ISTRO Working Group - Conservation Soil Tillage: book of abstracts

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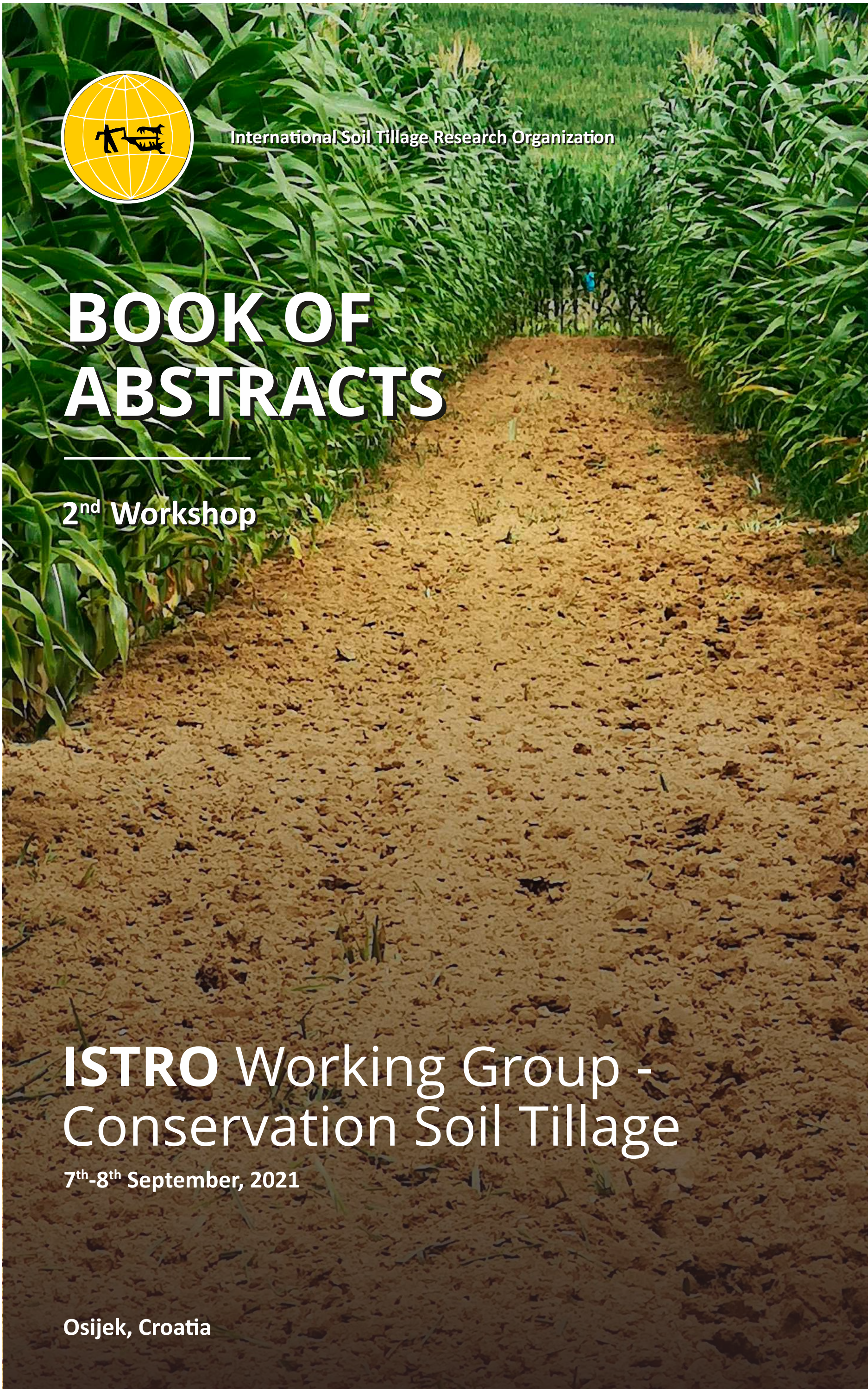

International Soil Tillage Research Organization

BOOK OF ABSTRACTS

2nd Workshop

ISTRO Working Group - Conservation Soil Tillage

7th-8th September, 2021

Osijek, Croatia

International Soil Tillage Research Organization

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Preface

Dear colleagues, ladies and gentlemen,

On behalf of the Working Group – Conservation Soil Tillage (WG-CST) of International Soil Tillage Research Organization (ISTRO), supportive institutions as well as sponsors, we are pleased to invite you to the WG-CST 2nd Workshop which will take the place in Osijek, Republic of Croatia, 7th-8th September, 2021.

WG-CST will organize a 2nd Workshop relating to and dealing mainly with ISTRO interest areas (e.g. Soil and Water Management, Tillage role on Greenhouse Gases Emissions, Plant Nutrition, Tillage tools and Implements, Crop Protection, etc.) but also any other topics related to Conservation Soil Tillage. WG-CST 2nd Workshop aims to open discussion and gathering basic and specific knowledge about current situation in science and professional work in domain of Conservation Soil Tillage.

WG-CST mission is based on the principles of connection, encouragement, promotion, transfer and application of knowledge about conservation soil tillage, and is realized through:

- connection of scientists and experts engaged in the research of conservation soil tillage and related scientific and research disciplines with the objective of achieving interdisciplinary,
- encouragement and promotion of the scientific research in the field of conservation soil tillage and interaction with similar disciplines,
- transfer of knowledge and scientific research results to the general scientific and professional community in order to improve the practical application of production.

Primary objective of that initiative is promotion, development and grow of interest and knowledge about conservation soil tillage science, exchange ideas and experiences and spreading modern approach of technology application in agroecosystems.

General Workshop topics will be discussed in the next sections:

- CST worldwide experiences / overview
- CST results from different experiments
- CST relation to other agricultural practices
- CST in and what we learn from experimental results
- CST as a challenge in changing world

This Workshop will cope with main goals of ISTRO respective research in soil tillage and field traffic and their relationship with the soil environment, land use and crop production.

WG-CST Secretary	WG-CST Chair
Daniel Plaza-Bonilla	Danijel Jug
(Spain)	(Croatia)

Workshop program

1st day – 7th September, 2021

Abstract presentations and topics discussion:

- **Effects of Artificial Plough Pans on Maize Growth in the Black Soil Region of Northeast China**

  Li Wang, Tusheng Ren

- **Conservation Soil Tillage and Fusarium sp.**

  Helena Ereš, Karolina Vrandečić, Jasenka Ćosić

- **Influence of vegetation cover on the quality of soil loss**

  Kisić I., Birkas, M., Perčin, A., Delač D., Papak H.

- **Influence of cultivation of maize (zea mays l.), soybean (glycine max l.) And oats (avena sativa l.) In crop rotation on mobile aluminum content, reaction and electrical conductivity of soil**

  Andrija Špoljar, Ivka Kvaternjak, Dragutin Žibrin, Mirjana Mužić, Miomir Stojnović

- **Conservation soil tillage: basic and important component of sustainable agricultural production**

  Irena Jug, Boris Đurđević, Bojana Brozović, Vesna Vukadinović, Bojan Stipešević, Gabriella Kanižai Šarić, Danijel Jug

- **Weed occurrence in conservation tillage systems**

  Bojana Brozović, Irena Jug, Boris Đurđević, Bojan Stipešević, Vesna Vukadinović, Iva Rojnica, Danijel Jug

- **Faba bean introduction to diversify long-term no-tillage rainfed cropping systems in NE Spain**

  Genís Simon-Miquel, Carles Ribera, Daniel Plaza-Bonilla

- **Conservation tillage as great potential to reduce carbon dioxide emission**

  Boris Đurđević, Irena Jug, Bojana Brozović, Vesna Vukadinović, Danijel Jug

- **Impact of strip tillage on soil properties during sugar beet cultivation**

  Beata Sokół, Edward Wilczewski

- **Tillage system and farmyard manure influence soil physical properties in organic farm in Croatia**

  Igor Bogunovic, Ivan Dugan, Ivica Kisic

- **Twin-row seeding pattern as a tool for maintaining soil conservation**

  Bojan Stipešević, Đuro Banaj, Danijel Jug, Irena Jug, Bojana Brozović, Boris Đurđević, Anamarija Banaj

- **Seaweed Extracts and Traces Elements to improve plant nutrition**

  Bruno Daridon, Benoit Le Rumeur

- **MIP technology, a tool for sustainable management of soils**

  Bruno Daridon, Benoit Le Rumeur

- **Conservation agriculture – respons to soil degradation**

  Vesna Vukadinović, Irena Jug, Boris Đurđević, Bojana Brozović, Danijel Jug

2nd day – 8th September, 2021

Field trip:

- **visit a progressive family farm**
- **CST experiment**
- **field demonstration**

ABSTRACTS

Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation – study project

Danijel Jug[1], Irena Jug[1], Boris Đurđević[1], Bojana Brozović[1], Bojan Stipešević[1], Vesna Vukadinović[1], Darko Kiš[1], Boris Antunović[1], Gabriella Kanižai-Šarić[1], Marija Ravlić, Branka Šakić Bobić[2], Zoran Grgić[2], Olga Jovanović Glavaš[3], Davorka Hackenberger Kutuzović[3], Ivka Kvaternjak[4], Andrija Špoljar[4]

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Increasing degradation of agricultural soils caused by a number of natural and anthropogenic factors puts the role of conservation soil tillage as a measure that is able to cope with these problems, following the principles of sustainable soil management. Conservation soil tillage as one of the fundamental postulates of conservation agriculture represent an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. Applying the conservation soil tillage principles improves soil quality, optimizes crop yields and reduces investment costs in agricultural production. Adopting the conservation soil tillage principles agricultural activity can significantly reduce the negative impact on physical, chemical and biological complex of the soil, as well as other natural processes. Previous research carried out these issues and in the ways of the proposed implementation, in Croatia are largely unsystematic, inconsistent and in any case insufficient, with the study only of the segments implemented by conservation soil tillage. Previous research not included a complex approach to conservation agriculture research, with the integration of its basic postulates, as proposed by this project.

As we found as extremely important of interdisciplinary approach to investigation conservation soil tillage as an integral part conservation agriculture and according aforementioned, we are established experimental stations with main intention to provide scientific research with several groups of research parameters, as follows: A) Pedophysical and pedomechanical; B) Pedochemical; C) Soil biology; D) Biodiversity (a-earthworms, b-weeds); E) Plant-growing (a-phenological observations, b-biometric components, c-elements compounds, d-contamination potential by Aflatoxin); F) Climate analyses and simulations; G) Economic analysis and projections.

Key words:

conservation agriculture, conservation soil tillage, interdisciplinary approach crop production, soil degradation

Acknowledgement

This work has been fully supported by Croatian Science Foundation under the project “Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation” (IP-2020-02-2647).

Effects of Artificial Plough Pans on Maize Growth in the Black Soil Region of Northeast China

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Plough pan, a specific soil structure that lies between the tillage layer and the subsoil layer, affects soil properties and movements of water, gas, heat and solutes. In the black soil regions of Northeast China, conservation tillage is being introduced to reduce soil erosion and improve soil quality. However, some researchers have the concern by replacing traditional plow tillage with conservation tillage, there is a potential risk that the plough pan may become thicker and shallower. To answer this question, we designed a field study to investigate artificial plough pans influence on corn growth in northeast China. The field experiment included three compaction levels (low, moderate, and high compactions with initial bulk densities of 1.2, 1.4 and 1.6 g cm^{-3}). The main objectives of this study were to investigate the effects of simulated plough pan on the growth of corn roots, shoots and yield. The major findings are: the presence of plough pan led to an increase of leaf area index during the filling stage, delayed leaf wilting, as well as the photosynthetic rate and stomatal conductance of maize leaves at the filling stage. Root growth was reduced in and below the artificial plough pan layer, but was promoted in the soil layer above the artificial plough pan layer. The total root length, surface area, volume and root weight of maize were increased with the increase of artificial plough pan strength. Thus, the loss of the root system due to plough pan was compensated in the topsoil layer. Finally, the existence of artificial plough pans showed no negative effects on maize yield, and some circumstances maize yield was increased.

Key words:

plough pan, maize growth, roots, shoots, yield

Conservation Soil Tillage and Fusarium sp.

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Genus Fusarium induces a fungal disease, which causes major problems in almost every region in the world where wheat is cultivated. Therefore, the most important issues it generates are yield loss, low test weights, low seed germination and contamination of grain with mycotoxins (Vrandečić et al. 2019).

Conservation soil tillage is becoming increasingly popular in the world. However, reduced tillage has an advantage over the conventional tillage due to its lower costs (economic profitability) (Ribera et al. 2004, Yalcin et al. 2005, Feizienė et al. 2006). Váňová et al. (2011) claimed that utilizing conservation of soil tillage, properly applied in particular soil and climate conditions, was one of the methods for realizing crop production with lower costs and a concurrent, long-term positive influence on the soil fertility. Usage of conservation soil tillage will become very important in reducing the intensity of the onset of the disease.

Vrandečić et al. (2019) argued that the lowest percentage of the infected wheat grain in the first location was registered using nitrogen fertilization reduced by 30% of the recommended amount and a conventional tillage, while in the second location the infected wheat grain was registered using the same nitrogen fertilization, but with no-tillage.

However, there are studies which are contrary to previously mentioned research. Dill- Macky and Jones (2007) established that yields of wheat were 10% greater in mouldboard plowed plots than in either chisel plowed or no-till treatments. In conservation tillage plots, a higher diversity of Fusarium species was found than in the mouldboard plough-based tillage plots (Steinkellner and Langer 2004).

Since there are only a few studies on this matter, further research is needed to determine the final impact of conservation tillage on Fusarium species.

Key words:

conservation soil tillage, Fusarium sp., wheat, disease

Influence of vegetation cover on the quality of soil loss

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Soil erosion by water is a pervasive and a significant environmental problem affecting all sloping terrains, causing soil physio-chemical changes and soil displacement. Considerable modification of the soil chemistry leads to decrease in soil fertility and in a disrupted nutrient balance. In this context, soil pH and organic matter content are of great importance as fundamental factors of soil fertility. Therefore, the basic objective of this work is to determine the influence of inter-row use on the soil quality affected by water erosion in the vineyards. The research included different treatments in two vineyards; grassed inter-rows and bare inter-rows. The vineyards are located in the same position, slope and soil type. Grassed inter-rows in the vineyard belongs to the family farm Mladen Papak, while the treated bare soil in the rows belongs to the vineyard of the family farm Drago Papak. The results of laboratory analysis show the influence of different soil use in vineyards on the changes of soil pH and soil organic matter content. Based on them, it is recommended to grass the inter-row space due to reduced soil erosion by water, retention of plant mass and organic matter, non-compaction of the inter-row space and easier passage of machinery through the rows. Also, it is important to emphasize and determine the direction of planting rows in vineyards because the direction of the row itself negatively can affect the increase of soil erosion by water. The results of this research indicate the importance of applying all preventive measures in reducing soil erosion by water on sloping terrains.

Key words:

soil erosion, inter-row grassing, vineyard, soil organic matter, soil pH

Influence of cultivation of maize (zea mays l.), soybean (glycine max l.) And oats (avena sativa l.) In crop rotation on mobile aluminum content, reaction and electrical conductivity of soil

Andrija Špoljar, Ivka Kvaternjak, Dragutin Žibrin, Mirjana Mužić, Miomir Stojnović

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During 2020 the influence of the cultivation of corn (Zea mays L.), soybean (Glycine max. L.,) and oats (Avena sativa L.) in crop rotation on the content of mobile aluminum, soil reaction and electrical conductivity (EC) was investigated at the experimental farm of the Križevci College of Agriculture. The research was conducted on molic "gleysol" on a plot of one hectare. During the vegetation, average soil samples were taken on three occasions at different phenological stages along the root system of plants. The following soil characteristics were determined from soil samples in the laboratory: mobile aluminum content, pH value in water and 1 MKCl, and electrical conductivity of the soil (EC). Statistically justified lower values of soil reaction measured in water and 1 MKCl up to 30 cm depth were found in black fallow compared to other investigated variants. The following order was determined for the measured values of soil reaction measured in 1 MKCl by variants up to 30 cm of soil depth: black fallow < oats < maize < soybean. It follows from the above that the cultivated crops did not condition the acidification of the soil. The order of mobile aluminum content according to the variants up to 30 cm of soil depth is as follows: black fallow > oats > corn > soybean. The highest value of soil electrical conductivity up to 30 cm of soil depth was in soybean cultivation. The following order of measured values of electrical conductivity according to variants up to 30 cm of soil depth was determined: oats < maize < black fallow < soybean. Possible higher water infiltration in the variants where the crops were grown certainly affected the concentration of the aqueous solution and the measured values of the investigated soil characteristics, so due to wetter conditions, higher soil pH values were measured in the variants with crops.

Key words:

crop rotation, soil acidification, electrical conductivity, mobile aluminum

Conservation soil tillage: basic and important component of sustainable agricultural production

Irena Jug, Boris Đurđević, Bojana Brozović, Vesna Vukadinović, Bojan Stipešević, Gabriella Kanižai Šarić, Danijel Jug

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Sustainable food production is one of the major challenges of the twenty-first century in the era of global environmental problems such as climate change, increasing population and natural resource degradation. According to FAO, the world's population will increase by one third over the next 30 years and agricultural production will have to increase by 60 % to satisfy the expected demands for food if current consumption growth trend continues. Soil quality is one of the most important preconditions in achieving sustainable farming systems, which attempt to balance productivity, profitability and environmental protection. Previous agricultural practices (such as conventional tillage) have led to various forms of degradation of the physical, chemical and biological properties of the soil, which has reduced its productive capacity and also had a negative impact on the environment. Conventional tillage, as part of conventional soil management practices, degrades the soil in many different ways: by increasing erosion, losses of water and nutrients, reducing the content of soil organic matter, forming a crust, soil compaction, creating a fragile structure, etc. These practices led to decreased water and nutrient used efficiency and, at last, low crop yields. The implementation of conservation tillage reduces the harmful effects on the soil as a non-renewable natural resource, preserve soil quality, reducing agrochemicals consuming and greenhouse gas emissions. Conservation tillage improves soil fertility, aeration, water infiltration, the stability of structural soil aggregates which enhances nutrient retention and reduces soil erosion, etc. Though conservation tillage has countless advantages, it is very important to adopt particular tillage system for a particular crop taking into account the climatic conditions of the agroecological area and the soil type with their properties.

Key words:

conservation soil tillage, sustainability, soil degradation, soil quality

Weed occurrence in conservation tillage systems

Bojana Brozović[1], Irena Jug[1], Boris Đurđević[1], Bojan Stipešević[1], Vesna Vukadinović[1], Iva Rojnica[2], Danijel Jug[1]

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Implementation of the principles of conservation agriculture with soil cover, minimum tillage and crop rotation regularly leads to various changes in the soil conditions. This refers to the possibility of preserving soil moisture, reducing erosion, nutrient losses, leaching of pesticides, etc. These advantages of conservation tillage are questionable when it comes to weed control as it implies a reduced intensity of tillage which is otherwise an important factor in weed management. The intensity of weeding usually will be greatest at the very beginnings of such a method of crop production. Knowing of the life cycle of weeds is very important for predicting changes in the population of weed species and developing management practices in conservation systems. Perennial weeds can become problematic in conservation tillage systems because they reproduce vegetatively and generatively. Tillage can control but also encourage the growth and development of weeds, all of which depend on their life cycle. Surface and shallow tillage such as disking creates favorable conditions for weed seed germination and increases the occurrence of many annual weeds compared to ploughing. Tillage has less efficiency in the control of perennial weeds, but to some extent it still exists because it reduces the number of weeds and their biomass because the regeneration from the vegetative parts of the weed is depleted. Reduced tillage can lead to a stronger spread of narrow-leaved and perennial weeds, of which Echinochloa crus-galli (L.) PB., Avena fatua L., Sorghum halepense (L.) Pers are very significant while the abundance of annual broadleaf weeds most often decreases. The increased incidence of wind-spread weed species is associated with conservation tillage. Successful weed management in conservation tillage systems involves the use of integrated measures with the inevitable use of herbicides and crop rotation as a key component in weed control.

Key words:

weed infestation, weed management, conservation tillage

Faba bean introduction to diversify long-term no-tillage rainfed cropping systems in NE Spain

Genís Simon-Miquel, Carles Ribera, Daniel Plaza-Bonilla

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In the semiarid rainfed areas of NE Spain, no-till (NT) arable cropping systems (around 15% of the arable land) are mainly devoted to the production of winter cereals such as barley (Hordeum vulgare L.) and wheat (Triticum aestivum L.). Cropping systems diversification with legume crops has been encouraged both by the 2013 Common Agricultural Policy reform and as a strategy to reduce small-seeded grass weeds pressure such as ripgut grass (Bromus diandrus R.), common in winter cereals under NT. In this regard, an on-farm rainfed cropping systems experiment was established within the framework of the LegumeGap EU Project (www.legumegap.eu) in Selvanera (41°49'52.3"N 1°17'41.0"E, Lleida, Catalonia, Spain). Soil management was based on long-term NT with the use of a sowing machine equipped with disc openers. The objective of the experiment was to determine the feasibility and potential of faba bean (Vicia faba L.) cultivation to diversify winter cereal monocultures and to compare it to winter pea (Pisum sativum L.) –the widespread choice among producers in the area. The experiment design was a split-plot design with the different crop sequences as the main plot, and increasing rates of synthetic N fertilizer (0, 40, 80, and 120 kg N ha-1) applied as top dressing as sub-plots. At the flowering stage, crop above-ground biomass, N uptake and N derived from biological N2 fixation (for legumes, using the 15N natural abundance method) were quantified. Weed pressure was visually determined at flowering. Same herbicide treatments were applied to faba bean and winter pea. Finally, the productivity of the crops was determined at physiological maturity. Faba bean outperformed winter pea in terms of above-ground biomass at flowering in the 2019-2020 cropping season (1258 g m-2 vs 761 g m-2, respectively) and in 2020-2021 (488 g m-2 vs 324 g m-2, respectively). The proportion of biological N derived from the atmosphere was 78 % and 59 % and 48 % and 37 % for faba bean and winter pea, respectively, in the first and the second season, respectively. Grain yield was 4186 kg ha-1 at 12% moisture for faba bean in 2019-2020, while a total loss of winter pea production occurred due to severe lodging. In 2020-2021 faba bean and field pea grain yields were 1346 kg ha-1 and 821 kg ha-1 at 12% moisture respectively. In 2020-2021 faba bean outcompeted with weeds compared to winter pea, with an estimation of weed soil coverage of 13% ±8 (std.dev.) for faba bean and 51% ±14 for winter pea, respectively. The main weed species were Lolium rigidum R., Papaver rhoeas L. and Sisymbrium runcinatum Lag.The remarkably rainier season in 2019-2020 in contrast to 2020-2021 (608 vs. 275 mm, respectively during the growing season) would explain the differences in above-ground biomass and productivity between seasons. These preliminary results point out the agronomic performance of faba bean as an outperforming alternative to the more common selection of winter pea by producers in long-term NT cropping systems of NE Spain.

Key words:

cropping systems diversification, grain legumes, Mediterranean climate, rainfed conditions

Conservation tillage as great potential to reduce carbon dioxide emission

Boris Đurđević, Irena Jug, Bojana Brozović, Vesna Vukadinović, Danijel Jug

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Agriculture in global scale accounts for 10–12% of total anthropogenic emissions of greenhouse gases (GHG). It is approximately estimated that it produces 5.1 to 6.1 Gt CO2 eq yr-1. The main loss of CO2 from soil is directly connected with decline of organic matter from soils in agroecosystems, due to unappropriated agricultural (incineration and the removal of crop residues, overgrazing, inappropriate tillage, etc.) and environmental conditions (rising temperature or heat waves events, frequent floods, erosion, etc.). Tillage systems especially annual ploughing has a major influence on soil GHG emissions, specifically, carbon dioxide (CO2). Intensive soil cultivation leads to a faster decomposition of soil organic matter (SOM) which accelerates organic C oxidation (release of large amounts of CO2, to the atmosphere). One of the possible solutions for reducing CO2 emissions is introducing the Conservation tillage (CT) as main tillage system in agricultural production. Conservation tillage is defined as any tillage which minimize or reduce loss of soil and water and leaves a 30% crop residue cover on the surface. Mainly it is divided in four types of tillage: mulch tillage, ridge tillage, zone tillage, and no-tillage but also reduced tillage and minimum tillage. Recent studies show that emissions under CT can be smaller comparing it with Conventional tillage. Main reason for that is increasing amount of C sequestered by implementing Conservation tillage. It is reported that CA can sequestrate approximately up to 10 times more of soil carbon than conventional tillage. Adoption of Conservation tillage practice surely will play a significant role in lowering CO2 emission footprint of agricultural practice and contribute to the efforts of climate change mitigation.

Key words:

conservation tillage, greenhouse gases, CO2, climate change, soil organic matter

Influence of conservation soil tillage on soybean nodulation

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Pre-sowing bacterization of soybean seeds is a recommended agrotechnical measure in the cultivation of all legumes. By bacterization, previously selected highly efficient, superior strains are introduced into the soil, which achieves close contact with the seed and the recognition process immediately after sowing and after the infection of the seed, soybean nodulation follows. In this way, biological nitrogen fixation is enabled. This is a specific process, so the appropriate abiotic but also biotic conditions in the soil must be met for this process to reach its full capacity. In soils with lower biogenicity and poorer pedochemical indicators, this measure is a necessary need. Different tillage systems have a significant impact on soil structure, soil porosity, soil water content, which directly affects the soil biota. This study aimed to determine the impact of different tillage systems (conventional, reduced, and conservation) with and without liming on the number and dry mass of nodules on a soybean root. The results showed that on average on limed treatment the number of nodules increased by 0 - 47% with conventional tillage, while in limed conservation tillage this parameter is higher by 7 to 60%. Reduced treatment with liming on average, did not show a positive effect on the number of nodules. The mass of dry matter of nodules varied depending on the treatment from 0 - 61% more in limed conservation treatment and 0-76% treatment. Reduced tillage, in this case, shows a higher number of nodules d 38-44% in limed and from 27-44% in non-limed soil depending on the treatment. The results indicate a predominantly higher number and dry mass of nodules in the conservation soil tillage system, which is expected because in this soil tillage system there is less impact on soil structure, organic matter is higher, and also soil biogenicity. Future research is needed that should clarify in more detail the interactions that have occurred as well as their impact on soybean yield itself.

Key words:

tillage systems, nodule number, nodule dry mass, rhizobium

Earthworms and conservation soil tillage

Davorka K. Hackenberger, Branimir K. Hackenberger, Olga Jovanović Glavaš

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The importance of soil organisms for soil health and, consequently, sustainable agriculture in the future became widely acknowledged. FAO's Status of the world's soil resources in 2015 concluded that the loss of soil biodiversity is considered one of the main global threats to soils in many regions of the world. Higher abundance and biomass of soil organisms are proven to reduce soil degradation and desertification. Soil biota can be classified in three categories: microfauna, mesofauna and macrofauna. Earthworms belong to a macrofauna and are also known as ecosystem engineers. They affect soil structure by mixing soil layers and making biopores by burrowing. Additionally, it is proven that they positively affect plant production and pathogen control. Literature review shows overall decline of soil fauna including earthworms under agricultural ecosystems in Europe. Tillage systems can impact earthworms through changes of organic matter content, moisture and temperature dynamics and by mechanical damage. Yet, the response to tillage varies between different earthworm species, climate conditions and physico-chemical soil properties.

Conservation tillage has been associated with numerous soil quality parameters improvements including increased earthworm activity and biomass. Moreover, under conservation tillage earthworms can play a more important role by exploiting their abilities of bioturbation and impact on nutrient cycling. Yet, experiments of different duration (mostly short-term vs. long-term) show some opposite effects and interactions between earthworms and conservation tillage. As we have to move forward to a more sustainable land management practices, more research is needed to fully understand those interactions and to resolve inconclusive or contradictory results.

Key words:

tillage practices, earthworms, soil fauna

Weed infestation changes in conservation soil tillage systems

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One of the responses to climate change nowdays are conservation tillage systems as a sustainable way to manage agricultural practices. Conservation agriculture is an agricultural system that promotes tillage with minimal soil disturbance (reduced tillage, minimum and zero tillage), permanent plant residues on the soil surface and crop rotation. From the beginning of crop production, weeds have been a constraint in the world of agriculture because, if left uncontrolled, they can cause significant yield losses. Due to the selection pressure of modern agricultural practice and the evolution of herbicide-resistant weeds makes the task of weed control more challenging. Tillage methods affect the accumulation and distribution of weed seeds in the soil profile. In conventional (plowed) tillage systems, the seed is distributed more or less evenly over the entire tillage layer, while in conservation systems a large part of the seed is concentrated in the surface layer of the soil where it finds favorable conditions for germination. Conservation systems with higher amounts of crop residues on the soil surface affect the appearance of weeds due to physical growth barrier, environmental conditions, and potential allelopathic effects of crop residues. Previous research suggests that total weed coverage is higher in a reduced tillage system, although these results are not the same for different crops. Zero tillage and minimum tillage systems lead to increased weed infestation compared to conventional tillage systems, especially with perennial weeds. Studies have shown that the tillage system affects the composition and functional properties of the weed community. Weed communities under reduced tillage were potentially less competitive because they were shorter, with less affinity for nutrients. Understanding the effects of tillage on weed community dynamics can be a challenge. The effects of tillage on weed dynamics vary depending on the interaction with other management systems, crop type, environmental conditions and weed biology. Weed control differs among different tillage systems where the conservation system is suitable for species with small seed which require different weed control strategies.

Key words:

conservation tillage, weed infestation, weed control

Brachiaria intercropped with maize improves structural and physical quality of an Oxisol under no-tillage

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Compaction control in no-tillage areas is important for conserving the healthy pore structure developed after years of no-till management. This study tests the hypothesis that short-term cultivation of brachiaria as an interrow cover plant (intercropping) in maize crops positively impacts the structure of a dystrophic Red Oxisol under no-tillage. The objective of this study was to evaluate if 83 days (short term) of brachiaria intercropping with maize improved soil structural and physical quality compared with only the cultivation of maize (Control). To do this, VESS (Visual Evaluation of Soil Structure) soil quality (Sq) scores, soil resistance to penetration, soil bulk density, air-filled porosity, soil air permeability, pore continuity index and water storage capacity were determined. Significantly lower VESS Sq scores and more favorable soil physical properties were found under the intercropping treatment. Two distinct soil layers were observed in both treatments, in the Control treatment there was a 0.03 m top layer of good quality soil found over a 0.22 m layer of moderate quality soil. The surface layer under the brachiaria was deeper (0.10 m) and of better quality (Sq 1.9), while the subsurface was shallower (0.15 m) and also of better quality (Sq 2.8) when compared with the control. The results showed significant negative relationships between VESS Sq score and air-filled porosity, soil air permeability and pore continuity, while positive relationships were found between VESS Sq and soil bulk density and soil resistance to penetration. The interrow cultivation of brachiaria in maize allows for a greater drying of the soil before resistance becomes limiting to the roots. Our results suggest that the cultivation of brachiaria intercropped with maize improves the structural quality of the soil, even if cropped only in the short term, 83 days after sowing, under a no-tillage system in a tropical/subtropical climate.

Key words:

visual assessment of the soil; crop diversification; soil quality, soil structure

Hot water extractable carbon content under the system of cover crops incorporation and following soybean sowing on chernozem

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The aim of the study was to determine the influence of different winter cover crops (WCC) followed with soybean on the content of organic matter (OM) level as well as the labile hot water extractable organic carbon (HWOC). Research was carried out at the Rimski Šančevi experimental station Novi Sad on Chernozem soil type. The WCC consisted of the combined intercrops: winter pea (Pisum sativum ssp. Arvense L.) + triticale ((×Triticosecale Wittm. ex A. Camus) (WPT) and mono WCC winter pea (WP) and control (C) (without WCC). Plowing of CC and control plots was carried out at a depth of 27 cm in the last decade of May 2020, and the sowing of soybean was done in first decade of June. Nitrogen fertilization was done in the form of top dressing with 50 kg N ha^{-1}. Soil was sampled in October at depth of: 0-20 cm, 20-40 cm. The analysis of variance determined a significant effect of cultivated crops (soybean) in the subsequent sowing period on the changes of the HWOC content, as well as soil depth. Total soil OM was not significantly affected by experimental treatments. The highest value of HWOC was found on the CN50 (20-40 cm) (349.4 μg g^{-1}) and the lowest value after soybean was measured on the control plots CN0 (20-40 cm) (217.2 μg g^{-1}). The highest share of HWOC in the total OM content was measured on the variant WP N50 (0-20 cm) (2.54%), while the lowest share was found on variant C N0 (20-40 cm) (1.45%). Our study showed that management of CC can change HWOC and contribute to nutrition of main crops. In order to improve our knowledge about HWOC dynamics in Chernozem it would be necessary to conduct a series of research in terms of selecting appropriate cover crops as well as the time of incorporation to be adjusted to the purpose of the research.

Key words:

winter cover crops, organic matter, HWOC, soybean

Winter wheat cropping in convetional and conservation tillage systems: challenges and perspectives

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Winter wheat is an important food crop and plays a decisive role in the arrangement of cropping pattern. Conversely, winter wheat is underrated in profitability and farmers do not use its full agronomic potential. As a result, the emphasis in wheat cropping is put on trade-offs between inputs and productivity. Therefore, tillage pattern is one of the major options in increasing effectiveness and conservation tillage provides a viable option in its production. It is estimated that in Serbia, the classic plowing is performed on about 75% of arable land, conservation tillage and shallow cultivation are practiced at 540.000 ha, while direct seeding is used at 42.000 ha. This representation of soil cultivation methods indicates that in the future the classical tillage – plowing will remain dominant, but the areas under methods that reduce the depth and number of operations are gradually increasing. The aim of our study was to assess the yield of winter wheat in conservation tillage and classical (plowing). For conservation tillage, shallow chiseling was used to mix crop residue with soil following the sowing with Horsch Pronto 3DC. The classical tillage consisted of plowing (27-30 cm soil depth), seedbed preparation (System Compactor – Lemken) and seeding with Amazone D8-30 Super. Phosphorus and potassium were added in accordance with soil analyses while N was amounted to 120 kg ha^{-1}. The trial was part of long term experiment "Plodoredi" established at 2018/19 on Haplic Chernozem and consisted of different cropping systems including winter wheat. In average, significantly higher yield was obtained at the 3-year rotation (7.71 t ha^{-1}) and lowest at monoculture (6.35 t ha^{-1}) across different tillage methods. Three year averages showed higher yields on classical tillage (7.32 t ha^{-1}) compared to conservation tillage (7.09 t ha^{-1}) but without statistical significance. However, the most pronounced differences between conservation and classical tillage derived from monocultures. Our study demonstrates that winter wheat in 3-year rotation benefited from preceding soybean crop compared to 2-year and mono-cropping. Also conservation tillage can match classical tillage in wheat yield though it will need more time to reach soil steady-state that can to reflect on yield.

Key words:

tillage, grain yield, winter wheat, crop rotation

Determination of crop and machine parameters relevant to the harvesting and postharvest handling of Acha

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Acha is a cereal crop produced predominantly in Nigeria. Harvesting acha *(Digitaria exillis)* is still being done by traditional methods. Existing regular combines cannot be applied to acha harvesting because of its unique grain characteristics. Appropriate harvester suited to the characteristics of acha seed are not available. The aim of this study was to determine some crop and machine Parameters (CMPs) relevant to acha harvesting.

A motorized acha havester rig was developed and tested using 33 factorial experiment, varying speed (V), Knife speed (S) and reel index. Field soil texture, moisture content, bulk density and core index were determined. *Acha* angle of repose, bulk density, fineness modulus, coefficient of uniformity and moisture content at harvest were also determined.

Results obtained showed that average angle of repose, bulk density, fineness modulus, coefficient of uniformity and moisture content at harvest of acha were 32.5°, 0.584 g/cm^3, 1.22, 1.62 and 31.7%, respectively. Operating speed, knife speed and reel index had varying effects on C_{mat}. The field soil which is sandy had moisture, bulk density and cone index of 14.1% (wet basis), 1.53 g/cm^3 and 71.49 N/cm^3 respectively. These results have implication of the harvest and postharvest handling of *acha* crop.

Key words:

acha cereal, *acha* crop production

Derivation of a Functional Relationship between Acha Harvest Material Capacity and its Operating Parameters

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Acha (Digitaria exillis) is a nutritious staple food crop in many parts of West Africa. Its harvest is still being done manually because an appropriate harvester is nonexistent. An attempt was made in developing a harvester that would be applied to acha harvesting. Predicting the performance of the harvester was essential for planning and budgeting purposes. The objective of this study was to derive a fundamental relationship between the operating conditions of the acha harvester and its material capacity (C_{mat}).

A 3^3 factorial experiment was conducted to collect harvesting data. Quantities varied were operating speed(V) (1,3,5 km/h), Knife speed (S) (300,400, and 500 rpm) and Reel index(I) (1,1.25 and 1.5). Data collected were subjected to regression analysis to determine the functional relationship.

Results obtained showed that the equations relating C_{mat} and rate of fuel consumption to the operating conditions of the *acha* harvester are

$$\begin{aligned} C_{mat} = 56.63 - 35.04I^2 - 10.442VI^2 - 4.29I - 135.23V - 0.04S + 23.00V^2 \\ - 22.20V^2I + 143.57VI - 0.06V^2S + 0.06V^2SI - 0.32VSI \\ - 0.00025S^2 + 0.35VS + 0.24SI \end{aligned}$$

and

$$\begin{aligned} &Rate\ of\ Fuel\ Consumption \\ &= 24.23 - 0.000007VS^2 + 0.003V^2S - 0.0035V^2 + 0.50V^2I - 5.95I \\ &- 0.02S - 6.47V + 0.01VSI; \end{aligned}$$

These equations have been able to predict the material capacity of an *acha* harvest as well as the energy requirements to achieve the observed capacity.

Key words:

acha cereal, *acha* crop harvest

Allelopathy for weed control in conservation agricultural systems

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Weeds continue to be major problem in agricultural production, competing with crops for space, light, water and nutrients, thus reducing quantity and quality of crop yields. Weed control in more sustainable crop production, which aims to protect soil from erosion and degradation, reduces production costs, minimizes chemical herbicide application and their negative effect on the environment, requires implementation of environmentally friendly alternative methods such as allelopathy. Allelopathy, a biological phenomenon, represents both direct and indirect, negative and positive interactions among plants through the production of allelochemicals. Present in all plant parts, allelochemicals are released in various quantities into the environment through volatization, leaching from living plants and through decomposed plant residues, and via roots as exudates. Allelopathy as a tool can be successfully utilized as main or supplementary weed control method in conservation agricultural systems. Use of allelopathic plants in crop rotation, as surface residues, cover crops, as well as plant water extracts alone or in combination with reduced herbicides doses, effectively suppresses weed germination, emergence and growth. Crops with allelopathic potential include cereals, such as wheat, rye and sorghum, as well as buckwheat, legumes, Brassica spp., and sunflower, and more recently, medicinal and aromatic plants.

Key words:

allelopathy, weed control method, crop production

Conservation soil tillage in the Czech Republic – approaches and legislations

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In the Czech Republic up to 51% of agricultural land is threatened by water erosion. According to legislation, the restrictions are concerned to cultivation of wide-row crops in areas seriously and slightly endangered by erosion. In seriously endangered areas, wide-row crops (maize, sugar beet, potatoes, sunflower, bean, soybean and sorghum) are not allowed. In slightly endangered areas, growing of wide-row crops is allowed, but using conservation soil tillage (CST), where a minimum crop residue coverage has been defined. CST systems with their modification are increasingly being introduced under the economic pressure in the agricultural praxis. Nowadays various species of intercrops (especially their mixtures) are included in farming systems without animal husbandry. Suitable species components in mixtures are tested in different production areas. Minimum tillage systems, when the straw or intercrops residues partly covered soil surface, are preferred. Also direct sowing of intercrops cereal harvest is used, when rapid coverage of soil surface with green biomass reduces water losses. Strip-till system looks might be promising in sloped areas, where soil loss is reduced to 85% in comparison with ploughing. Progressive farms started to apply cover crops, when they simultaneously grow mixtures of main crop with cover crop (as a second crop with positive role as bio-drilling, carbon sequestration, nutrient source and reduction of pesticide usage). Another benefit is increased biodiversity of agrophytocoenoses. The crucial role play legumes/pulses that can fix nitrogen from the atmosphere that is later available for the main crop. The aim of our current research is to verify the possibility of growing maize with various inter-seeding cover crops. Species as Italian ryegrass *(Lolium multiflorum ssp. italicum)*, phacelia *(Phacelia tanacetifolia)*, rye *(Secale cereale)* and crimson clover *(Trifolium incarnatum)* proved a rapid growth and high production of biomass. Above mentioned approaches could improve cropping systems with high concentration of cereals.

Key words:

conservation soil tillage, inter- and cover crops, minimum a strip tillage

Impact of strip tillage on soil properties during sugar beet cultivation

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Strip tillage (strip-till), enabling deep loosening (30-35cm) of narrow soil strips, is more and more important in cultivation of sugar beet (Beta vulgaris L.). This technology enables us improving soil moisture in the vicinity of seeds sown, reducing organic matter loss and improving soil properties.

The aim of the research carried out in 2017-2019 in Poland was to determine the impact of tillage technology (strip-till versus plow tillage) and catch crops (pea and vetch versus control) on soil properties and yield of sugar beet. The improvement of significant physical and biological properties of the soil as a result of the use of strip-till was demonstrated. This technology made it possible to obtain a higher moisture of the seedbed by 1-3 percentage points during the germination and emergence of sugar beet compared to plow tillage. There was no significant effect of strip-till on the soil temperature in the vicinity of the seedbed. Moreover, strip-till contributed to the improvement of parameters in terms of the intensity of soil biological life. In strip-till, a higher number and weight of earthworms (Lumbricidae) was found than after traditional plow cultivation. The beneficial effect of strip-till on the development of storage roots of sugar beet was demonstrated. The soil penetration resistance measured in the rows of plants was usually lower than in the conditions of plow tillage. The effect of cultivation technology on the yield of sugar beet roots was different in the years of research. On average, over many years, there was a tendency to increase the yield under the influence of strip-till. Strip cultivation is certainly an interesting solution in sugar beet production. It has a positive effect on the conditions for the growth of plants and enables reduction of the time and costs of soil tillage. Therefore, strip-till can be considered as prospective in the light of the need to reduce the labor intensity and cost-consumption of production and to limit the risks associated with soil degradation.

Key words:

conservation tillage; earthworms; soil properties; strip tillage; strip-till; sugar beet

Tillage system and farmyard manure influence soil physical properties in organic farm in Croatia

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Environmentally sustainable agricultural practices are key for preserving soil physical quality and providing stabile grain yields. The interacted impact of the tillage and organic fertilization on soil bulk density (BD), penetration resistance (PR), and grain yields is not well understood in a Mediterranean climate. A study was carried out on Anthrosols in a Mediterranean Croatia (Raša valley) during 2017-2018 period. In split-plot design in three repetitions main plots was conventional tillage (CT), minimum tillage (MT) and reduced tillage (RT). Subplots were treatments with 600 kg ha^{-1} organic fertilizer (OF), 30 t ha^{-1} (FMY30) and 15 t ha^{-1} (FYM15) of farmyard manure. During 2017, MT increased ($p < 0.05$) BD in the 10–20 cm depth in relation to RT and CT. During 2018 MT increased BD on 0-10 cm and 10-20 cm depths in addition to RT and CT. Reduced tillage treatment had a significantly lower PR comparing to MT and CT in 2017 and significantly lower than MT in 2018. In 2017, CT had significantly lower oat yields compared to RT. During 2018 barley grain yields was significantly the highest under the CT, while under MT was significantly the lowest. Oat grain yields were significantly lower under the PE treatment compared to FMY30 and FMY15 treatments in 2017. During 2017 and 2018 farmyard manure decreased ($p < 0.05$) BD in addition to OF. Reduced tillage treatments with addition of FMY30 can therefore be considered in Mediterranean environment as proper management strategy for desirable physical conditions and stabile grain yields.

Key words:

tillage management, soil physical properties, crop yields, organic management

Twin-row seeding pattern as a tool for maintaining soil conservation

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Twin-row seeding has been shown possibility of maintaining either the same summer wide-row crop (such as maize, but also sunflower, even soybean in some extents) population in better distribution, or denser crop population with the same inter-competition, in both cases gaining higher grain yield per area. Also, due to the nature of separate seeding mechanisms, it is also possible to plant at the same time main (cash) and cover crop, thus promoting soil coverage. By creating additional soil coverage, either by better plants distribution or by higher plant density, twin-row pattern should also promote soil health conservation, through lower sun insolation, consequently lower evaporation and lover soil temperature, both promoting higher soil moisture conservation, but also better live condition for crop and soil biota. In order to confirm this statements, field experiment shall be exercised at the Experimental farm of the Faculty of Agrobiotechnical Sciences Osijek, Croatia, where soil moisture, soil temperature and soil biota activity will be monitored, in order to confirm the advantage of twin-row seeding pattern for soil conservation for maize and sunflower main crops. In case of confirmed hypothesis, twin-row can be promoted as a valid tool for both higher grain yield and soil conservation method for summer wide-row crops.

Key words:

twin-row, maize, sunflower, evaporation, soil moisture conservation

Seaweed Extracts and Traces Elements to improve plant nutrition

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Terrestrial plant and soil micro-organisms build a strong exchange relationship in the rhizosphere. Plants give to the soil between 4 to 20 % of the carbon collected in the atmosphere. In exchange, microorganisms provide a better mineral and hydric nutrition to the plant. Moreover, they improve soil stabilization, bio-protection and improve plant yield and quality. These exchanges are essential for plant regular growth and health.

One of the main actors of these exchanges are the Mycorrhiza, a symbiotic association between a fungus and a plant root.

Olmix Group has developed a patented technology mixing specific trace elements (MIP Rhizo) and seaweed extract to improve the relationship between plant and soil microorganism.

A study with AGRENE laboratory in France showed that M MIP RHIZO increased soil organic matter mineralization and the nitrification process.

BIOEMCO laboratory from Pierre and Marie Curie University (France) showed a multiplication between 3 and 10 of the Alkaline phosphatase activities (enzyme involved in phosphorus mineralization) after MIP RHIZO application.

On the other side, a study set up with SAYENS AGRO-ENVIRONNEMENT showed that the use of specific seaweed extract in corn sowing line, stimulate the relative abundances of arbuscular mycorrhizal fungi Glomeromycota. The results showed a better photosynthetic activity, shoot diameter, roots growth of the corn after the seaweed application.

MIP RHIZO ingredients and seaweed extract mixed together showed in a rhizotron trial a development of maize roots. It is observed a significant increase as well of mycorrhization frequency and intensity. These results on mycorrhization improvement were found again in 4 multilocation field trials on corn

The combination between MIP RHIZO and seaweed extract applied on the soil promotes interaction with plant and microorganism. That leads to a better plant nutrition and an improvement of crop yield and quality.

Key words:

soil micro-organisms, rhizosphere, mycorrhiza, roots development, plant nutrition

MIP technology, a tool for sustainable management of soils

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Because soils provide 95% of food for people, it is essential to preserve and develop its ability to produce quantity and quality in a sustainable way. Soil functions are: organic matter decomposition, nutrients circulation, water retain and release and biological processes regulation.

Compacted soil and lack of organic matter disturb this system. Olmix develops technology based on trace elements mixtures (Mineral Inducer Process- MIP) applied to the soil by a new generation of inputs (Geo2) dedicated improving biological processes. As shown by the study led by Bioemco in France, MIP technology modifies predominant populations of microorganisms in the soil and balances soil's enzyme profile by amplifying diversity without causing a drop-in activity. The MIP ingredients act as a catalyst on plant/microflora/earthworm interaction.

A long-term trial realized by the Faculty of Agrobiotechnical Sciences Osijek and the CROSTRO Research team led by prof. dr.sc Danijel Jug was set up in 2017, crossing Soil Tillage, Fertilization and Soil biostimulation (with Geo2) during a classical crop rotation. After 3 years, results show that the application of Geo2 biostimulant (MIP inside) has a positive effect on the physical organization of the soil whatever tillage system was, compared with untreated area. Water retention was significantly increased, and chemical properties of the soil were also modified. The improvement of soil properties and water availability were heading to better utilization of water and nutrients uptake. The increasing of yield despite the reduction of P, K fertilization shows that Geo2 usage (MIP tech inside) during a complete rotation have restored soil productivity in comparison to control.

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

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

Key words:

soil micro-organisms, rhizosphere, biostimulant, enzyme's production, plant uptake

Conservation agriculture – response to soil degradation

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The continuous population growth on a global scale imposes as a priority the provision of sufficient quality food, but also the improvement of living conditions in poorer countries. However, food production is most often based on the principles of conventional agriculture, whose uncontrolled depletion of natural resources degrades the soil and accelerates climate change. The unsustainability of existing conventional systems is observed by intensifying soil degradation, most often by water and wind erosion, reduction of organic matter and destruction of the favorable soil structure. Due to structural degradation, crust is formed on the soil surface, water permeability and aeration are reduced, surface runoff and arable land compaction are increased. On sandy, powdery and loamy soils, after heavy rains or irrigation, crust is formed by drying the surface layer. The cover of the soil with the crust is caused by the degradation of the soil aggregates into elementary particles that fill the pores. The greatest risk of crusting is on bare or partially covered agricultural land.

Soil compaction by mechanization accounts for 4% of anthropogenic soil degradation and is the cause of reduced yields by 25-50% in Europe and America. According Thematic Strategy for Soil Protection (2006), soil compaction is one of the main threats to fertility and soil health because it reduces the porosity and restricts root growth. Therefore, abandoning conventional agriculture is a necessary precondition for increasing productivity and protecting natural resources and the environment. Conservation agriculture, as a sustainable agricultural production system, is based on minimal tillage and permanent coverage of the soil surface with organic residues or living mulch, crop rotation, integrated plant protection and nutrition. By adhering to these basic principles in food production, natural resources are protected and degradation is gradually reduced. Leaving crop residues on the surface, cover crops and using organic fertilizers, prevent erosion and improve soil structure, which ensures the production of sufficient quantities of quality food with maximum environmental protection.

Key words:

soil degradation, conservation agriculture

FIELD TRIP

- visit a progressive family farm
- CST experiment
- Experimental site Čačinci (description and basic information)
- field demonstration

Visit a progressive family farm

Host of experiment location and field demonstration site

Family farm "PG Knežević" – Traditional Croatian breakfast

- Estate: cca 300 ha agricultural land
- Main crops: soybean, wheat, maize and silage maize
- Service / rent for cca 1500 ha
- Service for Biogas plants
- Employees: 3 family member and 2 workers

CST experiment

Conservation soil tillage (CST) experiment has been fully supported by Croatian Science Foundation under the project “Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation” (IP-2020-02-2647). Basic information about Project can be founded below in Table 1 and for some other information please visit website on follow link

http://www.activesoil.eu/index.php/en/

Table 1. Basic information about Conservation soil tillage project.

Project title on Croatian:	Procjena konzervacijske obrade tla kao napredne metode uzgoja usjeva i prevencije degradacije tla
Project title on English:	Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation
Project Acronym:	ACTIVEsoil
Project identifier:	IP-2020-02-2647
Institution of project implementation:	Faculty of Agrobiotechnical Sciences Osijek - FAZOS
Project leader:	Prof. dr. sc. Danijel Jug
Project duration:	4 years (48 months)
Beginning date:	22/12/2020
End date:	21/12/2024
Project funded:	Croatian Science Foundation (HRZZ)
Collaborating Institutions:	- Faculty of Agrobiotechnical Sciences Osijek - Department of Biology Osijek - Faculty of Agriculture Zagreb - College of Agriculture Križevci

Experiment was settled as long-term on two different experimental sites (Appendix A.1. Experiment site locations). Different sites of experimental fields are assuming the implementation of research in different and representative agroecological conditions (climate/weather, soil), according to criteria and in a way that allows for future application in practice. At both sites, the same methodological criteria apply to all experimented parameters.

Both sites treatments description

(Appendix A.2. CST Experiment scheme)

Experimental treatment A - soil tillage - as the main experimental factor:

- ST - Conventional/standard tillage – (includes deep mouldboard ploughing tillage treatment and a number of secondary soil tillage treatments),
- CTD - Conservation System Deep (soil tillage without ploughing, e.g. soil chiselling and with leaving the required soil surface with minimum plant cover or plant residues of 30%,
- CTS - Conservation System Shallow (it's allowed only shallow tillage up to 10 cm and the soil surface need to be covered at minimum 50% with plants or plant residues).

Experimental treatment B - Liming

- CY-treatment with liming (according to recommendation for soil pH level raising)
- CN-treatment without liming

Experimental treatment C - fertilization/conditioners, as follows:

- FR-fertilization according recommendation (with NPK nutrients),
- FD-fertilization decreased by 50% (compared to recommendation),
- GFR- fertilization according recommendation (with NPK nutrients) + GeO2 (biophysiological soil activator with organic farming certificate in Croatia and other EU countries),
- GFD-fertilization decreased by 50% (compared to recommendation) + GeO2.

The experiment was set up on RCBD design with three repetitions (Appendix A.2. Experiment scheme). The size of basic experimental plot for each individual tillage treatment was 160 m^2 and 80 m^2 for each individual liming and fertilization treatment. Except for the soil tillage and fertilization treatments, all the other technology sequences (e.g. sowing, pests' control, machinery, equipment) were used identical in all the treatments.

Both experimental sites basic research parameters

- Pedophysical parameters
- pedomechanical parameters
- Pedochemical parameters
- Soil biology parameters
- Biodiversity (earthworms, weeds)
- Plant-growing parameters
- Climate analyses and simulations
- Economic analysis and projections

Experimental site Čačinci (description and basic information)

Site description

Stationary field experiment, tending to be long-term experiment, was established in autumn 2020, on experimental station in Čačinci in eastern Croatia at Stagnosol soil type. This experiment site was established as one of two sites which are included in project "Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation - IP-2020-02-2647", funded by Croatian Science Foundation (HRZZ).

Experimental site was settled in lowlands area with 1% slope (Long. 17.863508 E, Lat. 45.6134353 N, Alt. 121 m) and belongs to the most crop productive region of Croatia (Appendix A.1. Experiment site location). The mean annual precipitation and temperature in 35-yr average (650 mm and 11.0 °C) is characterized by wide variation from 320 to 1240 mm and 9.4-12.9 °C. Temporal and spatial changes of main climatic element follow, in most cases, next schemes; the temperatures increase from west towards the east, and from northwest to northeast, while precipitation follow inversely sequences (source Meteorological and Hydrological Service of Croatia - DHMZ). Experimental site belongs to region which are strongly influenced by climate and weather conditions in Pannonian basin and the peri-Pannonian region.

Soil sampling and analysis

Soil samples for basic chemical analysis (Table 2) were collected before setting up of experiment from 0 to 30 cm depth. Experimental site is treated as homogenous area and each composite sample were consisted of 20-25 individual soil cores.

Table 2. Soil chemical analysis (results from average soil sample on Čačinci site)

Sample	Depth (cm)	pH (KCl)	pH (H_2O)	AL-P_2O_5 (mg 100 g^{-1} soil)	AL-K_2O (mg 100 g^{-1} soil)	SOM (%)	Hy (cmol$^{(+)}$ kg^{-1})
Average	0-30	4.09	5.65	10.37	15.63	2.80	7.90

Soil type was determined from soil pit (soil pit/profile (Appendix A.3.) according WRB soil determination and classification. Soil samples with undisturbed structure for analyses and determination of selected physical properties (Table 3) were taken from two different soil layer (0-32 and 32-65 cm depth).

Table 3. Soil physical properties in soil profile

Soil depth, cm	FC, %vol.	ρ_b, g cm^{-3}	ρ_s, g cm^{-3}	PD, g cm^{-3}	ϕ, %vol.	φ_a, %vol.
10 - 15	43.04	1.50	2.65	1.76	43.50	9.07
40 - 45	42.58	1.56	2.74	1,87	42.97	9.36

FC = field capacity, %vol.; ρ_b = bulk density, g cm^{-3} ; ρ_s= particle density, g cm^{-3}; PD = packing density, g cm^{-3}; ϕ = total porosity, %vol.; φ_a = aeration porosity, %vol.

Soil samples for chemical properties used for soil type determination were taken from soil pit/profile (Table 4).

Table 4. Soil chemical properties of Stagnosol (from soil profile on experimental site Čačinci)

Soil depth	Soil reaction		mg 100 g^{-1} soil		SOM	Hy
cm	pH (KCl)	pH (H_2O)	AL-P_2O_5	AL-K_2O	(%)	($cmol^{(+)}$ kg^{-1})
0 - 32	3.92	5.12	4.8	11.15	2.83	7.48
32 - 65	4.23	6.16	2.0	10.69	0.83	4.07
65 - 200	4.39	5.92	1.8	11.37	0.48	3.15
200 - 240	4.72	6.11	6.1	6.50	0.31	2.67
240 - 280	4.65	6.07	8.8	7.47	0.28	2.19
280 - 305	4.73	6.17	9.1	8.89	0.34	1.79
305 - 330	5.12	6.21	11.8	9.75	0.59	1.40

Distribution of soil particle size (Table 5) was determined according ISO 11277, 2009. Soil texture determination was performed according USDA-NRCS (2016).

Determination of soil physical properties for long-term soil monitoring (Table 6), was performed according same methods.

Table 5. Soil texture and microaggregate stability

Soil depth,	Particle size mm, % fraction			Texture	Microaggregate stability	
cm	2.0-0.05	0.05-0.002	< 0.002		Ss, %	
0 - 32	9.81	60.84	29.35	silty clay loam	82.18	stability
32 - 65	8.31	57.61	34.08	silty clay loam	88.07	stability
65 - 200	10.79	58.92	30.29	silty clay loam	86.22	stability
200 - 240	30.79	55.66	13.55	silt loam	78.26	stability
240 - 280	30.46	57.14	12.40	silt loam	74.60	stability
280 - 305	26.15	59.46	14.38	silt loam	73.29	stability
305 - 330	29.24	56.14	14.61	silt loam	74.32	stability

Table 6. Soil physical properties for long-term soil monitoring

Treatment	Soil depth, cm	FC, %vol.	ρ_b, g cm^{-3}	ρ_s, g cm^{-3}	PD, g cm^{-3}	ϕ, %vol.	φ_a, %vol.
ST	5	37.22	1.45	2.60	1.72	44.17	11.95
	20	35.59	1.47	2.60	1.73	43.49	13.40
	45	33.86	1.59	2.67	1.90	40.30	11.09
RT	5	38.75	1.52	2.60	1.78	41.69	5.71
	20	39.55	1.38	2.62	1.65	47.16	14.74
	45	34.35	1.59	2.60	1.89	39.05	7.57
CT	5	38.24	1.48	2.57	1.75	42.31	9.46
	20	37.30	1.49	2.60	1.75	42.86	13.87
	45	37.03	1.53	2.67	1.84	42.59	13.74
ST-	5	37.85	1.41	2.63	1.68	46.27	13.99
additional plots	20	40.24	1.40	2.62	1.66	46.71	15.58
	45	35.07	1.55	2.63	1.86	40.86	11.69
RT-	5	36.98	1.47	2.61	1.73	43.65	14.47
additional plots	20	36.80	1.50	2.62	1.76	42.88	15.48
	45	32.42	1.56	2.63	1.86	40.77	14.58
CT-		37.51	1.43	2.62	1.71	45.11	14.37
additional plots		38.12	1.44	2.62	1.77	43.71	15.50
		33.97	1.55	2.64	1.87	41.01	13.68

FC = field capacity, %vol.; ρ_b = bulk density, g cm^{-3} ; ρ_s= particle density, g cm^{-3}; PD = packing density, g cm^{-3}; ϕ = total porosity, %vol.; φ_a = aeration porosity, %vol.

Field demonstration

Field demonstration will be organized as follows:

- A) CST experiment/project presentation

- B) Soil profile presentation

- C) Agricultural equipment presentation

Ad A)

Presentation of CST experiment on Experimental site Čačinci will be providing and leading by Project leader (distinguished professor Danijel Jug), with support and assistance of Project work group leaders (full professor Irena Jug, Associate professor Boris Đurđević, Assistant professor Bojana Brozović).

(See Appendix A.4. CST experiment/project presentation invitation).

(See titles (above information) "CST experiment" and "Experimental site Čačinci (description and basic information)")

Ad B)

Soil profiles presentation will be providing by OLMIX experts in collaboration and representatives of CROSTO and ISTRO. Total of six profiles will be presented and presentation will include different combinations of soil tillage treatments and soil conditioners (e.g. GeO2).

(See Appendix A.5. Long-term experimentation platform invitation).

Ad C)

Agricultural equipment presentation on experimental field will be providing by MEGRA which will present Eijkelkamp chosen equipment for soil sampling and analyzing.

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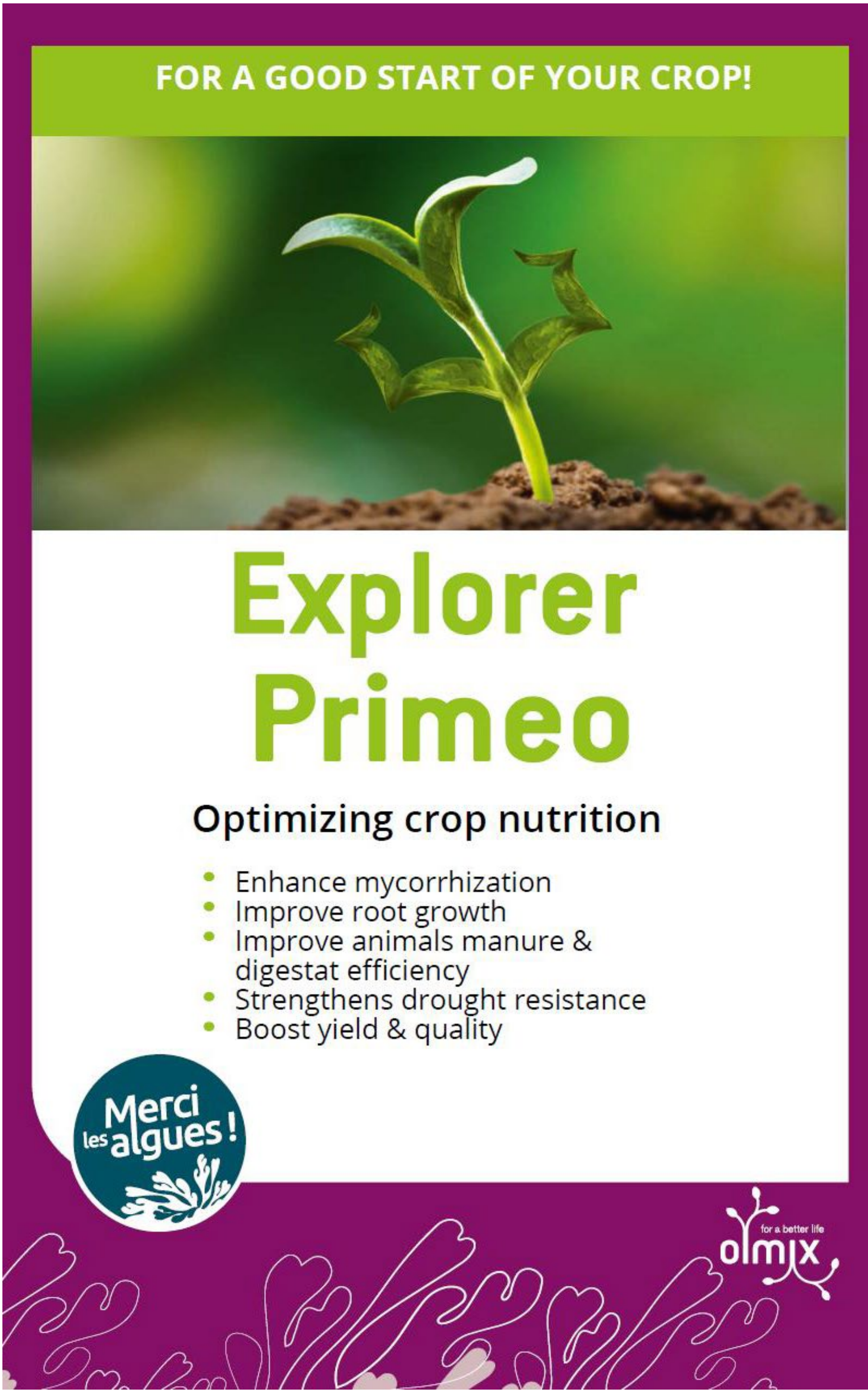
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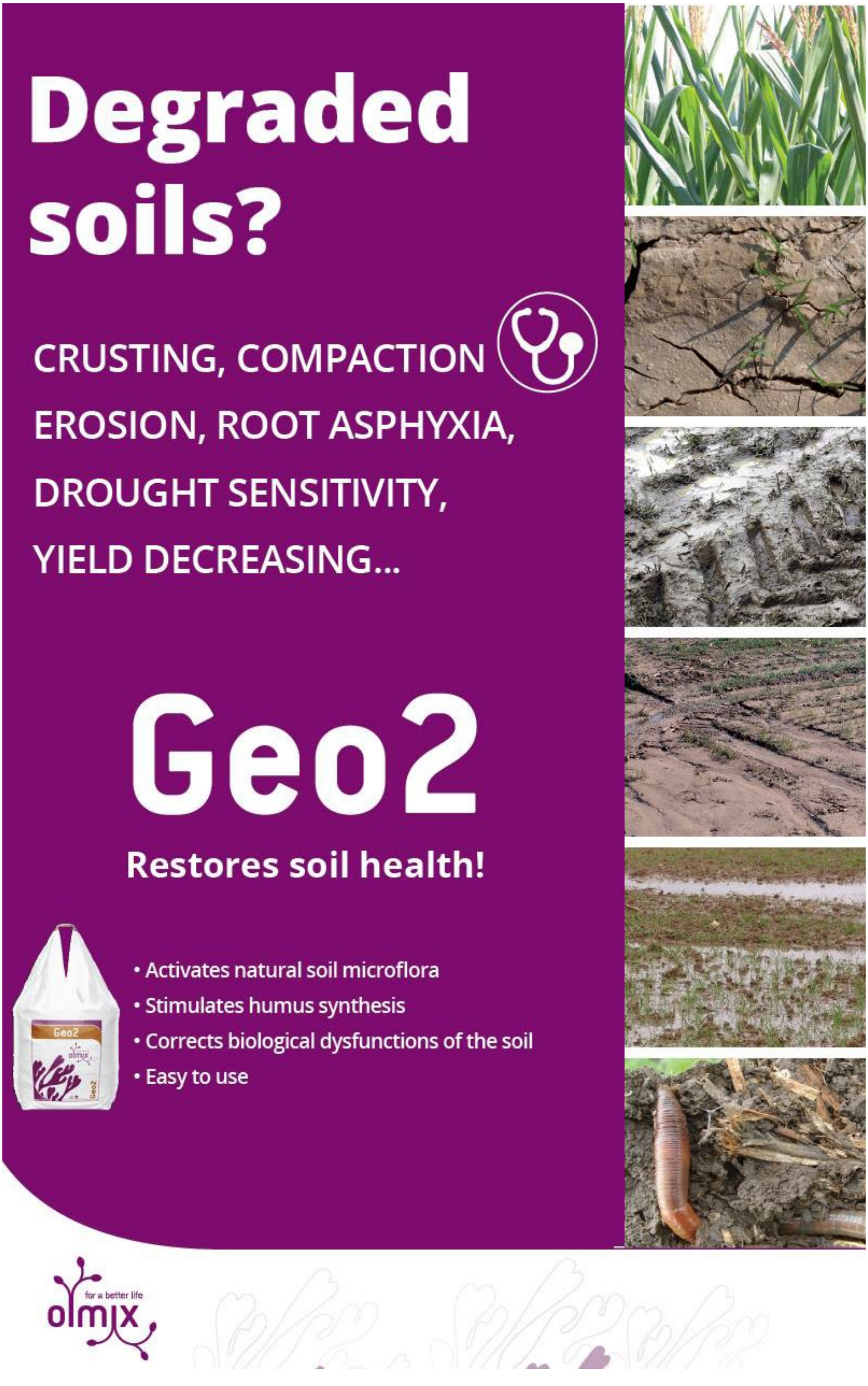
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BioQuant Ltd.

Research and development

Našička 4, 31000 Osijek, Croatia

About us

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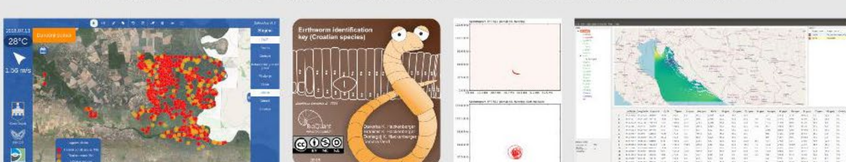

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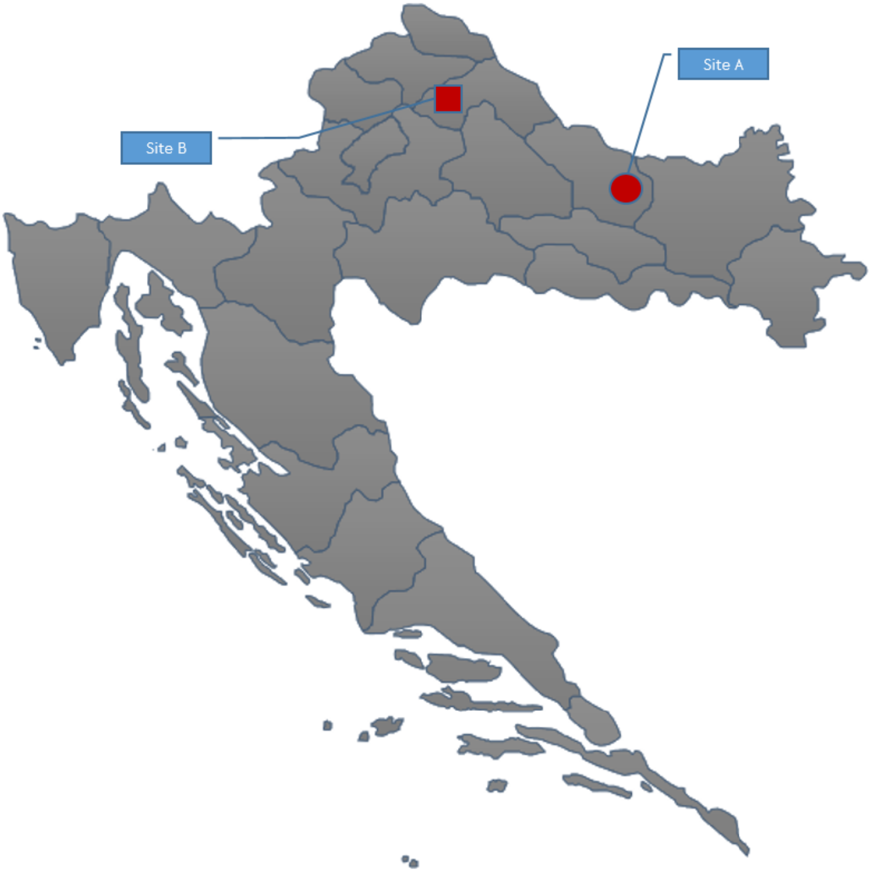
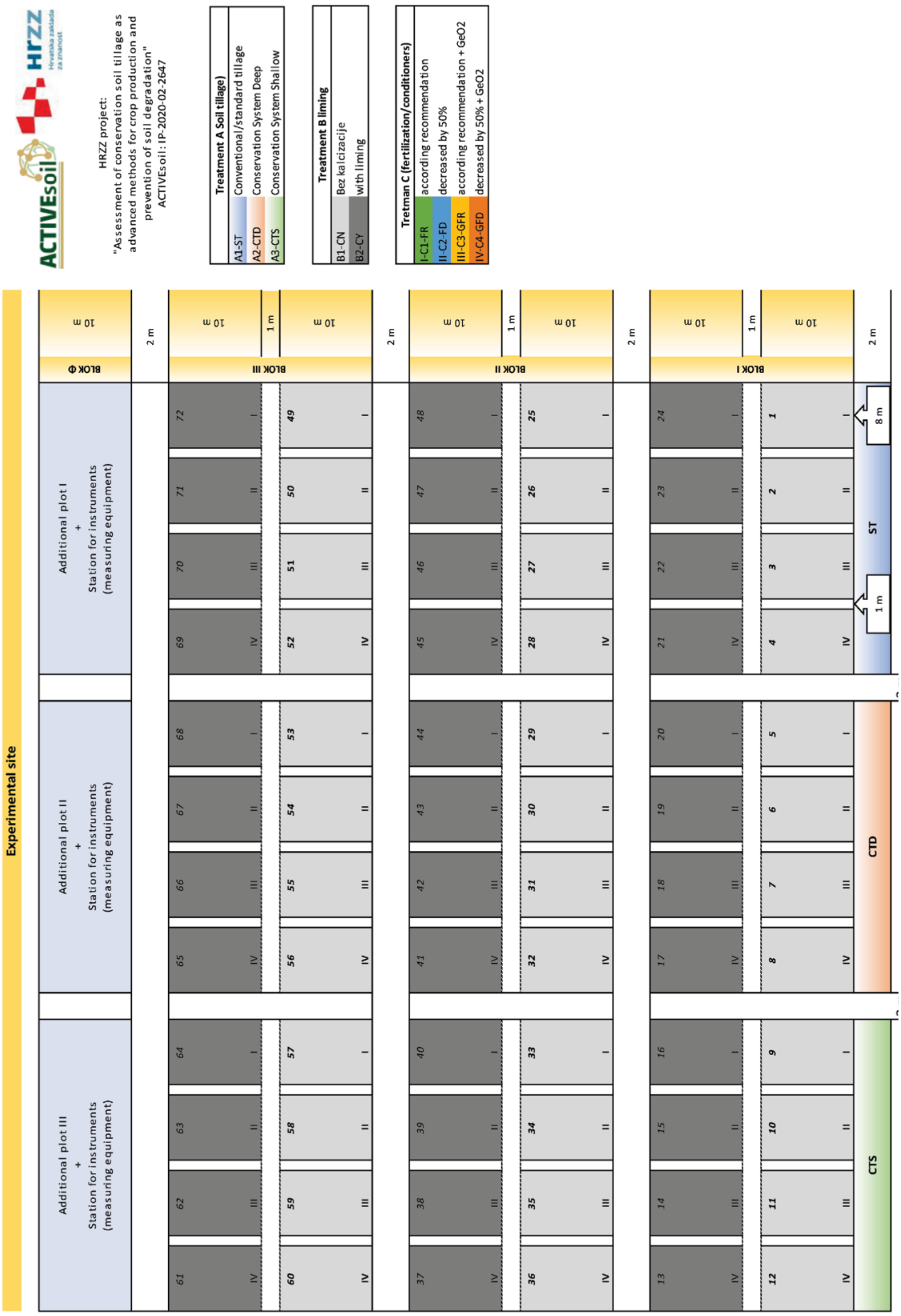
Appendix A.1. Experiment sites location

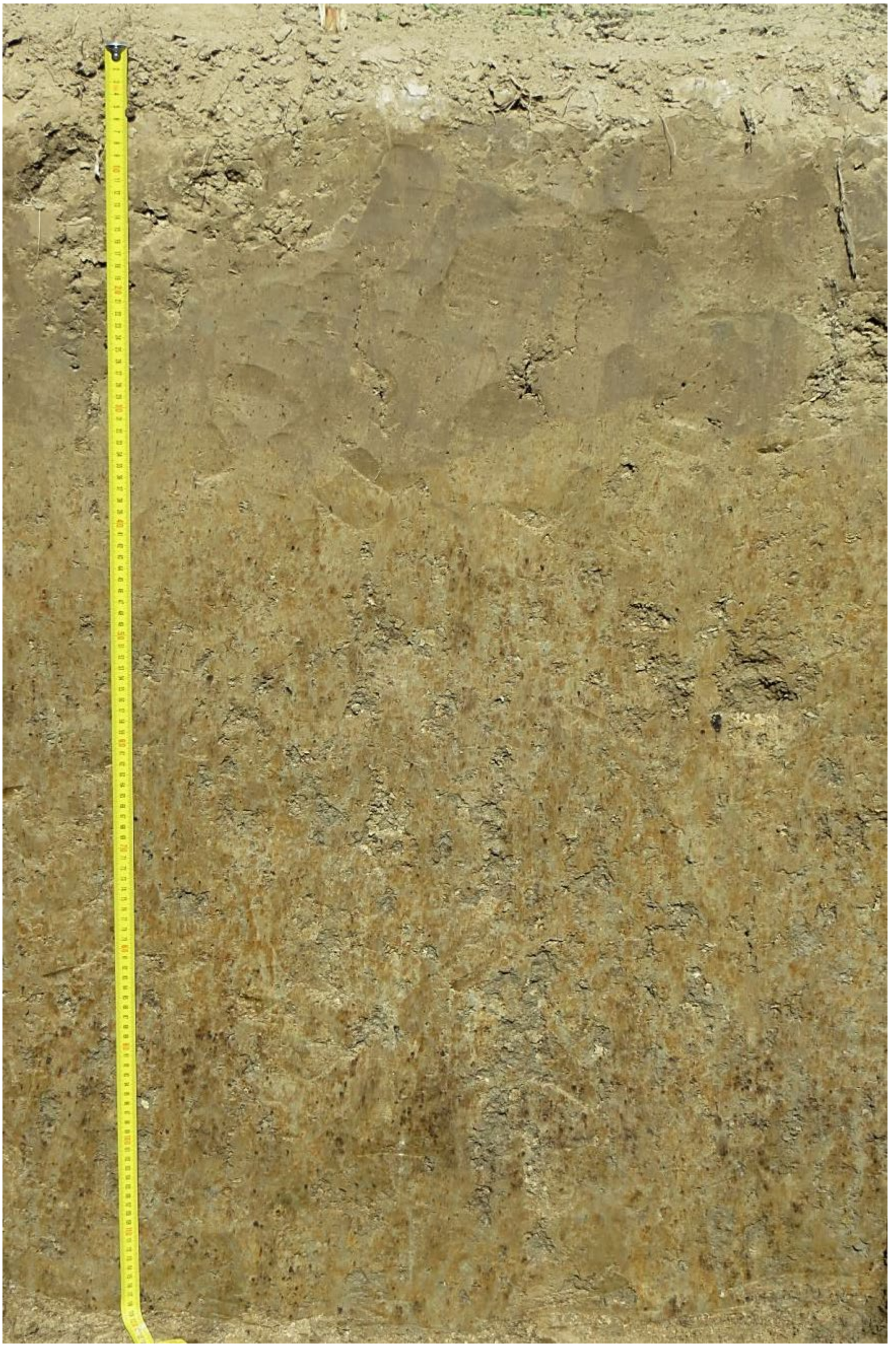
●	Site A: Virovitica-Podravina County (Čačinci Place – Owned by PG "Knežević") Long. 17.863508 E, Lat. 45.6134353 N, Alt. 121 m
■	Site B: Koprivnica-Križevci County (place Križevci – trial site of Križevci College of Agriculture) Long. 16.558217 E, Lat. 46.0278038 N, Alt. 141 m



Appendix A.2. CST Experiment scheme

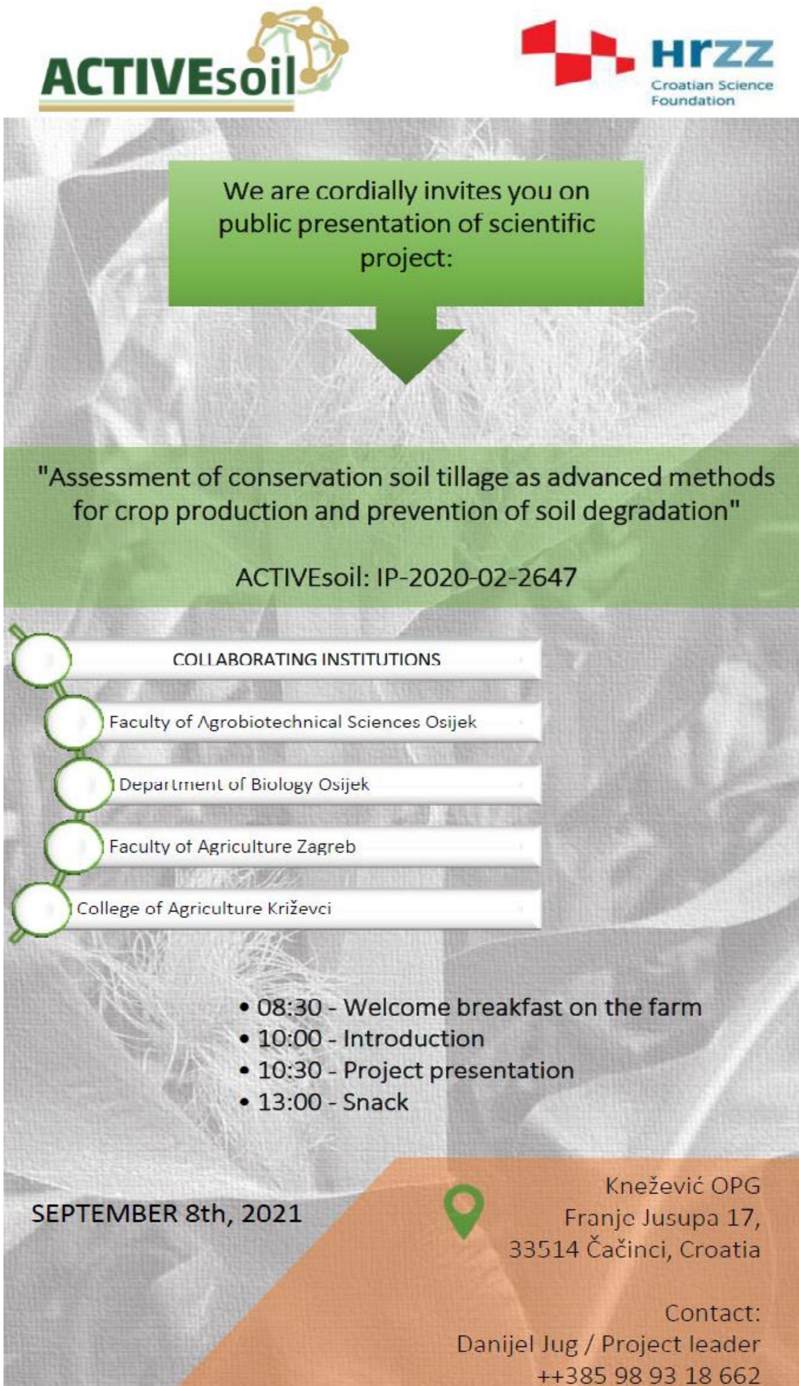


Appendix A.3. Stagnosol soil type



Soil Profile description: P - S - II S - C (on Čačinci site)

Appendix A.4. CST experiment/project presentation invitation



Appendix A.5. Long-term experimentation platform invitation

Appendix A.6. Photo documentations from experimental site

Main organizer contacts

Working Group – Conservation Soil Tillage (WG-CST):

https://www.istro.org/index.php/working-groups/wg-c-conservation-soil-tillage

International Soil Tillage Research Organization (ISTRO)

Webpage: **www.istro.org**

E-mail:

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- ISTRO President: Nicholas Holden **(nick.holden@ucd.ie)**
- ISTRO Treasurer: Stephen A. Prior **(steve.prior@ars.usda.gov)**
- Other ISTRO board members can be found on the board page

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