fiziološki aktivni kalij (K₂O). Pratili su se prinosi usjeva sa sideratom i bez siderata, i to 2021. godine kukuruza (*Zea mays* L.), 2022. godine soje (*Glycine max* (L.) Merr.) i 2023. godine krumpira (*Solanum tuberosum* L.). Istraživanje je provedeno u bloknom rasporedu parcela veličine 10 m puta 35 m, sa 4 ponavljanja. Tijekom trogodišnjeg istraživanja (2021.-2023.) i primjeni različitih sustava obrade tla utvrđene su značajne promjene fizikalno-kemijskih svojstava tla, posebice u sustavima sa sideracijom koji su pokazali povoljnije vrijednosti volumne gustoće, veću akumulaciju organske tvari i dušika te uravnoteženiji C/N odnos. U promatranom razdoblju nisu zabilježene značajne razlike u prinosima ovih kultura sa sideracijom ili bez sideracije. Prinos je kompleksna varijabla koja ovisi o mnoštvu čimbenika, pa su stoga važnije uočene promjene u fizikalnim i kemijskim osobinama tla, što je i bio glavni cilj istraživanja. Glavni ograničavajući čimbenik prinosa bili su klimatski uvjeti – suša 2021. i 2022. te višak oborina 2023. – što potvrđuje da vremenske prilike imaju presudniji utjecaj na prinos od samih agrotehničkih mjera. Ključne riječi: konzervacijska obrada tla, kalcizacija, zakorovljenost, bioraznolikost, kukuruz (*Zea mays* L.), soja (*Glycine max* (L.) Merr.), pšenica (*Triticum aestivum* L.), prinos

Ključne riječi: sideracija (zelena gnojidba), ugar, fizikalno-kemijske značajke tla, prinos usjeva, klimatski uvjeti

CHANGES IN THE PHYSICO-CHEMICAL PROPERTIES OF SOIL AND YIELDS OF SPRING CROPS UNDER THE INFLUENCE OF FALLOW AND GREEN MANURE

EXTENDED ABSTRACT

Conventional agriculture, characterized by intensive use of chemical inputs, abandonment of livestock farming, highly specialized production, and minimal human labor, has led to a decline in soil fertility through the degradation of its physical and chemical properties. Among traditional agrotechnical practices, fallow represents the oldest method for improving soil fertility, positively affecting soil microbiological activity and, consequently, its physical and chemical properties. Similarly, green manuring, which involves sowing short-vegetation cover crops (siderates) between main crops, improves soil quality by adding organic matter, loosening the soil through root activity, and, in the case of legumes (Fabaceae or Leguminosae), fixing atmospheric nitrogen, thereby increasing soil nitrogen content after incorporation.

This three-year study was conducted on the family farm (OPG) Dalibor Jurina in Veliki Zdenci, Croatia, from 2020. to 2023. The experimental design included four treatments: true fallow (soil left unsown), green fallow (soil without main crops but sown with cover crops), main crop cultivation (maize, soybean, potato) without siderates, and main crop cultivation with intercropped siderates. Physical and chemical soil properties, as well as crop yields, were monitored. Initial soil sampling was conducted in autumn 2020., followed by spring and autumn sampling in 2021., 2022., and 2023., resulting in a total of seven sampling events. Physical properties analyzed included bulk density (Stv) and particle density (Stp), while chemical properties included soil pH (in KCl), organic matter content (%), total carbon (TC), total nitrogen (TN), C/N ratio, plant-available phosphorus (P_2O_5), and plant-available potassium (K_2O). Crop yields of maize (*Zea mays* L, 2021.), soybean (*Glycine max* (L) Merr., 2022), and potato (*Solanum tuberosum* L, 2023.) were also recorded. The experiment was conducted in a block design on plots of 10 × 35 m with four replications. Data were analyzed using Statistica 12.0 (StatSoft Inc.), and statistical significance was determined at $p < 0.05$.

Results from the first year showed that different tillage systems, including green manuring, affected certain physico-chemical soil properties but not maize yield. The most pronounced changes were observed in autumn, particularly in fallow and green manure systems, where higher organic matter and phosphorus accumulation were recorded. Crop-based systems had lower TC and TN values, while the C/N ratio remained relatively stable across seasons with minor variations in spring. Plant-available potassium varied within seasons, bulk density increased in autumn, and soil pH remained stable. These findings indicate that although short-term changes in soil fertility occur, maize yield may not immediately respond, especially under unfavorable climatic conditions such as those recorded in 2021. Long-term use of tillage systems with green manure may improve the preservation of organic matter, phosphorus, and pH stability, supporting sustainable maize production.

In the second year, measurable changes in physico-chemical soil properties were observed across different tillage systems, with or without green manure, but no statistically significant differences in soybean yield were recorded. Fallow and fallow + green manure systems had a more favorable effect on organic matter, TC, TN, P_2O_5 , and K_2O , while crop-based systems often showed lower values, especially in autumn. C/N ratios and soil pH remained stable across seasons, whereas bulk density was higher in crop and crop + green manure systems. Extreme climatic conditions in 2022., characterized by summer drought and excessive rainfall in September, likely reduced the potential impact of soil property changes on soybean yield.

In the third year, bulk density continued to vary within seasons, with higher values in crop and crop + green manure systems, while particle density and soil pH remained largely stable with

minor seasonal fluctuations. Fallow + green manure systems positively affected organic matter and total carbon, whereas crop-based systems consistently showed lower values. Total nitrogen increased in most systems during autumn, with variations in C/N ratio indicating different mineralization dynamics. Plant - available phosphorus remained stable, except for lower values in the crop + green manure system in autumn, while fallow and fallow + green manure consistently exhibited higher potassium levels. These results emphasize the importance of green manuring in maintaining soil organic matter and nutrient availability.

Overall, the results of the three-year study (2021. – 2023.) showed that different tillage systems, including green manuring, significantly influenced physico-chemical soil properties but did not result in statistically significant differences in maize, soybean, or potato yields. Bulk density varied within seasons, while particle density remained stable. Green manure systems increased organic matter, total carbon, and nitrogen contents, and promoted more balanced C/N ratios, indicating improved organic matter accumulation and nutrient cycling. However, higher soil fertility did not translate into increased crop yields, primarily due to extreme climatic conditions, including drought in 2021. and 2022. and excessive rainfall in 2023. These findings highlight the critical role of weather conditions in determining yields, which may outweigh the effects of tillage systems and green manuring.

Keywords: green manuring, fallow, soil fertility, soil properties, crop yield, nutrient availability