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Preface

Dear colleagues, ladies and gentlemen,

On behalf of the Organizing Committee of Croatian Soil Tillage Research Organization (CROSTRO), Czech branch of ISTRO and HUISTRO – Hungarian branch of ISTRO, under the auspice of International Soil Tillage Research Organization (ISTRO) and many others supportive institutions, we are pleased to invite you to the International Scientific Conference that will take place in Osijek, Republic of Croatia, 19th-21st June, 2017.

Since the establishment of our national branches, Croatia, Czech Republic and Hungary are going to organize for the first time a joint Scientific Conference as a Central Europe Division of ISTRO initiative. Place of the first joint Conference will be Osijek, Croatia, whereas following joint Conferences will be held in other two countries (Czech Republic and Hungary) in the rotation after every three years.

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

- connection of scientists and experts engaged in the research of soil treatment and related scientific and research disciplines with the objective of achieving interdisciplinary,
- encouragement and promotion of the scientific research in the field of 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 soil tillage science, exchange ideas and experiences and spreading modern approach of technology application in agroecosystems.

General conference topics will be discussed in the next sections:

1. Sustainable land management
2. Coping with climate changes in plant production
3. Good agriculture practice and food safety
4. Precision agriculture, mechanization and renewable bioenergy
5. Facilitation of integrated crop protection

This conference 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.

Prof. dr. sc. Danijel Jug
President of Croatian Soil Tillage Research Organization
President of Organizing Committee

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SECTION I

[Sustainable land management]

Advances in soil research tasks and requirements for a better understanding of a sustainable environment

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Soils are non-renewable 3-dimensional bodies as the outer skin of the earth with liquid, gaseous and solid components containing inorganic and organic materials, including living organisms in a great number and variety. But soils offer only a limited rigidity concerning their chemical, biological and physical properties and react with an irreversible degradation if exceeding their internal soil strength as boundary condition. Food production for a growing population, irreversible soil degradation due to mis- or overuse, limited soil resilience and performance are important parameters to quantify. Soil compaction, erosion, carbon sequestration, urbanization problems, and soil remediation have in view of the expected global/ climate change effects all to be considered in order to prepare reliable data for modeling scale dependent soil management scenarios and preventing additional soil degradation and soil functionality losses. How far is the existing dataset sufficient for predicting future processes of e.g. crop yield, soil rigidity or impermeability – as only 3 examples- in a changing hydraulic, mechanical and chemical, biological reactor system "soil".
During the lecture new approaches in soil physics research will be determined for future approaches and based on the actual knowhow open questions of how to gain additional soil physical knowledge discussed.

Keywords: soil research, task, requirements, sustainability

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Soil deformation: effects on plant root growth and functions

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Soil deformation by machinery traffic and tillage is an increasingly challenging problem for plant root growth and soil quality in modern farming. Responses of roots to soil deformation include reduced root size, thickening and lower density of root hairs. The responses are frequently accompanied by flattening of roots, invaginations and associated deformation of root cells both in vascular cylinder and cortex. They are related with the soil pore shape and strength around roots. Recent studies showed that soil deformation affects cation exchange capacity and surface charge properties of roots that govern uptake of ions and shoot growth. The morphological, anatomical and physicochemical root traits in relation to root functions, plant species, yield and deformation intensity will be illustrated.

Keywords: soil, deformation, root, growth, functions

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The use of visual soil evaluation methods in soil structure assessment

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Soil structure, as one of the most complex and important soil characteristics, can be characterised and assessed by several methods and indices. Visual soil evaluation (VSE) methods are among the direct methods to assess the structural state of the soil. They have been developed and used for practical and scientists purposes since early 20th century at least. During the last 20 years, there has been an extensive work on refining, integrating and evaluating the methods. In general, VSE methods aim at evaluating soil quality for soil primarily as a plant growth medium. They are mainly used for characterising experimental sites and for assessing the effect of soil management and land use. The special issues 'Applications of Visual Soil Evaluation' in 2013 and the current 'Visual Soil Evaluation and Soil Compaction Research' *in press* of Soil and Tillage Research journal, compiled some of the most recent conducted VSE related studies, worldwide. In this summary, the capability and validation of the VSE methods for soil structure assessment, as well as the aspects requiring further improvements are highlighted based on some case studies. Munkholm and Holden (2015) enumerated 14 countries in Europe, North America, South America, Asia and Oceania where the impact of land management and land use on soil quality has been successfully evaluated using VSE methods. The references cited by the authors remark either biological or mechanical factors influencing soil quality on arable land and grassland under a wide range of climate and soil conditions. The findings of these studies provide knowledge on the applicability and validation of VSE methods under different conditions. As another example, Pulido-Moncada et al. (2016) confirm that VSE methods are sensitive tools in evaluating changes in soil structural quality over an agricultural cycle under different land uses. Agreement between VSE and quantitative results were found but differ in relation to texture, allowing the authors to suggest further work on seeking VSE methods' limitation or differences in classification according to texture.

In general, VSE methods involve key common criteria such as aggregate description (morphology and resistance to compression), visible porosity (abundance) and rooting (distribution and deformation) but differ in scope, scale and applicability. Improvements and further challenges of VSE methods are currently under consideration, which can be summarised and specified as follows (Munkholm and Holden, 2015; Guimaraes et al., 2016): i) Reproducibility has been taken account of by providing manuals and instruction videos for operators. Nevertheless, subjectivity related to the separation of structural units is still a limitation. This aspect is mainly dependable on training or expertise. ii) Soil moisture effects on soil

strength for compacted and fine textured soils is an issue of concern and a likely explanation for imprecise scoring in some cases. VSE methods are recommended to be conducted at soil water content near field capacity. However, an optimum range of water content for VSE is missing. To shorten this gap, studies are currently being conducted to recommend a range of matric potential for optimal VSE assessment. iii) Furthermore, in soil quality schemes it is desirable to include biological indicators as part of an integrated assessment of soil structural quality. Apart from root activity, earthworms number or activity have been included as an indicator in some VSE methods (Shepherd, 2009; Piron et al., 2016). Recent studies have highlighted the impact of faunal activity on soil structural quality and consequently the importance of its incorporation in further VSE improvements. Importantly, the rating of earthworms numbers has to be adapted to local conditions (Pulido-Moncada et al., 2014), and other studies suggest that evidence of biological activity such as earthworms borrows are better indicators than the number of earthworms counted during sampling (Piron et al., 2016). The abundance of other macroinvertebrates, such as termites and coleopterans, has also shown a relationship to soil structural quality on weathered soils from the tropics (Franco et al., 2016). For these reasons, soil fauna represents an interesting key soil structure quality related component to be further studied and well-defined when integrating it into VSE.
Finally, expansion of the role and future use of VSE are being considered in relation to sustainability, environmental conservation and climate change, soil monitoring and resilience, improvements of agricultural, marginal and urban soils, as well as spatial variability and description.

Keywords: soil quality, soil management, land use, soil moisture, biological activity.

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Yield improvement by using biostimulant products in winter wheat managed with No Till

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Crops productivity are closely linked to the use of fertilizers, being the form of application and the products used the principal factors affecting to yields. Not only is the higher cost for cereal production, but also produces the highest greenhouse emissions related to agricultural inputs. The use of different products commonly known as biostimulants (liquid fertilizers, different micronutrients, bacteria, enzymes, microalgae, etc.) have sown to be an effective method to improve the assimilation of the solid fertilizers and subsequently increase yields and the sustainability of agriculture.

The objective of the research is to evaluate the benefits that the application of different biostimulants can produce in the crops development and in the final production.

The study was conducted during one season in the Experimental Farm of the University of Cordoba. The research was developed with winter wheat (*Tritucum durum*) managed with No Till. Test plots had a surface of 3,000 m^2 (15 m x 200 m). There were five treatments with four replications, so the total surface was six ha. The treatments studied were:

Treatment	Products	Composition	Dose
T1	Control	No application	-
T2	Liquid fertilizer	28 % N total (11 % N ureic + 17% Urea formaldehyde "slow release")***1**	10 l/ha
T3	Biostimulant 1	6,08 % N total (3,7 % N ammonia + 2,71 % N organic) + 16,5 % amino acids + 31 % organic matter + 0,1% Mn + 0,1% Zn***2**	2 l/ha
T4	Biostimulant 1 + Liquid fertilizer	***2** + ***1**	2 + 8 l/ha
T5	Biostimulant 2	3,9 % N Total (ureic) + 15,2% Mg + 9,1% Mn + 4,9 % Zn + 3% Cu	3 l/ha

The products were applied mixed with herbicide with a sprayer in the month of February 2016. Furthermore, all the treatments was fertilized with: (1) 40 kg/ha of microcomplex fertilizer applied with the seeder along with the seed; (2) 130 kg/ha Nitrocom Expert 30% N applied with spreader; 200 kg/ha Nitrolent 40% N applied with spreader. The total amount of nitrogen applied was 130 kg/ha.

The research evaluated how affected the application of different biostimulants to

different parameters related to the cereal production: 1) Normalized difference vegetation index (NDVI); 2) Biomass production; 3) Number of spikes; 4) Yield; 5) Strow production.
The application of biostimulants increased the NDVI respect the control (T1) with statistics differences. A bigger NDVI produced more biomass and consequently a higher yield.
For the other parameters studied all the treatments with biostimulants (T2-T5) showed statistics differences respect the control (T1), except for the T5 that not presented differences respect T1 in straw production and number of spikes. Treatments T2, T3 and T4 showed very similar results for all the parameters. They approximately increase the biomass production respect the control in a 25%, T5 improve this parameter in a 15%. The straw production was increase in a 19% (T2-T4) and 12% (T5) respect the control. Number of spikes: 29 % (T2-T4), and 11% (T5). Finally, yield was increased respect the control in 26% (T2-T4) and 15% (T5).
Results showed how all the biostimulants product improve the sustainability of the wheat production. However, important differences were measured between some treatments.

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Keywords: *Rainfed arable crops*, s*ustainable agriculture, climate change, NDVI, yield.*

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Soil Functional Ability for groundwater recharge related with Land Use and Tillage system in a dry Mediterranean climate, southern Portugal

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Groundwater has capacities like storing, filtering and transforming, which allows regulates atmospheric, hydrological and nutrient cycles. For agronomists, groundwater recharge is defined as the quantity of freshwater derived from precipitation that infiltrates vertically downward from the land surface to below the root zone. At this point the water may move laterally to discharge in streams or downward to enter an aquifer. Fresh water sustains biomass growth in terrestrial ecosystems, and provides key ecological services that supports biodiversity, sequesters carbon and combats desertification. On the other hand, soils provide us services like give clean water and abundant crops. To do this, soils plays there function of "regulator" distributing water for the recharge of groundwater and for the use by plants and animals, regulating the drainage, flow and storing water. Soil functions are difficult to measure directly, so they are usually assessed by measuring soil quality indicators. The soil functional ability to provide groundwater recharge is dependent on the water flowing within soils, under natural conditions or ones affected by its exploitation. Thus Soil Functional Ability to recharge groundwater (SFAgr) and Land use are essential to study the environmental sustainability and agricultural production capability once groundwater is a key component of a healthy watershed. But it is necessary pay attention to the Tillage System and not only to Land Use because the same Land Use can be related with more or less soil mobilizations and that have a great influence on soil structure and its hydrological skills. The purpose of this study was to investigate the relationship between Soil Functional Ability for groundwater recharge (SFAgr), different Land Uses and different Tillage Systems in a Dry Mediterranean climate in Alentejo, Portugal. This will be achieved by building a SFAgr, generated with combination of four properties related to water infiltration and percolation into the soil: depth; bulk density; saturated hydraulic conductivity; and drainable porosity. The saturated hydraulic conductivity was calculated by an indirect method based on texture and drainable porosity was also calculated by an indirect method though the difference between total porosity and field capacity. Each unit Soil/ Land Use/ Tillage System was analyzed in several identical units within the same catchment. When comparing SFAgr for different Land

Uses and different soils, the results show a higher dependency of the groundwater recharge ability on Soil properties than on Land Use. The highest influences on SFAgr were bulk density and saturated hydraulic conductivity and the smallers were depth and drainage porosity. Better situations are where soils have bulk density rounding 1,2 covered by Cork/Holm Oak (50%) + Pasture and the worst situation are soils with bulk density greater than 1,5 even with Cork/Holm Oak (30%) + Pasture. When comparing SFAgr only for Annual Crops at same soils but having different Tillage Systems, the results showed that in both soils studied, the SFAgr was highest when Tillage System was a conservation one than when was a traditional system. The conclusions of this study for a Dry Mediterranean Climate are: 1 – Land Use influences the Soil Functional Ability to recharge groundwater, but more important than Land Use itself is the Tillage System used; 2- Tillage Systems associated with Conservation Agriculture more specifically No Tillage Systems provide better ability to recharge groundwater in clayey soils; 3 - The more years a system of No Tillage is practiced the higher Soil Functional Ability to Groundwater Recharge is expected in clayey soils.

Keywords: groundwater recharge; tillage system; land use; soil functional ability

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The changes of soil structure and water stability of soil aggregates under different compost doses

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During the years 2013 - 2015 different application of grape marc compost on soil structure and water stability of soil aggregates in the vineyard were studied. The trial was carried out in Velké Bílovice vineyard in Czech Republic. Altitude of locality is about 200 m above sea level, the long-term annual sum of precipitations is 550 mm, the long-term average annual temperature is 9.5 °C. The soil is Chernozem on loess, loamy textured. Three variants were established: Variant 1 – control, no compost, Variant 2 – 30 t of compost per ha, Variant 3 – 60 t of compost per ha. The compost from pomace, poultry droppings, mown grass and straw was made in an aerobic fermentor EWA in an intensive and controlled process in an enclosed space. The compost was evenly applied and shallow ploughed (0 – 0. 15 m) into the soil every year after harvest. Soil structure was assessed by sieving dry soil through sieves with the mesh size of 0.25; 0.5; 2.5; 10 and 20 mm. The water stability of soil aggregates was assessed using the method of wet sieving. Experimental results were statistically processed by the multifactorial analysis of variance and then by Tukey's tests of simple contrasts. It was found that the application of grape marc compost into the soil had a positive effect both on the soil structure and the water stability of soil aggregates.

Keywords: *vine yeard, compost, water stability of soil aggregates, structure*

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Characterisation of Luvisol compaction under two different tillage systems and field traffic zones by assessing soil mechanical properties

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Compaction of arable soils is a consequence of tillage systems and agricultural machinery traffic year after year. Its negative effects on crop production and on the environment have been put into evidence by several studies. However, soil compaction is a complex phenomenon and the understanding of the involved mechanisms related to agricultural practices still remains limited. This contribution aims to study the influence of the interaction between traffic intensity and tillage system on soil compaction. Soil samples were taken from topsoil (0.07-0.25 m), plough pan (0.30-0.35 m) and subsoil (0.35-0.52 m), on plots under long-term reduced tillage (RT) and conventional tillage (CT). For each tillage system, intensive traffic zones (IT) and non-intensive traffic zones (NT) were considered. Swelling index (Cs), compression index (Cc), precompression stress (Pc) obtained by pedometer test, porosity (n) and water content obtained by gravimetric determination were chosen to characterize the soil mechanical properties. An analysis of covariance (ANCOVA) was performed to study the effect of the depth, the tillage and the traffic intensity on the variables measured, with the water content as covariable.
The results show that, after ten years of reconversion from CT to RT, the plough pan is still present in RT and its compaction appears as important in CT(nRT_{-30cm}= 36.9% ,nCT_{-30cm}= 38.0%, p-value=0.098). In subsoil, the compression index was high in CT, as well as in RT (CcRT= 0.150kPa^{-1}, CcCT= 0.148kPa^{-1}, p-value =0.617), involving that this layer remains susceptible to compaction under heavy loads. Moreover, the mean value of the precompression stress (meanPc= 92±34kPa) remains lower than stresses induced by heavy machine such as beet harvesters. The results also show that the presence of two traffic zones induces a spatial heterogeneity in the field (CcIT = 0.138 kPa^{-1};CcNT= 0.154kPa^{-1}, p-value = 0.031). These main results could be used in computational modelling to develop decision support systems to mitigate the effects of soil compaction.

Keywords: *soil compaction, soil tillage, traffic intensity, mechanical characterisation, oedometric curve.*

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Green beans (*Phaseolus vulgaris* L.) root nodules number after treatment with nettle leaf extract

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Nitrogen fixation by soil bacteria could be used as a source of plant available nitrogen without fuel consumption. Symbioses between N fixing bacteria and legumes occur under favourable soil conditions regarding pH, salinity, amount of water and presence of nutrients, while excess soil N inhibits nodulation. Nettle leaf extract, commonly used as source of nitrogen in organic farming, is applied in green beans production to test its effects on root nodulation. The experimental plants were sown on August 9th 2016. Nettle dry leaves (183 g/10 L of water) macerated 24 hours (short) and applied foliarly, and the same amount of nettle dry leaves macerated 14 days (long) and applied by watering, were compared to plots fertilized with urea or without N fertilization. Six plants per treatment were sampled during last harvesting date, on September 11th 2016, for measurements of shoot dry weight, root dry weight and number of nodules per each plant. Nodules number per plant was the highest after application of nettle extract of long maceration (20.3±9.9) compared to nettle extract of short maceration (11.3±10.8), urea (5.0±6.0) and untreated plants (4.5±3.9). Root dry weight (g/plant) was the highest after application of nettle extract of short and long maceration (0.95±0.26 and 0.90±0.18, respectively) than after urea application and untreated plants (0.57±0.20 and 0.63±0.21, respectively). Urea treated plants had greater shoot/root ratio than nettle treated plants of short and long maceration (12.19±6.74 and 9.48±2.29, respectively), while untreated plants were similar to all treatments. Nodules number per root weight (g/plant) was the highest after application of nettle extract of short and long maceration (22.7±10.3 and 12.9±13.3, respectively) than after urea application and untreated plants (8.7±9.2 and 7.2±6.3, respectively) but the difference was of low significance (p=0.064). Shoot dry weight was similar for all treatments. Nodules number was negatively correlated to shoot/root ratio (-0.57, $p<0.05$). The results indicate the positive effect of nettle extract on beans nodulation and root growth. The effect of urea to nodulation was similar to untreated plants except it enhanced shoot growth. The research must be continued to confirm the positive effect of nettle extract on green beans nodulation.

Keywords: fertilization, legumes, organic farming, symbiotic N fixation, Urtica dioica L.

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Management effect in vineyards on compaction, water conservation and CO_2 emission in trafficking zones

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In Croatia, vineyards are usually intensively managed and little is known about their environmental impacts. Soil and water resources are affected by this management which influence on severity of degradation processes. Thus, studies are needed to identify the impacts of intensive soil management on vineyards and identify the possible sustainable land management practice. Soil compaction, determined by penetration resistance (PR), soil water content (SWC) and CO_2 fluxes from trafficked inter row positions were recorded in 2016 in an experiment in which four different soil management systems were compared in a vineyard raised on a silty clay loam soil, near Zagreb, Croatia: No-tillage (NT) system, continuous tillage (CT) and yearly inversed grass covered (INV-GC) and tillage managed (INV-T) inter rows are subjected to intensive traffic. Grape yield and must quality of grape variety Chardonnay was also monitored. INV-GC record highest PR, while NT records the lowest. The PR was significantly higher at 10-20 cm depth compared to 0-10 cm depth, and was significantly increasing with increase of number of tractor passes. Soil water content showed better conservation possibilities of INV-GC in drier period. The results of soil compaction under different management indicate that vineyard soil differently response to traffic intensity and impact on microfauna activity and CO_2 emissions. INV-GC and NT managed soils record lower CO_2 fluxes from vineyard soil compared to CT and INV-T treatments. Management treatments did not statistically influenced on grape yields. Overall, the tested treatments were affected in some by soil compaction problems, but only CT got a higher soil-water-gas movement and response against wheel traffic circulation impacts. However, we cannot recommend this management because it enhances soil erosion. Several years of investigation is needed to confirm the overall impact of different management treatments on the proportion of degradation process and their response to proportion of tractor circulation impacts.

Keywords: *tillage management; soil respiration; water conservation; soil physics*

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Tillage, farmyard manure, gypsum and sulphur effect on soil physical properties and yield of oats (*Avena sativa* L) in organic farm in Mediterranean Croatia

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Organic agriculture represents sustainable and environmental friendly management. Nevertheless, this kind of management request high level of knowledge due to limitations in use of agrochemicals. Proper agro-technical measures are especially important on organic farms on degraded saline-sodic soils. In this study, we study the impact of two tillage management (disc-harrow – DH and disc-harrow with ripping – DH+RIP) and three selected treatments on soil physical properties in saline-sodic soils of River Raša Valley, Croatia. Treatments were: control, G6+OM (6 t gypsum + 40 t farmyard manure) and G6S2 (6 t gypsum + 2 t sulphur). Results show that DH+RIP treatment record lower bulk density, penetration resistance and higher air filled porosity compared to DH treatment. Soil amendments also show implications on soil physical properties. Lowest compaction was noted at G6+OM, while control treatment records the highest. Yields of oat were generally low due weed infestation. DH+RIP treatments showed 15% higher yields compared to DH treatments. Amendments also record different response on oat yield. G6+OM treatment record 34% higher yields of oats compared to control, while G6S2 treatment recorded only 82% of grain yields compared to control. This can be justified with to short period between sulphur application into this treatment and sowing date. Research should be continued with expanded monitoring of soil hydraulic properties, carbon dynamics, soil structure and aggregate stability in order to find most appropriate and sustainable soil management on saline-sodic soils under organic production.

Keywords: *saline soils, sodic soils, Istria, bulk density, penetration resistance.*

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Carbon dynamic after conversion of permanent grassland into arable soil

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Carbon input and balance in soils is regarded as the main criterion of agricultural sustainability. Generally carbon dynamic depends not only on the carbon input and its decomposition rate, but it is also influenced by various agronomic practices. Therefore changes in organic carbon stock and humic substances quality were evaluated in two different agricultural management systems (permanent grassland and intensive crop sequences). *Eutric Cambisol* (Czech-Moravian Upland, locality Vatín, Czech Republic) was sampled twice a year (spring and autumn) in the depth 0-20 cm during the period 1996 – 2016. Soil was sandy-loam textured, with middle organic carbon content and low humic substances quality. Results showed that crop management practices directly influenced soil cumulative potential and quality of humic substances. Statistically significant differences were found.

Key words: carbon stock, crop management, permanent grassland

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Effect of different tillage intensity on physical and hydrophysical properties of soil

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This research is aimed on evaluation of possibilities using both minimum and conventional soil tillage technologies in case of maize grain in systems of soil management and of its influence on physical and hydro-physical soil characteristics. Observation was made within stationary field experiment conducted from 2001 on loam Ortic luvisol in maize production region on the plot of agricultural company Agroservis 1. zemedelska Ltd., Visnove in South Moravia. There were evaluated three ways of soil tillage: (1) ploughing to the depth 0.22m; (2) shallow soil tillage by discs equipment till the depth 0.10–0.12 m (aeration); (3) direct sowing. Observed was influence of different soil tillage on basic physical soil properties, water infiltration, penetrometric soil resistance and on yields of corn maize grown repeatedly on the same place. From the basic physical properties were evaluated bulk density, total porosity, minimum soil air capacity and soil moisture content. The lower intensity of soil tillage was the more statistically significant increase of bulk density and lower total porosity were observed. The highest values of bulk density were observed after direct sowing. Total porosity was the highest in case of ploughing. The lowest minimum soil air capacity was observed after direct sowing. The highest soil moisture content was on variant with direct sowing and the lowest on ploughing variant. Influence of different soil tillage on water infiltration was not (except extremely wet year 2010) statistically significant. Influence of different intensity of soil tillage on water infiltration was different in each year. In dry years (2008 and 2011) was higher speed of infiltration on variants with minimum soil tillage and in extremely wet year 2010 on variant with ploughing. In average was the highest intensity of infiltration on variant with ploughing and the lowest on variant with shallow tillage. Penetrometric resistance of soil was always higher under the treated lay of soil where is made more solid lay. On variants with minimum soil tillage were (in contrast with ploughing) in the depth 0.30 m recorded lower values of penetration soil resistance. Influence of different soil tillage on maize grain yields was not statistically significant. In average was reached the highest yield after ploughing (10.76 $t.ha^{-1}$), followed by shallow soil tillage (10.55 $t.ha^{-1}$) and lowest yields were reached in case of direct sowing (9.76 $t.ha^{-1}$).
Results show in the given conditions on possibility to use shallow sowing for maize grain.

Keywords: *soil tillage, maize grain, soil physical properties, water infiltration into the soil, penetrometer resistance*

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Modern approach to soil tillage in Serbia: from productivity and energy efficiency towards agroecosystems resilience and sustainability

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This study provides an overview how recent developments in Serbian agriculture have influenced farming practice and actual trends in soil tillage. Innovative research in the field of farming systems and soil tillage systems should comply to actual trends, with the strong requirements to respond both to industrial (corporative) farming vs. small scale agriculture, which afford their survival and sustainability based on traditional, ecological or alternative principles. The influence of conventional vs. conservation tillage and No-till practice on soil characteristics, yield performance and energy efficiency have been reviewed in order to provide basic information, both about its profitability and sustainability what is primary orientation of highly intensive agricultural farms and companies. Intensification of agriculture have influenced crop rotation on the way that specific cash crops like sugar beet have shortened rotation sequence, still requiring intensive moldboard plowing and precision agriculture - state of the art approach, especially remote sensing in variable rate fertilizer application. Another important issue considering sowing structure in the last few years is an increase of soybean production, comparing to maize, allowing better conditions for conservation soil tillage practice or no till in wheat production. Certain adoption of dominant farming systems on irrigated lands refers double cropping of No-till soybean, fallowing wheat or barley in rotation. Significant improve method intercropping systems as a sinthesys of agronomical, ecological and physiological issues should afford better understanding how to gain biodiversity and agroecosystems resilience. Finally, soil degradation processes and carbon sequestration concerns as a consequences of intensive soil tillage practice and possible solution trough cultivation of cover crops, have considered significant research interest.

Keywords: conventional vs. conservation and no-tillage, crop rotation, farming systems, agroecosystem resilience

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Lessons from a long-term tillage experiment at the James Hutton Institute, Dundee, U.K.

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We used a long-term soil-management experiment at the James Hutton Institute, Invergowrie to understand several key questions relevant for sustainable land management. The questions focused on soil physical and chemical conditions (including possible carbon accumulation) for crop growth and comparing cultivar and yield under different tillage regimes. To respond to these questions we used a number of approaches to characterize soil quality, particularly in ways relevant to root proliferation.

Based on our results there is evidence that for some newer cultivars the yield gains shown in standard testing and our inversion (plough) tillage treatments may not be realized under non-inversion tillage. With promotion of, and movement to, reduced (non-inversion) tillage in the UK this suggests a need for breeding programs to consider crop performance under soil conditions created by non-inversion (or No-Till) systems.

We found no strong reason for not advocating reduced (non-inversion) tillage in preference to ploughing. The hesitation from more strongly advocating non-inversion tillage comes from the plot-scale experiment which ran with no crop rotation (for more than 10 years) and which developed severe weed problems. Under these conditions ploughing helped control weeds and thus delivered better productivity.

Using a range of indexes our study, consistent with other research, found soil physical condition was well below optimal at the sites studied and in many instances offers very limited opportunity for root proliferation. In soils under non-inversion tillage, we sometimes found large improvements to soil physical conditions over a growing season driven by the growing crop. Under No-Till the pH of the surface soil decreased to an extent where it would contribute to further soil structural deterioration and limit plant productivity. Whether changing soil tillage regimes can alter the total amount of carbon (as organic matter) stored in soil is of wide interest. We assessed carbon storage over the soil profile to a depth of 60 cm and took account of bulk density and stone content. We found no gains in carbon storage under non-inversion tillage (compared with ploughed systems).

We over several years we used visual examination and evaluation of soil structure in conjunction with common field based assessments of soil conditions and found evidence that wet winters and water-logging may be detrimental to soil structure.

Keywords: *soil quality, visual evaluation, tillage systems, soil carbon, cultivar responses*

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Effect of different soil tillage on yield and chosen grain qualitative parameters of malting spring barley

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The aim of the study was to evaluate the effect of different soil tillage on yield and chosen grain qualitative parameters of malting spring barley (*Hordeum vulgare, L.*) from a long-term stationary field experiment. The experiment was conducted in 1990–2014 on loamy chernozem soil in a sugar beet growing region at the field experimental station of the Crop research institute in Ivanovice na Hané. Spring barley was grown in three crop rotations, always after sugar beet which was set after silage maize, winter wheat and spring barley. Four variants of soil tillage were evaluated: 1. ploughing (0.22 m); 2. ploughing (0.15 m); 3. direct sowing into non-prepare soil; 4. loosening (0,10 m). Influence of experimental factors on yield was evaluated in 1990–2014, on grain qualitative parameters in 2004–2014. The year 2006, when stands were destroyed by abnormal amount of rainfalls, was not involved in evaluation. Influence of experimental factors on yields and qualitative grain parameters was statistically significant. The highest average yield was reached in the crop rotation – spring barley, sugar beet, spring barley and the lowest yield in the crop rotation - silage maize, sugar beet, spring barley. In all crop rotations was the highest average yield on variant with ploughing to 0.15 m and the lowest on variant with ploughing to 0.22 m. Content of N matter, 1000 grain weight (TGW) and fraction of grain separated above a 2,5 mm sieve was determined to evaluate quality of grain. The highest content of N matter, statistically significant, was found in case of spring barley grown in crop rotation – silage maize, sugar beet, spring barley. The highest content of N matter was found on variant with ploughing to 0.22 m and the lower values were recorded in the variants with lower soil tillage intensity (variant 2, 3 and 4). Decreasing intensity of soil preparation lead to significant increase of TGW values and also ratio of separated grain was increasing.
Results of this observing shows that lower intensity of soil preparation in case of spring barley grown after sugar beet, under conditions of the given locality, is a suitable alternative to traditional way of soil preparation.

Keywords: spring barley, soil tollage, crop rotation, yield, grain quality

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The influence of agronomical factors on the yield of winter wheat in the crop rotation with livestock production

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The aim of the study was to evaluate the influence of three agronomical factors (preceding crops, soil tillage and fungicide applications) on the subsequent grain yield of winter wheat. In the years 2014–2016, there was conducted a field trial on the experimental field station in Žabčice (South Moravia, Czech Republic), within a long-term field trial which is focused on land management with livestock production. This field station is located in a maize production area with a fluvisol soil type. Winter wheat was grown after two preceding crops, namely lucerne and maize silage. The soil was processed by plowing to the depth of 0.24 m, shallow loosening (minimization) to the depth of 0.15 m and direct sowing. In terms of crop fungicide treatment, there were used two fungicide treatments that were compared with a variant without treatment. The achieved results were evaluated in statistical programme Statistica 12.0, using analysis of variance (ANOVA), which showed that year was statistically significant. The highest yield was achieved in 2014 (11.33 t/ha) when the yield was higher in comparison with 2015 and 2016. In addition, statistical significance was also found in soil tillage and fungicide treatment. As for soil tillage, the lowest yield was achieved after plowing (10.66 t/ha). Higher yields were after lower intensity soil tillage (shallow loosening and direct sowing) which, however, were not statistically significantly different. In terms of the fungicide treatment factor, it was found that a higher yield was achieved after fungicide treatment. The difference in comparison with the untreated variant was higher by 0.59 t/ha. On the contrary, the impact of preceding crops showed no statistical significance. Besides significant influence of the three above mentioned self-acting factors, the following interactions were manifested year*preceding crop, year*soil tillage, year*fungicide treatment and preceding crop*fungicide treatment. As for the interaction year with preceding crop, it was found that the highest yield had been achieved in 2014 after maize silage (11.92 t/ha). The difference in comparison with lucerne amounted by 1.18 t/ha more in this year. Also in 2016, there was a higher yield after maize silage amounting to 10.92 t/ha. On the contrary, in 2015, the yield after lucerne was higher by 1.53 t/ha. Although it was expected that the grain yield would be higher rather after maize for silage in 2015 which was drier than 2014 and 2016, since in comparison to lucerne, it does not impair the water system for the subsequent crop, in our case winter wheat. If we compare the interaction of year and soil tillage, the grain yield was significantly lowest in 2014 after plowing (10.40 t/ha), while the highest grain yield was in the same year after direct sowing (11.98 t/ha). This showed that the grain yield increased with the intensity of soil tillage in 2014. Statistically

significant differences after particular soil tillage technologies were found in 2014, while in 2015 and 2016, the values were not statistically different. For the interaction of year and treatment, statistically significant differences were found only in 2016, when the yield was higher by 1.52 t/ha after fungicide treatment while the values were not statistically different in 2014 and 2015. It is obvious from the interaction between preceding crop and fungicide treatment that the grain yield was higher after both preceding corps in the fungicide treated variant. The yield was by 0.26 t/ha higher in the fungicide treated variant than after lucerne. On the contrary, lower in the untreated variant by 0.23 t/ha, although the difference was not statistically significant in any of the cases. Based on the three year results of the more factor field experiment, not only the significance of the influence of year was confirmed which is generally known but also of the soil tillage technology and fungicide treatment. On the contrary, the influence of preceding crop was not confirmed. It also became evident that the grain yield of winter wheat was lower after plowing than after reduced methods of soil tillage (shallow loosening, direct sowing) whether in the interaction soil tillage with preceding crop or with fungicide treatment. This article was written due to the financial support of the IGA FA MENDELU no. IP 36/2017.

Keywords: *winter wheat, yield, preceding crops, soil tillage, fungicides*

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No-till in Europe: A review of problems and opportunities for sustainable agriculture

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Recent changes in the economic circumstances of crop production, the opportunity to develop the area of more profitable autumn-sown crops and concern about environmental damage associated with soil inversion by ploughing has increased the interest in no-till and minimum or reduced tillage. The objective of this paper is to review some of the problems and opportunities for the development of continuous no-till in Europe.

No-till can offer a number of economic and environmental advantages compared to moldboard ploughing for the preparation of soils. However, no-till remains relatively limited in Europe where intermediate forms of tillage (non inversion tillage) or occasional ploughing are preferred. Adoption of continuous no-till is under the dependence of a large number of aspects. In this note, we emphasize on crop and soil responses and the environmental issues of adopting no-till in the contrasting climates and soils in Europe.

Effects no-till on crop production

Any lack of yield reliability will strongly influence farmer acceptability of no-till. Many surveys of crop yields under no-till conditions have shown that yields were slightly lower in no-till than in ploughed situations. However, soil, crop and weather factors exert important influences. Yields of no-till crops tend to approach or exceed those after ploughing as the rainfall decreases from northern to southwestern Europe. In contrast, within areas of extreme aridity in northern Spain barley yields with no-till were sometimes twice those with conventional tillage.

Immediately after adopting no-till, crop yields are often lower than in plough tillage systems. However, yields improve after some years of no-till. Mechanisms for yield reductions under no-till vary according to local conditions. Among the main reasons there are: (1) compaction from previous harvest traffic, especially before soil strength and bearing capacity had increased; (2) limited time for build-up of soil structure improving factors under no-till (e.g., accumulation of organic matter, vertically orientated structure, stabilizing influence of roots and fauna); (3) reduced N availability; (4) lack of practical experience of no-till.

Soil type is, obviously, of major importance. No-till may be successful on certain soil types and quite unfavorable on others. Soils with imperfect drainage and weak structure generally led to lower yields with no-till than after ploughing. In weakly structured coarse-textured soils compaction is a severe limitation to the success of no-till and periodic non-inversion loosening and cautious control of vehicle traffic

are recommended. Sandy and sandy loam soils, especially if low in organic matter, may lack the ability to acquire a stabilized structure under no-till, and require regular loosening. Success of no-till is also influenced by climate. In northern and western Europe crop yields under no-till are frequently lower than those after ploughing in wet seasons while there may be little or no difference in dry seasons. In south-western Europe no-till can result in an appreciable increase in available soil water in dry seasons. Lastly, adoption of no-till introduces important changes to the incidence of weeds, crop diseases and pests, as well as the problem of volunteer cereals. Successful and economic control of these problems is a vital component in ensuring the commercial acceptability of no-till.

Soil response to no-till

Changes in soil structure due to the adoption of continuous no-till are now well documented. After a transition period whose duration is approximately 3 to 5 years, soil organic matter content and aggregate stability increase near soil surface. The development of vertically oriented soil porosity is observed, attributed to increased earthworm population, increased aggregation, stability of old root channels, and natural pedological activity due to shrinkage and swelling if the clay content is sufficient. Infiltration rate is subsequently increased. Lastly, the load bearing capacity is improved, with reduced damage from traffic. In the driest regions of Europe, the increase (compared to ploughed situations) of barley yields was attributed to the ability of no-till to increase plant available water. However, the adoption of continuous no-till leads to an increase of bulk density at 0-25 cm depth. It may also cause an increase of soil moisture and a decrease in soil temperature near soil surface, especially in spring in northern regions, delaying drilling. An increase of acidity near soil surface and an accumulation of P with risk of loss with runoff were also reported in many studies.

No-till regimes have widely been found to increase the biodiversity of soils, especially when considering the macro-, meso- and micro-fauna components of biodiversity. Regarding microbial activity, an increase is observed at shallow depth, probably associated with the increase in C content. At lower depth the earthworm activity is more probably the causing factor of the increase in soil respiration. Earthworm populations are invariably higher under no-till than under ploughing and increase with the duration of no-till. However, significant differences are found in the species and habits of earthworms and the anecic group is responsible of the improvements of soil infiltration and hydraulic conductivity.

Environmental impact

Emissions of greenhouse gases CO_2 and N_2O from no-till soils are highly variable and depend on complex interactions of soil properties. Emission of CO_2 from fuel during machinery usage is always appreciably reduced with no-till. Increased soil organic carbon in surface layers of no-till soils is widely found but may not be associated with increased carbon sequestration throughout the profile. The evaluation of

the relative carbon balance for no-till and ploughing depends upon complex inter-relationships between soil and climate factors, which are as yet poorly understood. In the future, adoption of no-till may be encouraged by public financial assistance in recognition of environmental benefits, although future restrictions on the use of herbicides may be an obstacle. Economics will dictate whether farmers find no-till an attractive alternative to ploughing but the components contributing to the overall decision are complex and research has seldom been undertaken to make a full analysis on a whole farm basis using all the relevant factors which affect farm management decisions.

Keywords: no-till, soil structure, crop yields, environmental impact; sustainable agriculture.

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Innovated retro: cover cropping and horse traction to combat soil compaction and improve soil fertility

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Soil compaction becomes an increasingly important issue in modern agriculture of industrialized economies. It adversely affects many components of soil fertility, like capacity to store water for drought periods, to provide a proper drainage and aeration of roots, to enable the richness of soil biota, and to give a favourable environment for plant growth. Many researches have indicated that the main causes of soil compaction are the use of heavy machinery and loss of soil organic matter. Fortunately, cover cropping has been recognized for decades ago to recovers many components of soil fertility, especially the richness of soil biota, soil's penetration resistance, capacity to store water and nutrients, and resistance to compaction induced by agricultural machinery. However, the restoration of soil fertility traits through cover cropping only may not be completely satisfactory and fast enough. Therefore appears an idea to research the effects of reintroduction of animal traction in agriculture to the soil fertility traits. The support for this idea comes from the recent findings that horse traction in agriculture prevents soil compaction magnitudes found in modern mechanized farming. Since there are no available data on the combined effects of horse traction and cover-copping to the soil fertility and compaction issues, authors deem it needed for a future research in field trials. The prospective field trials would provide not only the data about above discussed, but also about daily work outcomes, needs for human labour and economics of such improved traditional way of agriculture. The obtained data could serve for further projections of impacts to the people's welfare, national and regional economy, farming sustainability and environment protection.

Keywords: *soil compaction, soil fertility, farming sustainability.*

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Tillage system between intensive farming and sustainable intensification of agriculture

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In the former state Croatian agriculture was quite sharp divided on very intensive farming practised on the large public (state) farms, and low intensity (but sustainable) family farms. During the long period official agricultural policy, education system, research programmes supported the intensive, industrialised agriculture of state farms and marginalized the private one. State farms neglected crop rotation and practised narrow crop rotation, unfavourable crop sequence and monoculture, with maize as dominant arable crop. Contrary, private farms practised combined agriculture with fodder crops, mostly some kind of "Slavonian three-field crop rotation". The central tillage operation in intensive arable farming was deep winter furrow aimed for snow-water accumulation. Drainage of unfavourable hydromorphic soils resulted by about 160 000 ha of land with installed pipe drainage. The self-standing of Croatia opened the process of abandonment of concept based on state farms and started privatisation of state agricultural land. Traditional conviction is that there are only some soil types usable for no-tillage practice. On soils of unfavourable properties in praxis was the concept defined as; *the first maximum* (investment in amelioration-drainage), *and than minimum* (tillage) !!!. Results of our long-term research of effects of no-tillage on Stagnogley in Central Croatia show the yield of winter wheat, maize and oil rape statistically on the same level as using the standard tillage practices. Intensive tillage and soil aeration on one side and permanent declining of livestock animal unit/ha resulted by reducing of fodder crops in crop rotation and humus content in the soil. Today we insist on sustainable intensification of agriculture, following the concept of "Zagreb agro ecological school) in which all crop-growing, means tillage practices are soil bio-complex and humus-enrichment oriented. The concept of sustainable intensification is based on principle; deep (rhizosphere) loosening but shallow (practically seed-bed) rotating. Permanent green cover and/or luxuriant biomass is the best sink of glasshouse gases, including of CO_2, which means the CO_2 - neutral farming system.

Keywords: intensive farming, low intensity farming, winter furrow, sustainable intensification of agriculture.

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Effects of biochar and sugar factory lime application on soil pH in acidic soils

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Soil reaction, expressed as a pH value, is an indicator of acidity or alkalinity of soil and can strongly influence physical, chemical and biological processes in soil, plant nutrition and fertilizer efficiency. Furthermore, the soil acidic reaction causes increased mobility of aluminium in the soil. If toxic concentrations of aluminium are reached, they will have negative effects on root growth, i.e. decreased growth and development of the whole plant. Plants can grow and develop in soils of different soil reactions, but the optimum reaction is between slightly alkaline and slightly acidic. The aim of this research was to determine the differences between the effects of biochar and sugar factory waste lime on soil reaction in acid soils. Currently mostly used soil conditioner for acid soils in Croatia is sugar factory waste lime, which is a by-product from the production of sugar and contains 30% Ca. Biochar is the product obtained through the pyrolysis of waste biomass. In agriculture, it is used as soil conditioner and can have positive effects on several physical, chemical and biological soil properties. The research was carried out on stationary field trials at two locations on acid soils in Osijek-Baranja, and Virovitica-Podravina County, Croatia. Experimental design was a split-plot with four repetitions and the crop used was corn. Biochar was the main factor which was compared to liming with sugar factory waste lime. The treatment were: C - control, B1 - 5 t ha^{-1}, B2 - 10 t ha^{-1}, B3 - 15 t ha^{-1} of biochar and L1 optimal dose of sugar factory waste lime that was calculated for each field trial location. Two steps of sub factors were also applied, F0 - without fertilization and F1 – with recommended fertilization. Soil samples were taken in V3 and silking stages of corn growth. Initial soil analysis revealed a strongly acidic soil reaction at the location Osijek-Baranja (pH 5.12) and very strongly acidic reaction at location Virovitica-Podravina (pH 5.0). The average soil pH value in V3 stage of corn growth was 5.42 and was under a very significant influence of soil conditioner and fertilization treatment. The highest pH values were measured in treatment with liming and compared to other treatments the differences were at 99% significance. The average pH value in silking was 5.93 and its variation was under significant influence of soil conditioner treatment. Again, the highest soil pH values were measured in soil samples with liming and non-fertilized soil samples had a higher pH value than soil samples where fertilization was applied (99% significance). Also, in the silking on both locations, significantly higher soil pH value was measured in

treatment B3 (95% significance) compared to C, B1 and B2 treatment, indicating a positive effect of biochar on soil reaction. The most common soil conditioning measure conducted on acid soils is liming, which has already been proven to be the fastest way to raise soil pH. This statement was confirmed by this research, but it must be noted that together with liming we usually must implement many other different soil restauration measures like humization especially in degraded soils. It can be concluded that biochar, is a powerful soil enhancer that positively affects several important physical, chemical and biological soil properties, and it can be easily used as soil conditioner for acid soils, especially if we consider its prolonged action in soil.

Keywords: *Biochar, sugar factory waste lime, acid soil*, *soil restauration measures, soil reaction.*

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The Application of the drip irrigation in the production of tobacco and sugar beet in the Republic of Croatia

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Beside fertilization and soil drainage, irrigation is a very important agrotechnical measure in the production of agricultural crops. Irrigation compensates the lack of water in the soil, and the quantity of water added depends on the amount of precipitation and their disposition during the vegetation period. In our conditions, irrigation should be applied as a mandatory agrotechnical measure, especially in the dry part of the year. Irrigation ensures optimal conditions for the development of the plants, because the plants must continuously receive the necessary nutrients that are dissolved in the water. This way, along with the high quality of applied technology (processing, fertilization, drainage) irrigation achieves more stable production which is manifested in larger and better yields of the cultivated crops. The quantity of nutrients in the fertilization of tobacco and sugar beet depends on soil fertility, and the use of irrigation water depends on the amount and disposition of rainfall during vegetation period. In the Republic of Croatia very small percentage of the agricultural area are irrigated and the lack of systematic irrigation is a significant risk factor for the production of agricultural crops. Irrigation (drip system) is used mainly for production of tobacco in Podravina and Slavonija on more than 20% of the growing area. Irrigation significantly increases the yield and the quality of the dried leaf tobacco (20-30%). For the past few years, Danon d.o.o. company has aimed to expand the application of irrigation in the production of sugar beet on the production area of Belje d.d. The application of fertigation has increased the yield of roots by 20.6-42.7% in in 2014, 2015 and 2016. In a very dry year of 2015 fertigation increased sugar content by 1.4%. Virginia-type tobacco is grown on light soils (luvisol) and sugar beet on more fertile soils (humogley) which contain more organic matter. On the basis of the measured rainfall and water content in the soil, irrigation was applied six times in 2014 and 15 times in a very dry year of 2015.
115 millimeters of water are applied in 2014 and 270-310 mm of water in the very dry year of 2015. In multi-year macro experiments irrigation has significantly increased the yield and quality of tobacco and sugar beet. The results of the research have shown the need for the mandatory application of this agrotechnical measure.

Keywords: irrigation, fertigation, flue-cured tobacco, sugar beet

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The impact of various soil tillage methods on soil physical properties in grain maize stands

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Growing of grain maize has an increasing area in crop rotation in the Czech Republic in the past decades. This requires looking for new innovative maize management practices. The systems of differentiated soil tillage and fertilization have been intensively investigated in Europe in the last time. Differentiated soil tillage systems present modern trends in maize growing and they are fully in harmony with the goals of sustainable land management. The primary objectives are the energy and economic efficiency of this growing systems and reducing the degradation processes of the soil.

For verification working tools and prototype machines for differentiated soil tillage was proved in field experiment with various variants of soil tillage in the maize production region. This area is in the very warm and dry climatic region (average annual temperature 9.2°C, precipitation total 480 mm). Soil type there was Fluvisol modal carbonate. It is medium-heavy soil.

Five variants of differentiated soil tillage were prepared in the autumn agrotechnical term of soil cultivation – 1. Ploughing (0.25 m), 2. Deep cultivator (0.30 m), 3. No-till – control variant (0 m), 4. Chisel cultivator (0.25 m), 5. Strip-till cultivator (0.25 m). The maize was sown by a precision seed drill machine in the spring of 2015.

Soil penetrometric resistance measurements were performed to determine the effect of differential soil treatment on soil properties changes in the experimental site after establishment of field experiment. During the vegetation the Kopecky´s physical cylinders were taken from three depths (0-0.10 m, 0.10-0.20 m and 0.20-0.30 m) in five repetitions. Sampling was done in three terms. The bulk density was determined. We can include that bulk density is a set of minimum data for soil quality monitoring as an indicator of soil structure and soil strength. The change in bulk density reflects changes in total porosity. As other characteristics, minimum air capacity and volume soil moisture were selected. All selected soil properties well reflect changes in three-phase soil composition. Soil compaction measurements were performed using a hand-held cone penetrometer the Penetrologger with digital recorder from Eijkelkamp. The device complies with the American Society of Agricultural Engineers (ASAE).

The observed physical soil properties well reflected any mechanical interference to the three-phase soil system (solid soil, water and air). Ploughing showed favourable values for bulk density (1,32 t m^{-2}) total porosity (49.62 %) and minimum air capacity (19 %) compared to ploughing-less technologies (average of variants 2 – 5 – 1.40 t m^{-2}, 45.86 %, 13.98 %). Loosening strips by the Strip-till variant had a very similar effect on the soil physical properties (1.33 t m^{-2}, 49.15%, 16.78%). On the contrary no-loosening strips by the Strip-till variant (1.42 t m^{-2}, 45.73%, 12.45%) behaved

similarly effects on the soil physical properties as No-till variant (1.54 t m^{-2}, 47.38%, 10.34%).
Measurement capturing the amount of water in the soil showed a higher proportion of water in minimum tillage technologies. The higher volumes of moisture are caused by a less loosened shallow soil layer of the soil profile and a higher proportion of capillary pores. It has worsened the parameters of the physical soil properties with increasing depth of sampling by all compared variants. The soil moisture increased with depth of sampling. Optimum values of bulk density, porosity and minimum air capacity were achieved at the first sampling date. The physical soil properties gradually changed during vegetation. The volume of moisture was the opposite. The highest soil moisture values were for the last sampling and for all variants of soil tillage.
Recorded measurements of penetrometric resistance showed that between variants are not significant differences in the Cone index. Higher values were measured in the third variant – No-till. This is logical, because in this variant was in the original condition as after the harvest. The values of penetrometric resistance in the soil profile of variants confirmed this fact. The curves of the values recorded during the measurement had approximately the same shape for all variants. We can say that there was no any difference between the variants when setting up a field experiment. It was a slight increase in penetrometric resistance at a depth of approximately 0.25 m. It showed to the remains of ploughing from past years. This compacted layer was eliminated by the effect of loosening at a depth of 0.30 m by the deep cultivator Digger (variant 2). Any change in the method of soil tillage necessarily leads to changes in the soil environment. The extent of these changes depends on the degree of reduction of soil depth and intensity and on the quantity of plant residues. The content, availability and movement of the soil water were changing vegetation based on current amount of precipitation and due to variants of soil tillage. The surplus but also a lack of soil water is harmful for development of grain maize stand. This is the reason for the choice of appropriate soil tillage technology. Differentiated soil tillage is used on the entire land area to increase soil throughput and to eliminate compaction if we use a deeper depth setting of the working tools of the machine. The results showed a positive effect of strip-till technology. This is a compromise between traditional technologies with intensive cultivation and no-till technology. The loosening strip has a positive effect on the soil physical properties and it facilitates the establishment of maize and its development. The no-loosened strips support more effective management of water and soil erosion control. Strip-till technologies may be a suitable alternative for the establishment of growing wide row crops.
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Keywords: *grain maize, differentiated soil tillage, soil properties, soil compaction.*

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Monitoring of agricultural land as a basic tool for sustainable land management in Croatia

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Strategies for sustainable land management must consider long term data weather conditions, soil loss and run-off, physical, chemical and biological parameters of the soil, and contrast this information with the total crop and land management practices including soil tillage, crops selection, nutrient management and other conservation measures. The aim of this study was to analyze the existing systems of permanent monitoring of agricultural land, as well as achievements in the Republic of Croatia. Also, need to draw attention to its importance considering the systematic monitoring of agricultural land as one of the most important preconditions for sustainable land management. Monitoring systems should containe the information's on changing soil parameters and evolution of soil quality in topsoil and subsoil. Without the monitoring systems it is impossible to timely notice negative changes that occur in it, which inevitably lead to the degradation of the most important properties of soil. The permanent monitoring of status of agricultural land aims to permanently keep track of all the changes which occur in agricultural land (physical, chemical and biological, and notably the content of harmful substances). The strategy of sustainable development of agriculture is almost inconceivable without the permanent monitoring of agricultural land and identification of high-risk areas as part of the environmental monitoring, considering the hazard to the soil as a resource that is essential to its primary function, food production. Establishment of the information system of contaminated agricultural land as well as the analysis and recommendations of its fertilization represent the basis for complete protection of agricultural land, which are integral parts of the system monitoring of agricultural land. Sustainable agricultural development has become most important segment, as is increasingly evident the importance of proper management of agricultural land, which is considered the most important source of food. Croatia has a great potential for the development of agriculture based on ecological and sustainable principles. However, this potential is not fully utilized what is also noticeable through the soil monitoring. Although Croatia has designed projects and plan soil monitoring, it still did not become a priority for the sustainable management of agricultural land in Croatia.

Keywords: *sustainable land management, monitoring, agricultural land.*

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The role of soil suitability assessment system for sustainable food production

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Because of the accelerated growth of the world's population over the last 50 years, global food production has increased by 145%, ~70% of which is a result of higher yields of agricultural crops. Higher yields require more energy and natural resources, which reduces the ability of the biosphere to maintain sufficient food production while keeping soil, water and air quality but also to regulate climate. Soil suitability assessment is the basic precondition for sustainable land management (SLM) and a strategic component of sustainable development.

Agriculture in Croatia is still primary branch of industry. Because of that, the quality of life and opportunities for economic development of agricultural producers are directly related to the size of the production areas and their quality. Soil suitability management system imposes as an optimal solution for land preservation and growth of its ecological functions. It can be used as a sort of land monitoring that can provide insight into agricultural land management through identifying the symptoms of unsustainable land management, such as soil degradation, water quality decline, loss of biodiversity, spread of plant disease and others. Gathered experience from implementing soil suitability assessment system in the area of Osijek-Baranja County from 2003 to 2015 have shown that it is an important precondition for sustainable land management. The analysis of the 26914 soil samples, that are stored in the interpretation base (iBase), shows that the agricultural land of the County is on average classified as a moderately suitable (S2) for crop production. According to the productivity indicators of average corn yield of 9.65 t ha^{-1} it is necessary to incorporate 173 kg ha^{-1} N, 94 kg ha^{-1} P_2O_5 and 102 kg ha^{-1} K_2O in soil.

Keywords: *soil suitability assessment system, sustainable land management, Osijek-Baranja County*

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Characterization of household differentiation from the perspective of farmland transfer in eastern China using an agent based model

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Along with a large amount of rural labor flow to non-farm industries over the past several decades, farmland transfer has been a general trend in China, resulting in significant differentiation of farmer households and changes in agricultural land use pattern. The differentiation of households has been an essential concern in solving agricultural problems and formulating effective agricultural policies in China, especially for scale operation of farmland and the urbanization of surplus rural labor. In this study, an agent-based model was developed to explore the differentiation process of farmer households and the resulting concentration of agricultural production by characterizing the households' decision-making behavior with respect to farmland transfer. This agent-based model was applied to Jinze Town, located in the developed eastern region in China. Farmland transfer in this area has been rapid and well-developed, providing a typical development path for other regions. The model simulated the household agents' farmland transfer behavior, reproduced the evolution and differentiation of household agents and explored the dynamic changes of farm area distribution across household types. Small households, the dominant demographic as well the main agricultural cultivators in the beginning, decreased radically and cultivated the smallest area of farmland in the end. In contrast, scale-cultivation households (farming-oriented and large households) increased rapidly and became the main force of agricultural production in the research area. Most of the households evolved into off-farm families that entirely exited farming. They were the potential rural population for urbanization. Farmland transfer from small households to scale-operation households resulted in a concentration of production at the region level. The agricultural land use pattern transformed from small-household production to appropriated scale cultivation. These emerging phenomena are highly consistent with observed changes in the study area. This paper examines how farmer households' attributes influence their farmland transfer behavior and evolution disposition, and analyzes the underlying socio-economic and political factors that facilitate the rapid development of farmland transfer in the study area. We also discuss the transitions in household livelihoods and man-land relations. In so doing, we put forward corresponding policy suggestions on how to adjust households' behavior and how to provide a favorable external environment for farmland transfer under the promise of respecting the man-land relations and fitting the specific contextual conditions. These findings can provide references for land use policies in other transitional rural areas.

Keywords: farmer household, differentiation, agent-based model, farmland transfer

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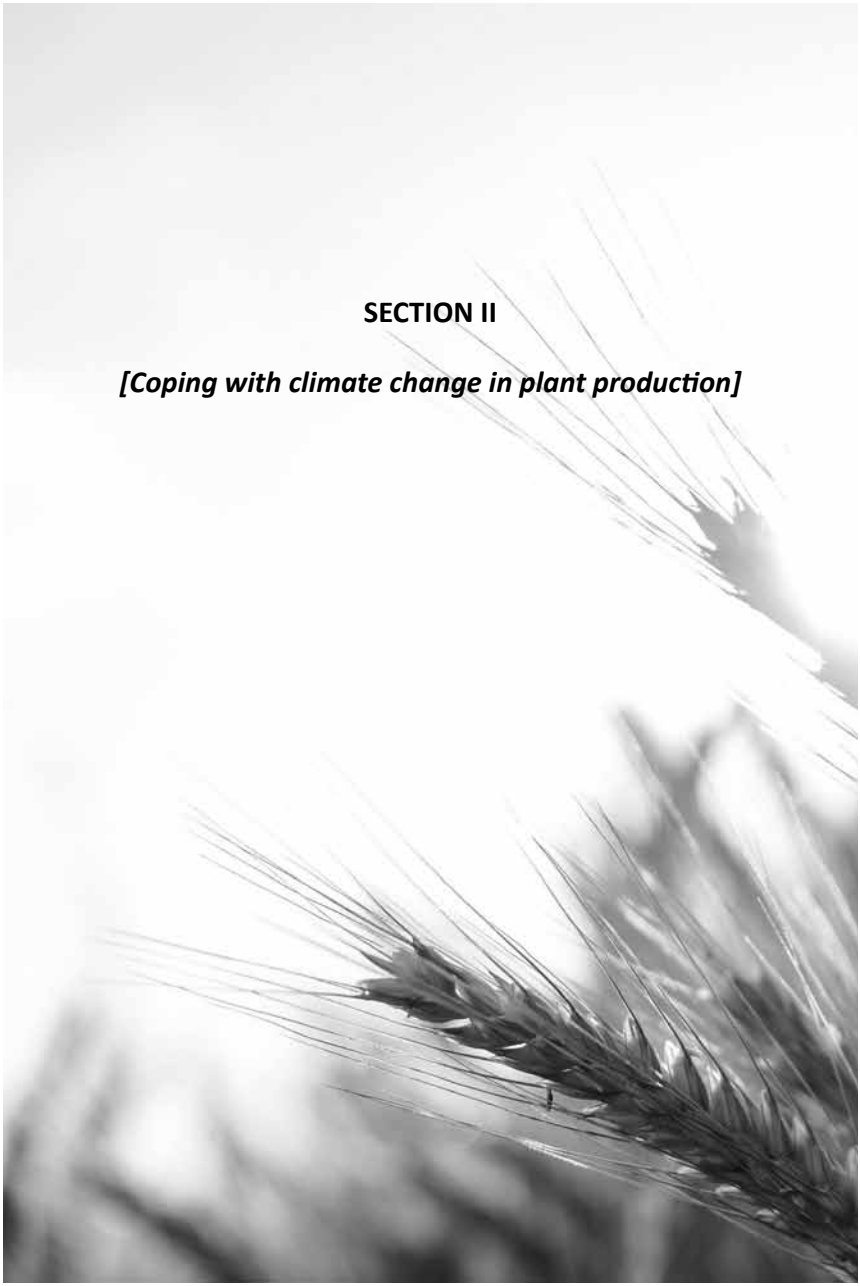

SECTION II

[Coping with climate change in plant production]

Yield and Yield Components of Maize (*Zea Mays* L.) Hybrids as Affected by Irrigation Scheduling and Meteorological Conditions

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During the last decade eastern Republic of Croatia have experienced several drought and flood events which seriously affected crop production and economy as well. Climate variability does not only affect the yield of crops but also the effectiveness of irrigation practice, meaning irrigation scheduling and water use efficiency. This study was conducted to quantify the effect of irrigation scheduling on yield and yield components (hectolitre weight (HW), 1000-grain weight, cob weight (CW), cob length (CL), cob height (CH), grain weight (GW) and grain number/cob (GN/C) of maize (*Zea Mays* L.) hybrids during three growing seasons (2010 – 2012) characterised by extreme weather conditions. The study was conducted at the research site of Agricultural Institute in Osijek, eastern Croatia. Three irrigation treatments (a1 = rainfed, a2 = 60 – 100% field water capacity (FWC), a3 = 80 – 100% FWC) and four maize hybrids (b1 = OSSK 596; b2 = OSSK 617; b3 = OSSK 602; b4 = OSSK 552) were studied. Standard agro technical procedures were performed in terms of soil tillage, fertilization and crop protection. Maize crop was irrigated using a traveling sprinkler system. Irrigation scheduling was based on measuring soil water content with the Granular Matrix Sensors (GMS). During the study grain yield ranged from 7.4 t ha^{-1} (2012, a1) to 10.3 t ha^{-1} (2012, a3). In extremely wet growing 2010 the highest yield ($p<0.01$) was obtained on rainfed plots (9.2 t ha^{-1}). Due to excessive amount of water grain yield on irrigated plots was reduced for 8% (a3) compared to control (a1). This was opposite to growing seasons 2011 and 2012 when irrigation water increased grain yield for 18% (a2) and 25% (a3), and for 13% (a2) and 40% (a3). As for yield components irrigation water very significantly ($p<0.01$) reduced CW (a1 = 0.8 kg; a3 = 0.7 kg) and CH (a1 = 72 cm, a3 = 38 cm) and 1000-GW (a1 = 284 g; a3 = 254 cm) while significantly ($p<0.05$) reduced CL (a1 = 16 cm; a3 = 15 cm) in first year of our experiment. In the second year of our study irrigation scheduling very significantly increased only 1000-GW (a1 = 305 g; a3 = 330 g) while in the last year of our study irrigation scheduling increased all tested yield components as follows: 1000-GW (a1 = 340 g; a2 = 361 g); CH (a1 = 116 cm; a2 = 126 cm); CW (a1 = 1,15 kg; a3 = 1,79 kg), GN/C (a1 = 578; a2 = 701) and HW (a1 = 67 kg; a3 = 69 kg). As for maize hybrids (b), according to results of our study yield of maize grain varied ($p<0.01$) across tested hybrids in all three growing seasons while the significance for tested yield components was year dependent. The analysis of correlation revealed that connection strength between yield and yield components was also year dependent. For instance, in the first year of our study only significant ($p<0.05$) correlation was

between yield and 1000-GW (r = 0.5, n = 36) while in the second and the last year of our study significant ($p<0.05$) correlations were between yield and HW (r = 0.5, 2011), r = 0.4, 2012), CW (r = 0.4 (2011, 2012), CL (r = 0.5, 2011), GN (r = 0.5, 2012) and 1000-GW (r = 0,4, 2012).

Keywords: *maize hybrids, yield, yield components, irrigation, climate change*

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Soil tillage responses to the climate threats – Revaluation of the classic theories

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This study intends fulfilling two tasks. The first task was revision the classic theories related to the ploughing practice at present climate conditions. The factors that closely depended on the ploughing are the method of stubble tillage in summer, clod formation, a cloddy surface before wintering and misinterpretation of the frost effect. The second aim was evaluating the soil condition evolved by different soil tillage methods and the ranking the methods in dry and in wet seasons. The fulfilment of the tasks based on the results that were elaborated in a long-term experiment. The six tillage treatments are fairly adopted in Hungarian fields however the impartial judgement, especially in extreme seasons, is rather incomplete. Six treatments comprised deep – ≥ 0.30 m (that is loosening, L, ploughing, P, and tine tillage, T) – and shallow – ≤ 0.22 m, (that is tine tillage, ST and disking, D) – soil disturbance along with direct drilling (DD). That is, among the treatments ploughing was also included.

Attention to the ploughing has originated from the multi-year experience obtained in the regional practice. The ploughing has dutifully applied in the Pannonian region for centuries, despite of the negative consequences that have become well known both in European and in the worldwide relation. The main disadvantages of the ploughing, according to the literature are the limited depth of the loosened layer, the humus and the water loss and the soil structure deterioration. Most of the damages are visible e.g. soil kneading, pan compacting in wet seasons or soil lumping in the dry conditions. Ploughmen do not want to recognize these harms despite they are to face the negative consequences of their practice in extreme seasons. Ploughmen have regrettably remained indifferent to the sustainability ideas up to now. Changing the attitude to the ploughing practice seems to be really urgent considering the impacts of the extreme climate phenomena on ploughed soils.

The second aim was studying the effects of the tillage treatments on dry and wet soils and minimizing the possible damages. Only the treatment was used might have received the optimal degree which has resulted in slighter and easily reparable damages that occurred during the dry (2011, 2012, 2015) and wet (2010, 2014, 2016) seasons.

Realising the tasks that were assigned above, some important conclusions can be

drawn:
- Creating the black surface (by ploughing) in summer stubbles is really outdated considering the exposure of soils to the heat and the rain stress. It was found that regeneration of the soil condition after summer harvest can only be implemented by shallow soil disturbance and adequate (45-55%) surface cover.
- According to the classical approach an advantage of the ploughing created large clods is the poor weed emergence in summer. Considering this practice, the weed infestation has postponed to the time after sowing. It was found that the effective weed control should be achieved in stubbles where weeds emerged in number considering the effectual soil water conservation.
-Summer ploughing was acceptable despite of the clod formation because of the clod breaking effect was hoped by the alternation of the higher and lower temperature in the day and night. The reality is far from this belief that is the fragmentation process is adequately occurred, but in the meantime the biological activity of the soil has ceased and decomposition of the stubble residues has also stopped.
-According to the classic principles, stubble residues are considered to be materials that make difficulties in soil tillage therefore removed that most often. It may stress that stubble residues are source of the humus and was found to be important to alleviate soil sensitivity to the drought and the rain stress.
-Leaving the ploughed surface in cloddy state is typical. The explanation is to retain more rainwater and snow. New results state the disadvantages of the ploughing in water storing capacity in contrast with subsoiling and the deep tine tillage. While the snow events are continuously decreased, catching the snow is also doubtful hence, more effective water conservation can be implemented throughout the year.
- The frost effects was believed favourable in the past, considering the fragmentation of the big lumps created in autumn. Nowadays, large, kneaded lumps are produced by modern ploughs, and fragmentation occurs only in the external parts of the big lumps, and internal parts have remained unbroken during winter period. It was found that the frost effect is often dangerous on soil structure.
- Frost effects were considered to be critical when amount of the frost-dust was high (50-55%) in the samples taken from the upper 10 cm layer.
-The quality of the ploughing treatment in the experiment surpassed the regional average, but comparing to another treatments it proved to be less advantages.
Among the findings of the long-term experiment results that occurred in both dry and wet seasons are discussed. Results state again the advantages of the ploughless tillage.
-The depth of the loosened layer was the same as the depth of the tillage at the treatments where a compact pan has formerly occurred, that is after ploughing and disking.
-Larger clods (with ≥100 mm diameter) were usually formed in ploughed soil in both dry and wet seasons.
-Larger (≥30 mm) soil particles unwanted in the seedbed was also found in the ploughed soil due to the clean surface following primary tillage.

-Ratio of the dust reached largest proportion in ploughed soil in dry periods considering the surface exposure to the climate stress factors. Both siltation and crust formation became critical in soil that ploughed earlier.
-Distribution of the chopped stubble residues in the entire cultivated layer proved to be more beneficial to the decomposition and the earthworm activity than that inverted to the bottom of the ploughed layer.
-The experiment made a chance establishing the optimal ratio of the surface cover. The cover ratio affected by size of the chopped residues. Thus, the chopped straw may optimal at ≤60-80 mm length and the chopped maize stalk at 80-100 mm. In alleviation of the heat and rain stress, 85-100% of cover ratio was optimal after cereal and maize harvest. However, at least 40-45% of cover ratio had beneficial impact on soil protection between the period of primary tillage and winter or spring sowing. The impact of torrential rains on crumb deterioration after sowing was moderated at higher (35-40%) surface cover.
-Based on the results, aim of soil tillage can also be reworded. Instead of stressing the crop requirements the soil protection has become priority in soil tillage. Soil condition research was supported by the AGRÁRKLÍMA.2 VKSZ_12-1-2013-0034 project.

Keywords: soil conservation, climate stress mitigation, ploughing, ploughless tillage

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Carbon footprint of rainfed and irrigated arable crops under tillage compared to no till & guide assistance

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One of the most important key points for agriculture in the next years is to reduce its impact over the climate change (CC). This work try to demonstrate which crops and soil and water management systems are more profitable in order to reduce the contribution of agriculture to CC.
This work belongs to the Life + Climagri project. It shows the results of two seasons carried out in the experimental farm of the University of Córdoba. Different arable crops were studied in rainfed (wheat, beans, barley) and irrigated (corn) conditions. Two soil management systems were compared: Tillage (T) versus No Till (NT) and Guide Assistance (GA). For irrigated crops, two water supplies were studied: 550-750 mm. The parameters on mechanized operations were logged using a remotely data acquisition system. The equivalent Carbon Dioxide (CO_2) emitted was calculated by an energy analysis. The CO_2 fixed was a transformation of the yield. Two parameters were defined, CO_2 Efficiency (CE): CO_2 emitted by CO_2 fixed. Carbon Productivity (CP): Kg of yield by each kg of CO_2 emitted.
Irrigated yields in corn doubled the production of cereals and were 10 times bigger than beans, especially for higher irrigation. There were no differences between T and NT & GA, except for wheat. The CO_2 emitted in T always were more than a 20 % higher than NT & GA. This situation caused that NT & GA always provided best results of CE and CP. Barley under NT & GA obtained the higher values of CE and CP due to the scarce use of fertilizers. Corn with sustainable techniques produced better results than wheat, the first season, but not the second one.
It is possible to reduce the carbon footprint of agriculture by using sustainable techniques. The used of high inputs systems it does not seem to be the answer. The application of rainfed crops with a low application of fertilizers (barley) showed the best results. However, more years of study are needed in order to get robust results.

Acknowledgements
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Keywords: *sustainable agriculture, climate change, energy, efficiency in the use of natural resources*

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PEG-induced drought in wheat genotypes at the germination stage

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Drought is a common abiotic stress worldwide factor that has a negative impact on plant growth and development thereby affecting wheat quality and yield due to climate variability which represents a considerable challenge to plant breeders. In plants, drought primarily causes an osmotic stress leading to cellular dehydration but effect of drought mainly depends on developmental and genotype properties. Seed germination is particularly sensitive developmental stage to water deficit so first step of our study will be focused on observing the influence of drought in the seedlings of six wheat genotypes (Katarina, Srpanjka, Kraljica, Žitarka, Antonija, Vulkan) under controlled environment, using polyethylene glycol-6000 (PEG) solutions at two different concentrations (10% and 20%) as the moisture stress inducing media. During 14 days of treatments we will check the germination rate, fresh and dry weight of the roots and shoots, water content (WC) and the shoot/root length. As well, we will check the enzymatic antioxidant response in early plant stage. The aim of present investigation is to make preliminary survey of the seedling reaction to induced drought. We want to correlate specific parameters in different genotypes in early plant stage with differences in the antioxidative response. This will give us an insight if there are differences among wheat genotypes in the manner of better drought tolerance during the stage of germination which can be fast and cost effective screening method in the wheat breeding program of Agricultural Institute Osijek. Later we will complete the study by monitoring the drought response of the same wheat genotypes in the adult plant stages in purpose of screening the most tolerant genotypes.

Keywords: *drought, seed germination, wheat, PEG-6000*

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Forage legumes breeding strategies for adaptation on the future environment challenges

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Global climate change is resulting in extreme temperature (high or low) situations in different regions of the world, which affected in new growth conditions for forage crops production. Furthermore, increasing pressure to farmers to adopt more sustainable agricultural practices requires new approaches in breeding forage legumes. New environmental conditions and turning towards sustainable agriculture has compelled forage breeders and breeders of other agricultural crops to develop climate change resilient cultivars, which can withstand broad spectrum stresses such as drought, heat, cold, salinity, flood, submergence and pests, thus helping to insure stability and increase production.

Alfalfa and red clover are the main perennial legumes in most European regions. Understanding genetic and physiological basis of these crops for adaptation in the future climate challenges is one of the most important objectives of forage breeding programs.

Forage crops breeding to environment challenges involves several key activities: (i) create new and better adapted cultivars by identifying and improving useful traits such as winter survival, thermal tolerance of photosynthesis, resistance to waterlogging and, autumn dormancy range, fungal disease resistance that are expected to be even more important in future due to changes in temperature and humidity, (ii) use available genetic variation within natural gene pools (local ecotypes, landraces and cultivars) and / or wild adapted genetic resources and exotic germplasm for crossing and pre-breeding to increase favourable loci and resilience in the elite breeding populations, (iii) increase persistency under severe drought conditions, (iv) encourage the use of legume species in pure or mixed stands (mixtures of alfalfa and grass species may help to regulate forage production during the year and to reduce the disequilibrium between spring and summer production), (v) integrate marker assisted selection (MAS) and genomic selection into practical breeding programs. Genotyping-by-sequencing (GBS) data and other genomic investigations identified QTL regions influencing various traits in alfalfa such as aluminum tolerance, drought tolerance, salt tolerance, freezing tolerance, and biomass yield under drought stress. In red clover two studies have identified quantitative trait loci (QTLs) for traits related to persistence in red clover. The latest research identified candidate genes for further analysis of the genetic basis of drought tolerance in red clover.

The impact of climate change on crops resistance is difficult to predict and is likely to be variable depending on the crop and environment. Genomics-assisted breeding is

considered to have the greatest potential for overcoming challenges and ensuring a sustainable increase of food production by adapting available crops to biotic and abiotic stresses and breeding novel crop cultivars.

Keywords: *forage crops, breeding, climate change, genomic selection*

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Agrometeorological forecast of soil temperatures

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Agrometeorological forecast in Croatia is promoted in different mass media – TV, radio and Internet. In addition to standard forecast, specific numerical products for agricultural needs are of great importance. Agrometeorological forecasts are made for the following week using numerical products nine days ahead. Elementary data offered by agrometeorological forecast are expected highest and lowest air temperature values, precipitation levels and mean daily soil temperature usually at depth of 10 cm. Additionally published are data on expected insolation, amount of evaporated water from the free soil surface, relative air moisture and temperature sums. Agrometeorological forecasting provides the most useful information for the mitigation and prevention of the damage that can be caused by unfavourable weather conditions. Prediction of the start of the vegetation is also part of the agrometeorological forecast because air temperature needs to be above some temperature threshold. However, the beginning of the growing season will be delayed if soil temperature is not high enough. For that reason, agrometeorologists analyse soil temperatures at different depths up to depth of 100 cm. Another forecasting tool is analysis of numerically forecasted soil temperatures. Numerical models are related to different uncertainties and limitations. Hence, the crucial part is comparison of measured data and numerically predicted data which is in the hands of agrometeorologists. To improve agrometeorological forecast of soil temperatures, verification of soil temperatures is necessary. The method of making and verification of soil temperatures will be presented on the conference.

Keywords: *agrometeorology, forecast, models, soil*

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Projections of temperature-based agroclimatic indices in southern Romania

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In this study future changes in five temperature-based agroclimatic indices in southern Romania were investigated. Agroclimatic indices have been calculated from daily maximum and minimum air temperature data for the historical (1981-2010) and future (2020-2100) climate. For the recent climate observed data from six weather station were used, while for the future climate, data extracted from three regional climate models outputs (ALADIN, REMO2009 and WRF331F) under RCP4.5 scenario were employed. Quantile-mapping method was employed for adjusting future modelled data. Agroclimatic indices consist in: the length of the growing season (GSL), three heat accumulation indices which predicts plant and animal development (GDD_5, GDD_{10}, GDD_{15}) based on a threshold of minimum 5°C, 10°C, and respectively 15 °C, and the annual number of frost days (FD). Results showed that GSL will extend in the future indicating an earlier start and a delayed end of the growing season, respectively. A longer GSL could shift the productive area to higher latitudes and altitudes and add more flexibility to some agricultural practices which could maximize yields. GDD indices will have higher values, while FD index will decrease in the future. This fact may be beneficial for crops. However, further studies should investigate in more depth frost by employing more frost-related indices such as occurrence of the first and last frost days to determine if frost period shortened as well or if free-frost period extended. Changes in temperature-based agroclimatic presented in this research are consistent with the results of other studies worldwide and showed enhanced condition for crops in the future. Nevertheless, since changes in other essential factors such as precipitation and evapotranspiration could have a negative impact on agricultural sector and crop yields, these should also be investigated in future studies.

Keywords: *climate change, temperature-based agroclimatic indices, regional climate models, southern Romania.*

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Product of NDMI, NDVI and LST to detect the impact of climate variability on agricultural land

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In terms of anthropogenic factors, over the last 30 years, in Southern Romania, there have been major changes in land use, some of them due to the geopolitic context, while some other have been associated to climate variability. Warm season in Southwestern Romanian Plain is experiencing changes in both climatic conditions and land use. The main purpose of this paper is to investigate the relationship between moisture cover, vegetation cover, and high LST in one of the driest region in Romania.

The climatic data used for this study covers a period of 55 years (1961–2015). Climatic variables analyzed to identifiy climate variability are monthly preciptiation amounts and mean monthly temperatures for two weather station. The satellite data has been acquired from U.S. Geological Survey (http//:glovis.usgs.gov). Two satellite scenes have been used to cover the entire territory. They were recorded by the Landsat missions 5, 7, and 8, and they can be identified as WRS 2-Path 184/Row 29 (44.6 N, 23.9 E) and WRS 2-Path 184/Row 30 (43.2 N, 23.4 E), respectively. The dataset covers a period of 30-yr period (1986-2015), especially recorded during the warm half of the year (April-September), and mainly overlaps the growing season for the great majority of cultivated and natural plants.

We processed the satellite data to get the NDMI (Normalized Difference Moisture Index) and NDVI product (Normalized Difference Vegetation Index). After getting the raster images, the reclassification process followed. Three classes have been established (hight, moderate and lack of moisture/vegetation). By intersection method first we got the share overlapping areas with humidity over each class determined of vegetation cover, and secondly the share overlapping areas with humidity over higher temperatures of equal than 30.0°C, 35.0°C, and 40.0°C respectively, derived from LST (Land Surface Temperature). Intersection of surfaces with lack of moisture, lack of vegetation, moderate vegetation and healthy vegetation and high LST (LST≥ 40.0°C), has the largest area affected in July 2007, covering 53 % or the total area considered. The situation in July 2007 seems to be the most dramatic one among all considered for this study.

Keywords: *NDMI, NDVI, LST, Romanian Plain, agricultural land.*

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Future projection of warm spells and cold spells in transition seasons in low-lands of Western Romania

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At present, research in climatology is mainly focusing on climate change and especially on global warming. Since climate change is already affecting large areas worldwide, it is important to study in details these changes at regional and local scale and to reduce its negative impact under different economic sector. Warm spells during the winter will trigger the crops to de-acclimate, and hence become more susceptible to winter injuries. Also, in spring season, plants will be more vulnerable to cold spells, when temperatures drop fast. The aim of this study is to analyse future changes in warm spells and cold spells characteristics in transition seasons (spring and winter) in Western Romania over the periods 2041-2070 and 2071-2100. In this study, four variables were calculated and then analysed for warm spells and cold spells resulting a set of eight indices: seasonal number of warm spell and cold spell events (WSN/CSN), the seasonal number of days participating in warm spells and cold spells (WSF/CSF), maximum length (WSD/CSD) and mean intensity (WSI/CSI) of warm and cold spells. As intensity threshold for warm spells the 90th percentile was employed, while for cold spells the 10th percentile was used. The percentile thresholds were calculated over the 1961-1990 baseline period. Modelled data for daily minimum and maximum temperature was extracted from EURO-CORDEX Project database. RCP4.5 scenarios of six regional climate models (ALADIN53, CCLM4-8-17, RACMO22E, RCA4, REMO2009, and WRF331F) were considered. Next we compared the average values of the historical period (1961-1990) with the 2041-2070 and 2071-2100 periods for RCP 4.5 scenario to obtain the future changes. The results of this study shows an increase in the number of warm spells events and duration for future sub-periods for both seasons (spring and autumn), while cold spells indicates a decreasing trend in the seasonal number of events and duration for future periods. In terms of intensity, warm spells will increase and cold spells will decrease. For all indices, the period 2071-2100 presents the highest changes under RCP4.5 scenarios analysed. The impacts of warm and cold spells on the onset of phenological seasons will differ strongly depending on species, phase, and timing.

Keywords: *climate change, warm spells, cold spells, regional climate models, Western Romania*

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Future changes in Consecutive Dry Days index in Central Romania

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The effects of drought play a large role in different social and economic fields, especially in agriculture, water resources and human health. The aim of this paper was to study the evolution of Consecutive Dry Days index (CDD), a precipitation-based drought agroclimatic index in Central Romania. CDD is explained as the longest dry spell or as the maximum number of consecutive dry days, when daily precipitation is lower then 1.0 mm. The importance of this precipitation-based index results from the fact that it can describe the climate of an area in terms of dryness or wetness. Depending on the season CDD occur and on its duration, the impact intensity translated in to damage to crops may vary. Also, it has a significant importance in irrigation planning and in other various decision making processes related to climate. Due to this fact, in addition to annual analysis, seasonal analysis of CDD was conducted. Briefly, the longer and more frequent CDD is, the proner to drought the area is.

In this paper, we investigated the changes produced both in present (1961-2015) and future (2020-2100) climate based on hystorical and projected daily precipitation dataset. For the hystorical period, climate observed data from seven weather stations was used, while for the future climate, data extracted from three regional climate models outputs (ALADIN, RCA4, and WRF331F) under RCP 4.5 and 8.5 scenarios were employed. In order to calculate CDD, ClimPACT2 software was used. The main finding of this paper is that changes in CDD showed an increase in both annual and seasonal duration of this precipitation-based drought agroclimatic index.

Keywords: *precipitation, CDD, projected data, Central Romania*

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The assessment of carbon footprint of major field crops in Vojvodina Province of Serbia

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Global warming resulting from increased GHG emission has been identifying as a one of the key environmental issue, therefore decupling the economic growth and emissions becomes important research task. Agriculture significantly contributes to the GHG emissions, and much attention is given to the adaptation of the management practice to alleviate climate change. The quantity of GHGs could be as expressed CO_2-equivalent, while carbon footprint (CF) stands for a certain amount of gaseous emissions that are relevant to climate change and associated with human activity or consumption activities. The aim of the study is to assess the CF in Vojvodina Province of Serbia from the winter wheat, maize, soybean and sunflower that covers >80 % of arable area. The data (crop yield, total area) were obtained from Statistical Office of the Republic of Serbia (2014-2016), within recommended management practices for each crop (crop operation, fertilizer and pesticide application) to calculate kg CO_2-eq ha^{-1} by using IPCC (2007) methodology. Significantly higher emission had maize 2292.8 kg CO_2-eq ha^{-1} while lowest was found in soybean 1085.5 kg CO_2-eq ha^{-1}. It appears that N fertilization largely contribute to the area-related emission. CF was highest in sunflower 0.42 kg CO_2-eq kg^{-1} $grain^{-1}$ and lowest in maize 0.29 kg CO_2-eq kg^{-1} $grain^{-1}$. Maize cropping is associated with > 50% of area-related emission due to higher growing area. Soil organic carbon preservation, judicious fertilizer application, crop residues management and erosion could help in prevention of agricultural activities to global warming. Obtained result could help in estimation of warming potential of farming operation and input as a criteria for development of different strategies and policy that would develop climate smart agriculture.

Keywords: carbon footprint, field crops, global warming, crop management

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Current arable farming systems in the Czech Republic – agronomic measures adapting to soil protection and climate change

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In the Czech conditions according to the database of Research Institute for Soil and Water Conservation, individual types of degradation differ with the area, the most notable being water erosion which threatens more than 50% of agricultural areas. This is followed by wind erosion (11%), extreme soils – clay soils (4.5%), and soils affected by dryness (1.5%). Agriculture belongs to strategic branches of national economy of the Czech Republic as summarized by its production and off-production functions. Agricultural land resources occupy 54% of the country's acreage. Production potential of the Czech agriculture represents the area of 4.25 mil. ha of farm land with more than 70 % of its plough-up. The level of arable land is higher compared to EU states with similar soil-climatic conditions. Approximately 50 % of farm land is located in less favoured areas (LFA) because of lower soil quality and adverse climatic conditions. After "Velvet Revolution" in 1989, in the Czech Republic, there was a period of agriculture transformation, when state farms and cooperatives were privatised. Since entry into the EU and during gradual integration of the Czech Republic to common market and implementation of the Common Agricultural Policy, deepening of structural disequilibrium has occurred. Changes in crop structure, i.e. total decrease of animal husbandry, especially of pigs, decrease of acreage of crops which are too demanding on quality labour including management and marketing (fruits and vegetables), and also acreage of forage crops (clovers and alfalfa) on arable land with significant positive impacts on the environment. These structural changes cause at the same time the decrease of total agricultural production. Although the current regulatory measures (cross-compliance) and stimulation agro-environmental measures within the rural area development strive for better relationships between agriculture and the environment, further soil quality degradation, water regime deterioration and biodiversity loss continuously occur. Soil quality and water regime are predominantly affected by inappropriate large-area utilization of farm land together with reduction or even giving-up of animal husbandry accompanied with shortage of organic fertilizers. Reduction of desirable diversity of soil use e.g. by growing forage crops is also one of the courses. Maize (*Zea mays* L.*)* is a crop which has an important place in a structure of crops grown in the Czech Republic. In recent years became silage maize the main source of biomass used in biogas stations. Inappropriate use of predominantly rented farmland contributes to the increase of internal and external negative impacts of climate change on soil quality, water regime and risk to conduct a business in agriculture under more and more frequent periods of drought and floods. Climate

change causes the transformation of some regions into new ones, often with adverse climatic conditions (e.g. constant increase of temperature and water shortage in the South Moravian region) together with higher importance of agriculture in less favoured areas (LFA). Soil tillage in a sustainable land management harmonises the soil protection with demands of the crop to be grown on the given land and aims soil conservation, without increasing the production risks even in the long term. Results to date from the field trials and experience from agricultural practice demonstrate the favourable influence of conservation tillage technologies on soil quality parameters and economy of crop production. For optimization of suitable soil tillage systems, appropriate post-harvest residues management could be improved. Role of inter-crops, especially in poor crop rotations is coming more important. The effect of inter-crops on the reduction of erosion risk depends on the crop stand establishment, height of plants, leaf area index (LAI) and duration of soil coverage. The highest values of coverage were found for variants with white mustard, phacelia and crambe, the lowest for buckwheat and common millet in field experiment in south Moravian region. However, the results were strongly influenced by the year. Minimum or strip-tillage systems are usually used form maize stand establishment. Comparable or higher maize production was found out in narrow spacing and this approach is efficient reduced water erosion in combination with conservation tillage system. For future, harmonization of conservation tillage systems with integrated pest management practices would be the main task for environmentally friendly crop production.

Keywords: agronomic measures, soil erosion, soil tillage, inter-crops

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The effect of water deficit on yield and yield component variation in winter wheat

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The study was focused on the effect of drought stress on yield and yield components of wheat. Soil water deficit is known to be one of the major factors limiting the productivity of cereals. Water deficit can affect plant growth and development in all stages, in early stages the rate of tiller appearance, leaf appearance and leaf area is reduced, later on the length of stems is reduced together with the number of grains per ear, and stress after anthesis shorten the duration of grain filling, thus reduces a grain size. The compensatory effects between yield components are much stronger under stress conditions than under favourable conditions.

The response of selected cultivars of winter wheat to water deficit was studied at the Field Research Station of the Mendel University, Brno, Czech Republic, in 2012/13, 2013/14, 2014/15 and 2015/16 growing season. A set of 26 cultivars was grown in two independent small plot experiments using three or four randomised replications. The experiments were performed at two sites with different soil conditions, first site was characterised by loamy soil with good water retention and high yield potential, the second site was situated on drought prone sandy soil. The yield on sandy site was strongly dependant on precipitation rates during vegetation period. Two from four experimental years were classified as very dry (2014 and 2015), one as wet (2013) and one as normal (2016) according to the comparison of the sum of precipitation in particular period with the long-term mean value valid for the Field Research Station (1961-1990). Due to uneven distribution of rainfall even in the "normal" year the plants were affected by periods of limited water availability. Yield components of wheat that are relevant for the assessment of stress reaction were measured: grain yield, canopy density as the number of ears per area, and thousand grain weight as a parameter characterising grain size. The number of grains per ear was calculated using the grain yield and the number of ears per area. Stress tolerance index (STI) was determined to detect cultivars with relatively high yields under both stressed and optimum conditions. Correlation analyses and principle component analyses were performed both for stressed and optimum conditions to show the relationships among traits and to identify superior cultivars.

The average grain yield per plot was reduced by 33-58% under stress as compared to the optimum conditions. A reduction in average tiller numbers was observed from 3 to 35%, and the number of grains per ear was reduced by 3-33%. A decrease of average thousand grain weight under stress was also observed, particularly in 2015 and 2016 year. Grain size is the last yield component to develop, therefore the potential for bigger kernels is considered as significant under stress conditions.

Although the effect of water deficit in different stages of plant development on final yield is difficult to analyse due to yield component compensation, it is possible to identify cultivars with higher mean grain yields.

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Keywords: *winter wheat, cultivars, drought stress, yield components.*

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Conservation soil tillage effectiveness in severe weather conditions

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Conservation soil tillage is known as one of the most adaptive techniques which arise as more effective way to combat primarily negative influence of climatic changes especially in last two decades. Heterogeneous agroecological conditions and unsuitable soil tillage techniques on wide scale influence yield levels from year-to-year. Yields variation primarily depends on climate aberrations but also on variation of extreme meteorological conditions. Most common, and at the same time most dangerous weather conditions are represented with severe water and temperature regime. Both, water and temperature regime, have influence not only on yields but on other aspects which are in physical, chemical and biological domain.
Since agriculture is faced with changing climatic conditions and with consequences which already arise, soil tillage plays a major role in soil vulnerability to climatic change and affects many soil quality aspects. According to 15 years of experimental results it can be concluded that conservation soil tillage, as a component of conservation agriculture, represents one of the main technology operations in crop production whose proper application could significantly improve yields. Main studied crops (Maize, Wheat and Soybean), depending on the soil tillage system, has shown different levels of reaction to extreme or severe weather conditions. Besides higher yields, arising side effects are mainly positive (reduction of soil erosion, increase biogenity and quality of soil, less traffic and soil compaction alleviation, nutritional status and quality traits of crops, weed infestation etc.), but are still in the background of wide rang conservation soil tillage adoption.
Experiments with main goal of choosing the “best cropping system” or “best solutions” are a process which needs to be elaborated according to site-specific methods and crop-specific responses to mitigate climate threats. In this process, application of conservation soil tillage principles has a unique and specific role which can make a difference from successful and sustainable crop production compared to traditional principles. Since climatic changes do not follow national borders and since agriculture is extremely vulnerable to them, a common action to find adequate and effective measures to face climatic changes is an imperative. Conservation soil tillage is one of the best possible ways to combat primarily negative influence of climatic changes and consequently severe weather conditions.

Keywords: *Conservation soil tillage, climate change, severe weather conditions.*

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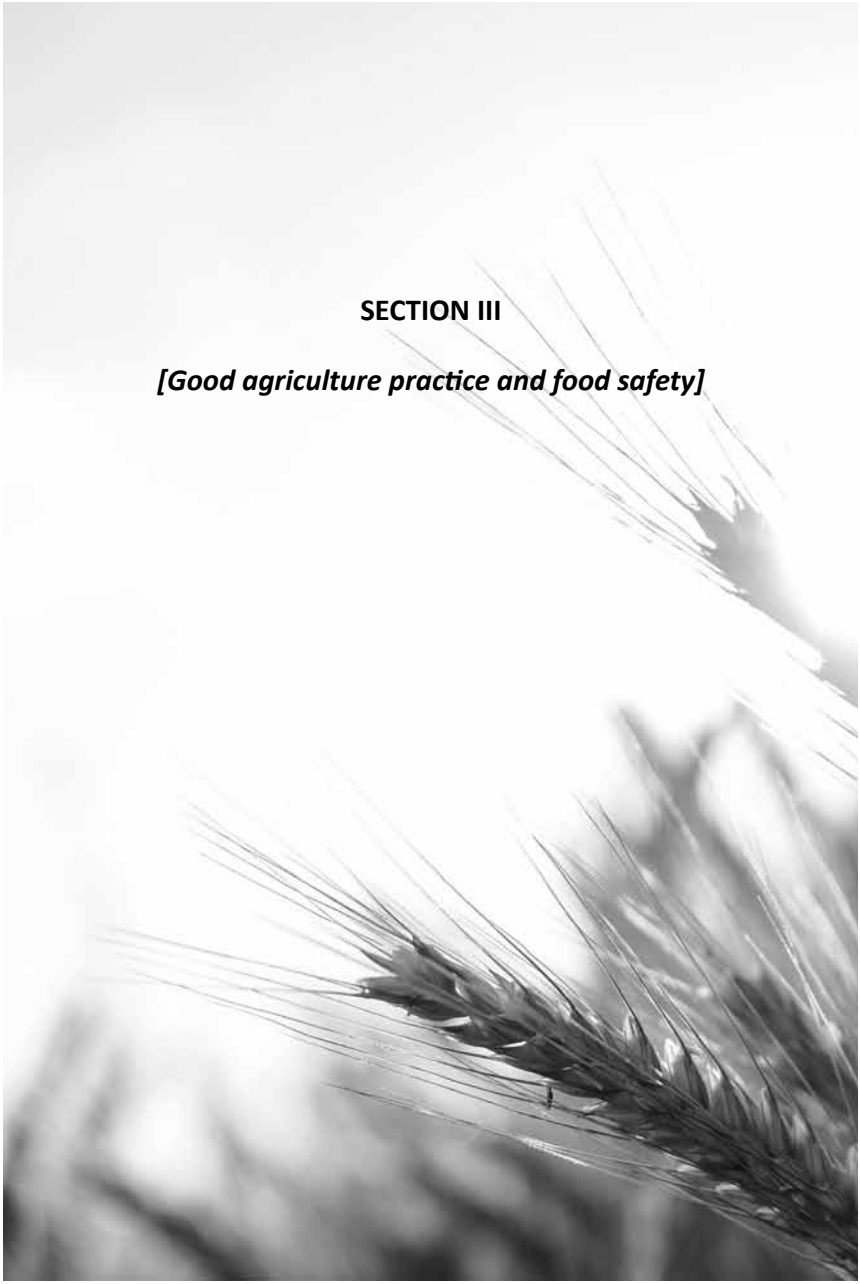

SECTION III

[Good agriculture practice and food safety]

Impact of soil tillage and fertilization on soil properties

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Nowadays, when it comes to intensifying agricultural production, it is very important to bear in mind the costs of production and, in particular, the conservation of land as a non-renewable resource on which production takes place. For the cultivation of field crops, in the region of Vojvodina is mainly applied conventional tillage, which means plowing and a number of other operations to land led to a state suitable for planting and prepare rhizosphere for optimal development of cultivated plants. This kind of tillage has its advantages and disadvantages. When it comes to deficiencies, it is primarily thought of economic and ecological. The profitability of agricultural production imposes the need for new land-based technology, where the emphasis is on saving energy, saving human labor, saving machine labor and at the same time ensuring the permanent preservation of land characteristics. New technologies bring along a series of uncertainties that can only be solved by direct application in practice, or by applying on site in specific location conditions dictated by microclimate and soil properties.
The results obtained should provide answers to the doubts that bring with them new soil tillage concept, and which tillage system is suitable for a particular site, and which is not. It is very often the case that farmers, in their desire to reduce the costs of their production, choose technology that has not been tested for the climatic conditions and the type of land, which is poorly reflected in yield. This is why they are usually returned to conventional tillage concept. In addition, the burden of tradition is another reason why new soil tillage concept are not introduced or sporadically applied.

Key words: tillage, conditions, soil, preservation, labor, conservation.

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The Presence of Cadmium in Cattle Meat and Offal on the Area of Central Bosnia Canton with the Risk Assessment on Human Health

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The aim of this study was to determine the levels of cadmium in cattle meat and offal on the area of Central Bosnia Canton and to estimate the level of population exposure to cadmium through consumption of cattle meat and offal. Fifty samples of cattle meat were analysed using inductively coupled plasma mass spectrometry (ICP-MS), out of which twenty samples of kidney tissue, twenty samples of liver tissue and ten samples of muscle tissue. Determined cadmium levels in cattle kidney varied between 0.176 and 4.493 mg/kg, while the cadmium levels in liver were determined in the range from 0.016 to 0.206 mg/kg. The mean value of cadmium in kidney was 0.750 mg/kg, while the mean value of cadmium in liver was 0.076 mg/kg. Cadmium levels in muscle tissue were less than 0.008 mg/kg in all analysed samples. In three samples of kidney (15% of the analysed) cadmium levels exceeded maximum permitted level, while no such case was found for liver and muscle tissue. A semiquantitative questionnaire consisted of questions about the frequency (daily, weekly, monthly, yearly) and the amount of consumption of certain types of cattle meat and offal was conducted on a random sample of 150 respondents. Estimated weekly intake of cadmium due to the consumption of cattle meat is 1.74×10^{-3} μg/kg body weight. Weekly intake of cadmium by consuming cattle kidney is 9.08×10^{-3} μg/kg body weight, whereas weekly intake of cadmium via cattle liver is 1.23×10^{-3} μg/kg body weight. The intake of cadmium due to the consumption of cattle meat and offal in the examined population is within the tolerable weekly intake. Exposure to cadmium from cattle meat in the examined population does not pose a risk for health.

Keywords: cadmium, cattle meat, kidney, liver, risk assessment.

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Human health risk assessment of heavy metals from the agricultural soil in South Herzegovina

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Contamination of agricultural soils can present a significant risk to human health through oral ingestion, particle inhalation, and dermal contact. The aims of this research were to determinate the concentrations, distribution and human health risk of various heavy metals in soil samples from three agricultural areas of South Herzegovina. A total number of 32 soil samples were collected and analyzed for Lead (Pb), Cadmium (Cd), Cobalt (Co), Copper (Cu), Nickel (Ni), and Zinc (Zn). The Hazard Index (HI) was used to assess the human health risk of the study area. For the adult and children population, the HI value for dermal exposure to Cobalt (Co) was greater than one (HI>1), and non-cancerogenic effects are therefore considered as significant for human health. Our findings impose consideration of taking risk management measures in order to reduce risk for human health from Cobalt (Co).

Keywords: heavy metals, soil, risk assessment

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Strategies of growing several sorghum cultivars as a post-harvest crop in North-Eastern Croatia condition

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Recent climate changes lead toward possibility of using longer period of warmer temperatures after winter crops harvest (such as wheat, barley, oilseed rape, etc.) for establishing post-harvest crop, such is sorghum, which can produce significant biomass, useful both for feed and bioenergy, even in drier summers, with reduced soil tillage preparation. The trial was set up in Poljanci, Croatia, in years 2015 and 2016 as a split-plot design with foliar fertilizers and sorghum cultivars treatments, established by diskharrowing soil after winter wheat harvest in mid-July, and picked before autumn frosts at the end of November. Foliar fertilizers treatments were C) Control (no fertilization), B) Biological (Condi agro) and M) Mineral (EcoTop Folimax) foliar fertilizers. Cultivars used in trial were KSH3723, KSH3724, Lemnos, Leonie, Merlin, Sammos, Santos, Sole, Tarzan and Zerberus. Foliar fertilizer treatments B and M showed trend of higher dried biomass yield 7 and 11% in comparison with C, respectively. Trend was higher at fresh biomass yield, where B and M scored 12 and 22% higher than C, respectively. The highest fresh biomass yield was recorded for Leonie (32933 kg ha^{-1}), followed by Lemnos (27467 kg ha^{-1}) and KSH3724 (26600 kg ha^{-1}), whereas the lowest yield was recorded for Zerberus (19600 kg ha^{-1}).

Keywords: *sorghum, post-harvest crop, foliar fertilizers*

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Grain yield of spring barley grown in long-term stationary experiment

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This contribution is focused on the assessment of long-term effect of different methods of soil tillage on grain yields of spring barley (*Hordeum vulgare* L.) growing in monoculture and in Norfolk crop rotation. Long-term experiment is conducted in maize-growing region on heavy gleic fluvisol from the year 1969 in Zabcice (experimental fields of university). Experimental factors are: two variants of soil tillage (conventional tillage to 0.22 m and shallow tillage to 0.12-0.15m) and three variants of nitrogen doses (30, 60 and 90 kg N ha^{-1}) for both crop rotation and more, three variants of straw management (straw removed, incorporated into soil and burned) for spring barley under monoculture. The grain yields were evaluated for the period 1975-2016. Grain yields results of spring barley carried out under monoculture showed statistically significantly higher grain yields with conventional tillage to 0.22 m, straw burned and with the highest nitrogen dose, compared with other treatments. Grain yields results of spring barley carried out in Norfolk crop rotation are with the similar tendency for experimental factor of nitrogen fertilization but with different tendency for soil tillage effect (results were depended on weather impact during the year). In general, the long-term field experiments are very important source of information, especially nowadays in agricultural systems on arable land without animal husbandry. Questions linked with straw management are essential for crop stand establishment, soil microbial activity and development of some fungi pathogens.

Keywords: *Long-term field stationary experiment; spring barley (Hordeum vulgare* L.*); grain yield; soil tillage; nitrogen fertilization; straw management.*

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Maize response to conservation tillage and nitrogen management

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Tillage system and fertilizer-N management are needed to improve sustainable maize production. The aim of the study was to investigate the impact of conservation tillage and nitrogen rates at various growth stages on maize production. Experiments were conducted at two locations: Čačinci (GPS: Long. 17.86336 E; Lat. 45.61316 N) and near Magadenovci (GPS: Long. 18.70648 E; Lat. 45.55555 N) on hydromorphic soil types during 2012/2013. The field experiments included three nitrogen fertilizer levels (N1 level was 30% lower compared to fertilizer recommendation, N2 level was equal to fertilizer recommendation and N3 level of fertilization was 30% higher compared to fertilization recommendation) on four different soil tillage treatments (SS- subsoiling, DH- chiselling, NT- direct seeding and CT-conventional tillage).
According to the data, the level of nitrogen fertilizer, soil tillage system and specific locations had significant impact on corn stalk weight, weight of cob, grain weight per cob, biological and agricultural yield. All parameters had higher values on Magadenovac location. Thousand grain weight was under significant influence of tillage systems and fertilization treatments. No significant differences in thousand grain weight were found between CT (324 g), SS (305 g) and DH (307 g), while NT produced significantly smaller weight (276 g) according to other tillage treatments. The nitrogen fertilizer level according to the recommendation (N2) recorded the highest thousand grain weight (313 g), corn stalk weight (344 g), weight of cob (362 g), grain weight per cob (185 g), biological and agricultural yield (46 and 12 t per hectare). The stalk weight, weight of cob, grain weight per cob, biological and agricultural yield were highest on CT, SS and DH treatments without significant differences between them. The lowest value was detected on NT treatments for all parameters.
This research has proven that using conservation tillage and fertilization according to recommendation can achieve equally high yields and yield components as conventional soil tillage.

Keywords: *maize, yield component, nitrogen fertilization, conservation soil tillage.*

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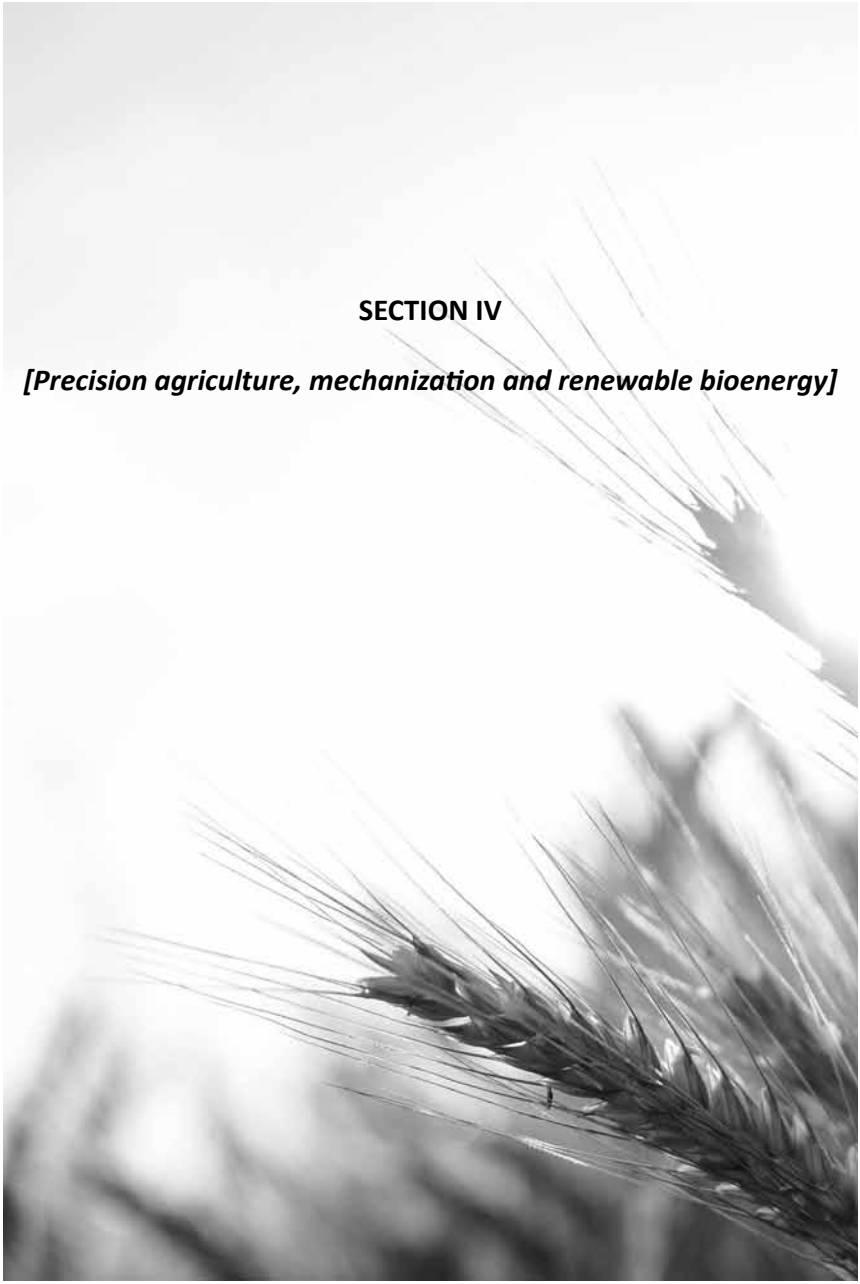

SECTION IV

[Precision agriculture, mechanization and renewable bioenergy]

Role of post-harvest residue treatment on the spring crops productivity in haplic chernozems

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The investigation was carried out at Dobrudzha Agricultural Institute during 2014-2016. The effect of the traditional soil tillage systems and sowing machines and of the type of the previous crop post-harvest residue treatment (wheat) on the yields from sprig crops (beans, maize, sunflower) was investigated in six-field crop rotation. The wheat post-harvest residues (PHR) were utilized in three different ways (removed from the field; chopped and subsequently incorporated into the soil, and burned).
The productivity of the spring crops in the crop rotation was significantly affected by the meteorological conditions during the investigated period and by the ways of utilizing the plant residues from the previous crop. The complex action of the main meteorological elements (rainfalls and temperature) was determining for the productivity of bean (cultivar Eliksir) and maize (hybrid KWS Kladus). Under the conditions of the experiment, these crops reached maximum productivity in 2014. The mean yields were 2550 kg/ha from bean, and 9417 kg/ha from maize. The Express-resistant sunflower hybrid (Pioneer P64LE25) demonstrated high productivity in all three years of the investigation (over 3000 kg/ha), with a maximum in 2016 - 3517 kg/ha.
The removal of the post harvest residues from the field decreased the productivity of bean and maize in comparison to their plowing or burning. The burning of the post harvest residues from the previous crop had negative effect on the productivity of sunflower in all three years of the investigation. In 2016, the greatest differentiation of yield was observed depending on the way of post harvest residue utilization. Among the three spring crops, the positive effect of the plowing of the plant residues was most expressed in sunflower. The interaction between the meteorological factor and the way of post harvest residue utilization was decisive for its productivity. The strength of this interaction amounted to 75.47%. The productivity of bean and maize depended mainly on the meteorological conditions of the year. The strength of their interaction was 62.11% and 87.27%, respectively. The independent effect of the ways of post harvest residue utilization was significantly lower on the productivity of the crops in the crop rotation. In bean, the strength of its effect was 18.92%, in sunflower - 13.01%, and in maize - 0.25%. Averaged for the investigated period, the ways of post harvest residue utilization did not significantly influence the productivity of maize.

Keywords: ways of utilization of post harvest residue, spring crops, yields, grain physical propertie

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Effect of the main soil tillage types on the agronomic response of wheat in the region of south Dobrudzha

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Wheat yield (*Triticum aestivum* L. – cv. Enola) obtained under different main soil tillage systems in 4-field crop rotation (bean-wheat-sunflower-grain maize), is strongly influenced by the regional soil (Haplic Chernozems) and the climatic conditions. This study was carried out at the trial field of Dobrudzha Agricultural Institute-General Toshevo from 2014 to 2016. The influence of seven main soil tillage systems (MSTS) on the yield and the physical properties of wheat grain was investigated. Four of these MSTS were applied independently and annually in crop rotation: 1. CP - conventional plowing (24-26 cm); 2. D – disking (10-12 cm) 3. C – cutting; 4. NT - nil tillage (direct sowing). The other three MSTS systems included: 5. Plowing (for spring crops) – Direct sowing (of wheat); 6. Cutting (for spring crops) - Disking (for wheat) and 7. Plowing (for spring crops) - Disking (for wheat). The mineral fertilization in the crop rotation was as follows: Bean – $N_{60}P_{60}K_{60}$; Wheat – $N_{120}P_{120}K_{60}$; Sunflower - $N_{60}P_{120}K_{120}$ and Maize – $N_{120}P_{60}K_{60}$.The objectives were: (i) to investigate the seasonal variability in wheat yield as influenced by the tillage systems; (ii) to investigate the variability in the physical properties of wheat grain and (iii) to evaluate the correlations between the grain yield and the physical properties of wheat grain. A significant differentiation in the productivity of wheat was found depending on the tested MSTS systems. Lowest mean yields were obtained at the annual use of systems 3 and 4 - 4541 kg/ha. Among the annually applied systems, constant disking was the most favorable for expression of the crop's production potential. The mean addition to yield according to constant plowing in the crop rotation was 4541 kg/ha. The systems involving annual alternation of tillage types with and without turning of the plow layer exceeded with 232.0 kg/ha (4.77%) the same systems, which were applied independently. The alternation of plowing for root crops with direct sowing of wheat was most efficient from an agronomic point of view. In comparison to annual plowing, the increase of productivity was with 280.5 kg/ha (5.62%). The values of the physical properties of grain were also highly differentiated according to MSTS. The constant application of disking in the crop rotation contributed to the production of grain with the best physical indices – absolute weight 43.15 g and test weight 76.86 kg. The use of the systems Cutting – Cutting and Direct sowing – Direct sowing had negative effect on both the yield and the physical properties of gain. Averaged for the period, the correlation between the grain yield and the physical indices of grain was high and positive. The mean value of the correlation coefficient between the yield and the test weight (0.930^{**}) was higher than the correlation coefficient of the yield with 1000 kernel weight (0.780^{**}). The correlation between the absolute and the test weight of grain was very high in

all three years of the investigation.

Key words: main tillage of soil, wheat, yield, physical properties of grain

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Low grain yield of soybean and its temporal variability are improved by deep ripping tillage

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Driven by increasing grain prices, the area occupied by grain crops in the South American Pampas has presented a substantial growth since 2002. This large increase in cropped area was achieved by shifting the production systems from crop-pasture rotations to continuous annual cropping under no-till systems (CCNT) (Wingeyer et al., 2015). Soil compaction is a yield-limiting factor. Increased soil compaction has been proposed as one of the causes of decreased yield quantified after several years of CCNT. Spatial variability in soil properties and topographical land features, on a field scale, results in spatial and temporal variability of crops yield (Kravchenko y Bullock, 2000). Nevertheless, field production is managed as if it was a homogeneous unit. Different soil compaction levels can be characterized through penetration resistance. An alternative to improve compaction problems is deep ripping, which could make the new production system feasible. Our hypotheses were: (i) spatial variability and temporal variability of soybean grain yield (YSV and YTV respectively) are defined by soil physical and chemical properties; (ii) it is possible to delimit homogeneous yield zones from YSV and YTV; (iii) soil compaction is a limiting factor that explains both, YSV and YTV; (iv) this yield limiting factor could be achieved by using deep ripping. The objectives of this study were to: (i) quantify spatial and temporal variability in soybean yield; (ii) identify zones with high yield and low temporal variability; (iii) quantify crop response to deep ripping within each of the zones identified. The study was carried out after 15 years of CCNT under on-farm conditions. Two treatments were applied in two consecutive years (2014 and 2015): deep ripping and no tillage, in plots of 20 by 300 m. In each plot a grid for sampling consisting of 14 points was taken as reference for each measurement. The measures taken were: penetration resistance, apparent electrical conductivity, concentration of P and K in plant at R1 growing stage. Yield data were recorded by using combine, fitted with a grain yield monitor system and GPS. Crop sequence was Soybean - winter fallow - Soybean. Following the methodology proposed by Blackmore (2003), homogeneous yield zones within year were identified for control treatments and a temporary stability index of yield was determined considering yield variation between years. Spatial trend and temporal stability were brought together and five different zones were identified: high yield stable (HYS), low yield stable (LYS), high yield intermediate stability (HYI), low yield intermediate stability (LYI), and an unstable yield zone (UY). Crop and soil response to deep ripping was studied using Analyses of Variance.

Table 1: Effect of deep ripping on soybean yield (Y), soil penetration resistance (PR), and plant nutrition (foliar N and K concentration) under high yield_stable (HYS), low yield_ stable (LYS), high yield_intermediate stability (HYI), and low yield intermediate stability (LYI), and unstable yield (UY) zones. Response (Δ) was estimated as difference between treatments, deep ripping minus no tillage.

Zone	ΔY (Mg ha^{-1})	ΔPR (HPa)	ΔN (%)	ΔK (mg kg^{-1})
HYS	0,13	-289,61	0,13	0,07
LYS	**0,45**	-195,8	-0,04	**0,22**
HYI	0,16	**-426,69**	0,18	0,12
LYI	0,14	-232,66	0,16	0,01
UY	0,33	-248,5	0,1	0,06

Bold type indicates significant response at p≤0.05. N: nitrogen, K: potassium in plant at R1 growing stage

Response to deep ripping occurred in LYS zone only. This effect could not be explained due to a change in soil penetration resistance. Only K content in the plant was increased (p≤0.05), suggesting that the effect of deep ripping resulted from improving the absorption capacity of this nutrient.

Keywords: soybean, spatial variability, deep ripping

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Adapting the spraying machinery to increase the environmental safety in PPP applications in traditional and intensive olive orchards

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The new perspectives in pesticide applications in Europe run against the traditional practices in which a low efficiency in the product use led to important environmental problems. The traditional and intensive olive orchards present in the Southern Europe, and particularly in Spain, make difficult to reach high efficiency degrees as a result of the irregular geometry in the canopy shapes and the wide tree and row spacing. Nevertheless, treatments are carried out with conventional airblast sprayers, well adapted to hedgerow orchards but not to isolated, big-sized trees. Therefore, an adaptation of the spraying machinery to the canopy shape is mandatory to make further improvements in the application efficiency and, therefore, to ensure the environmental, personal and food safety. The Mecaolivar project aimed to develop pre-commercial airblast sprayer prototypes that improve the efficiency of the commercial airblast sprayer in traditional and intensive olive orchards.
Three prototypes were developed and tested against a conventional airblast sprayer in real field conditions in commercial farms with traditional and intensive cultivation systems. In order to test their application quality, the spray deposit and coverage was assessed by using a spray tracer and artificial collectors made up of filter paper and water sensitive paper. Three trees per system were selected and monitored by dividing the tree crown in sixteen sampling zones. The same trees were sprayed from both sides with all the equipment, replacing the collectors between each two subsequent applications.
Results showed that the developed sprayers can improve the spray quality of the conventional airblast sprayer in both cultivation systems. Spray deposits collected when using the prototypes showed to be nearly 200% those achieved with the commercial equipment in traditional trees. In the case of the intensive trees, these were 220% in the best sprayer. Spray coverage was improved in the same way. These results are very important, as they remark the importance of the spraying equipment in the final result of the treatments, even when the operating parameters were not optimized for the prototypes as they were for the commercial sprayer. This is, therefore, a forward step for improving the quality of the treatments in olive orchards.

Keywords: *airblast sprayer, olive, machinery design, adaptation to canopy, sensors.*

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Produced levels mechanic vibration in operator cabin of agricultural tractor by various agrotechnical surfaces

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Agricultural tractors have wide use on road and also off road, which is at exploitation and moving on the agrotehnical surfaces. Beside speed and uneven surface on which they are moving, very important factor that have an effect on exposure of operator by the high level of vibration that effect on whole body are the oldness of the technical system. Vibration generally present oscillatory moving of the body, and in the addiction of the trajectory form of moving body there are linear and angular oscillations. Human body perceives and absorbs vibration of 1 to 1000 Hz, and speed of vibration is distance which vibrated body passed in the unit of time and it is expressed in ms^{-1}. Acceleration of vibration is change of speed of vibration in the unit of time, and it is ms^{-2}. Purpose of the research is determination vibrations that have an effect on the operators whole body in relation to working hours of technical system in years 2015 and 2016, in accordance with prescribed standards HRN ISO 2631-1 and HRN ISO 2631-4. Measurement has been made 2015 and 2016 with tractor LANDINI POWERFARM 100 on access roads and production areas of Agricultural and Veterinary High School in Osijek. Vibrations that have an effect on whole body of operator were measured by device MMF VM30 with associated sensor. Results of research are pointing on increase level vibrations that have an effect on operators whole body on every measuring surfaces (asphalt, grass and macadam) with increasing working hours of tractor. Even though these research confirmed that on different agrotechnical surfaces the intensity of vibration is increasing in year 2016 in relation with previous one, the same will not be harmful on the health of the operator because they are not excessing the vibration limit that have an effect on whole body on the operator of 1.15 ms^{-2} by the European directive requires 2002/44/EC.

Keywords: *agrotechnical surfaces, agricultural tractor, human whole body, human vibrations*

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Distribution of manure and slurry - case study

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This research was performed in order to determine the effect of tractor tanks and manure spreader in distribution of slurry and manure. The study was conducted in 6 measurements for each port using measuring methods. In the research was used 2 aggregates. The first observed unit A is composed of the tractor "IMT 558" and tank for manure "Eisele" volume of 5.000 l, and the second unit B is composed of the tractor "IMT 558" and the manure spreader. Tested aggregates were working on the surface size of 800 m^2. In research was followed indicators of effective work time, total realized performance and efficiency rate. The results showed the distribution of the slurry had efficiency of 0.31 with a working capacity of 4.7 ha per shift, while the manure spreader had efficiency of 0.11 with working capacity of 14.88 ha per shift. At the end of the study it can be concluded that unit B has a better performance in opposition to aggregate A. In order to better examine the performance it is necessary to do more research.

Keywords: manure, slurry, performance, measuring methods

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Soil processing technology and nozzles type as factor of pesticide residues in the soil

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Pesticides, alongside the benefits, carry with them some unwanted consequences. When considering the harmful effects, the most important place occupies the danger of environmental pollution. It is very often the case that soil treatment with pesticides is carried out uncontrollably, ie inadequate treatment standards are applied, use of pesticide application equipment that do not meet the environmental norms of use and technical correctness are used. The consequence of this is excessive pollution of land and environment. In order to investigate the adverse impacts of pesticides on soil and the content of pesticide residues in the soil itself, during the duration of the study pesticide treatment was performed with three different types of nozzles. Each of the six plots on which have been implemented different soil treatment technologies is divided into three equal parts. On each trial plot, three different nozzles were used, giving a different droplet range, with the treatment rate being the same for each nozzle. The influence of various nozzles, ie different droplets of pesticide residues in the soil, was determined.
The pesticides applied are biodegradable, have a short break time and are not detected in the soil. The use of various nozzles in the treatment of pesticide crops has no effect on the residues of pesticides in the soil.

Key words: pesticides, residues, processing, nozzles, spraying norm.

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Foliar fertilizers deposition quality with different nozzle types in wheat

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Foliar fertilization is an important tool for the sustainable and productive management of crops, and is of significant commercial importance worldwide. The practice of foliar fertilization has the advantages of low cost and a quick plant response, and it is particularly important when soil problems occur and root growth is inadequate. Research efforts were applied to try and characterize the chemical and physical nature of the plant foliar cuticle, the cellular physiology and structure of plant leaves as well as focusing first on physically penetration of liquid fertilizers in plant then on potential mechanisms of penetration in plant.

The rationale for the use of foliar fertilizers may appear when soil conditions limit availability of soil applied nutrients or in conditions when high loss rates of soil applied nutrients may occur or when the stage of plant growth, the internal plant demand and the environmental conditions interact to limit delivery of nutrients to critical plant organs. In each of these conditions, the decision to apply foliar fertilizers is determined by the magnitude of the financial risk associated with the failure to correct a deficiency of a nutrient and the perceived likelihood of the efficacy of the foliar fertilization. Current understanding of the factors that influence the ultimate efficacy of foliar nutrient applications is, however, incomplete. One of the factors which influence on the performance of foliar nutrient is pesticide application equipment. Nozzles may have impact on foliar fertilizer efficacy in the same way affect on systemic pesticide efficacy.

It were used five different nozzles for foliar fertilization with three different norms. Different types of nozzles have to affect on deposition quality of foliar fertilizers and should lead to more efficient adsorption by plants. The main purpose of nozzles is to make droplets with different diameters which penetrate to every leaf of wheat and make better coverage even in windy conditions.

Air injector nozzles are most used nozzles in windy conditions but less efficacy may occur due to coarse droplets. Even more, lowest pressure less then 3 bar is not good for air injector nozzles because droplets are extreamly coarse.

Furthermore, wheat canopy, leaf directions and leaf area in early stages of growth are challange of farmers and researchers to make beter coverage and appropriate droplets for better uptake. In this way, pressure for air injector nozzles should be more then 4 bar for better deposition and coverage. Great impact on better

deposition in dense crop have nozzles with two flat fans. Deposition reach more then 70% of foliar fertilizer on wheat leaves.

Key words: foliar fertilizers, nozzles, droplets, efficacy, wheat.

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Estimation of soil properties on the base of multispectral remote sensing data and derived indexes

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Accurate knowledge of soil properties is an important aspect in the implementation of site specific farming (precision agriculture). The aim of this paper is to evaluate the use of multispectral remote sensing data to assess the spatial variability of main agrochemical soil properties.
For this study was used a scene taken by Sentinel 2 on 27. March 2016 depicting the area of Rostěnice, LC. farm enterprise (Coordinates 49.238N, 16.965E) in the South Moravian region of the Czech Republic. This date was supposed because greatest incidence of bare soil (spring jobs, seeding). The scene contained multispectral data with 13 bands in visible, infrared, shortwave infrared part of the spectrum with spatial resolution in the range of 10-60 meters. Data were obtained from ESA SciHub in L1C level and corrected on the band atmospherically corrected reflectance in to level L2A.
For the determination of soil properties, soil samples were taken from depth 0-30 cm and analyzed by Mehlich III methodology. The content of accessible nutrients Phosphorus, Potassium, Magnesium and Calcium have been determined together with exchangeable soil reaction (pH) and soil texture. Sampling was performed in 2014 on selected fields at the density of 1 sample per three hectares. A total count of 2,136 samples were taken.
Data were analyzed on the level of whole sampled territory and also on the level of individual fields. In the analysis of soil samples was detected within the monitored area middle positive correlation (r = 0.4 - 0.5) between soil texture and soil color index (CI) ,which was developed to differentiate soils in the field and is calculated from red and green band. In whole area was found a mean negative correlation between CI of soil and Ca (r = -0.61), then between CI and pH (r = -0.51). At the level of the plot was found a strong positive correlation (from 0.7 to 0.9) SWIR band (B11 and B12) and Calcium. In rare cases showed a strong positive correlation (0.91 – 0.93) values of Potassium and Phosphorus with those bands SWIR.
The observed level of correlation found in the data of remote sensing is not able to fully replace the information obtained by soil sampling, but can predict some soil properties in fields that have not been subjected to soil sampling and facilitate learning about soil properties for decisions in site specific farming.

Keywords: *precision agriculture, Sentinel 2, soil sampling, SWIR, colour index.*

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Mapping of soil spatial variability by on-the-go measurement of soil electrical conductivity

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For modern crop management practices, known as precision farming, is crucial information about detailed spatial distribution of soil properties. Traditional mapping in form of soil sampling is inefficient for assessment of high level of spatial variability due to the high costs.
For this reason, a study was conducted within the research project NAZV QJ1610289 to evaluate the on-the-go measurement of soil electrical conductivity for mapping of agronomical relevant soil properties.
The experimental work was carried out on the selected fields of Rostenice a. s. farm enterprise, located in the South Moravia region of Czech Republic. The measurement of apparent electrical conductivity of soil was done by using CMD-1 instrument (GF Instruments, Czech Republic) in 2013 (117 ha) and 2016 (334 ha). This device measures the electrical conductivity by the principle of electromagnetic induction (EMI) with 0.98 m dipole center distance and effective depth of measurement of 1.5 m (vertical mode) or 0.75 m (horizontal). The instrument was mounted on the plastic sledge in horizontal mode and drawn by off-road car in 20 - 25 m track-lines. The measurement in 2016 was extended by testing six dipole experimental instrument CMD-6L for simultaneous measurement in six soil depths over next 268 ha. Measured values were recorded in 1 – 2 sec intervals together with geolocation by Trimble CFX 750 DGPS with sub meter accuracy and later processed by ESRI ArcGIS software. Soil properties were obtained by soil sampling in irregular grid with the density of 1 sample per 3 ha. Soil samples were taken from the depth of 30 cm and analysed for soil texture (percentage of clay, silt and sand particles), content of available nutrients (P, K, Mg, Ca), cation exchange capacity (CEC), soil organic matter content (SOM) and wilting point (WP).
The results of correlation analysis showed main sensitivity of EMI to the percentage of finest clay particles smaller than 0.0001 mm (r = 0.617) and content of SOM (r = 0.598). The correlation between EMI and nutrients content in soil and pH value was not significant. The range of spatial dependency of EMI, estimated from semivariogram parameters, varied from 240 to 480 m. As the main advantageous of EMI measurement is identification of main zones within the fields at high spatial level, which represents different soil properties. Recent studies showed that these zones can be used for directed soil sampling or to delineate the management zones for site specific crop management.

Keywords: *digital soil mapping, precision agriculture, soil properties, electromagnetic induction.*

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Assessment of the main agro-ecological parameters effects on the cultivation of *Miscanthus x giganteus* grown on marginal soils in the Republic of Serbia

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The aim of this study was to evaluate the influence of climatic parameters, in particular the amount and distribution of the precipitation in the vegetation period, then, the type of soil and fertilization on the yield in the first two years of growing *Miscanthus x giganteus* as a test crop. The experiment was performed on two types of soil with limited productive capability - Eutric cambisol and Stagnosol, on the experimental fields of Institute of Soil Science, Belgrade, in Mladenovac and Varna. It was implemented the planting density of 2 rhizomes m^{-2}, since it as was shown in previous studies as a suitable for achieving the maximum plant formation and tillering in order to achieve the maximum yield. Miscanthus fertilization was performed in the second vegetative season, using different quantities and types of the complex NPK fertilizers (50 kg ha^{-1} NPK 15:15:15; 100 kg ha^{-1} NPK 15:15:15; 50 kg ha^{-1} NPK 20:20:20). Unfertilized variant was used as a control. Weather conditions during the monitoring of the experiment were characterized by two extremes: floods in the planting year (year 2014) and the long term drought in the second year (year 2015).

At the site of the experimental field Mladenovac, on Eutric cambisol type of soil, on the variant treated with 50 kg ha^{-1} of NPK 15:15:15, it was achieved the highest yield of miscanthus (2.95 t ha^{-1} of dry biomass), and the lowest - by applying 50 kg ha^{-1} of NPK 20:20:20 in the form of kristalons (2.1 t ha^{-1} of dry biomass). At the site of the experimental field Varna, on Stagnosol type of soil, the highest yield was recorded on the variant treated with 50 kg ha^{-1} of NPK 20:20:20 in the form of kristalons (2.3 t ha^{-1} of dry biomass), and the lowest - by applying 50 kg ha^{-1} of NPK 15:15:15 (1.68 t ha^{-1} of dry biomass). The yields of miscanthus on both experimental sites were not significantly different in relation to control (2.75 t ha^{-1} of dry biomass in Mladenovac, 2.23 t ha^{-1} of dry biomass in Varna, respectively). Based on these results it is evident that the application of fertilizers had no significant effect on the yield of cultivated culture and that this agrotechnical measure was not required in the first years of miscanthus growing.

Keywords: *Miscanthus, yield, Eutric cambisol, Stagnosol, fertilization*

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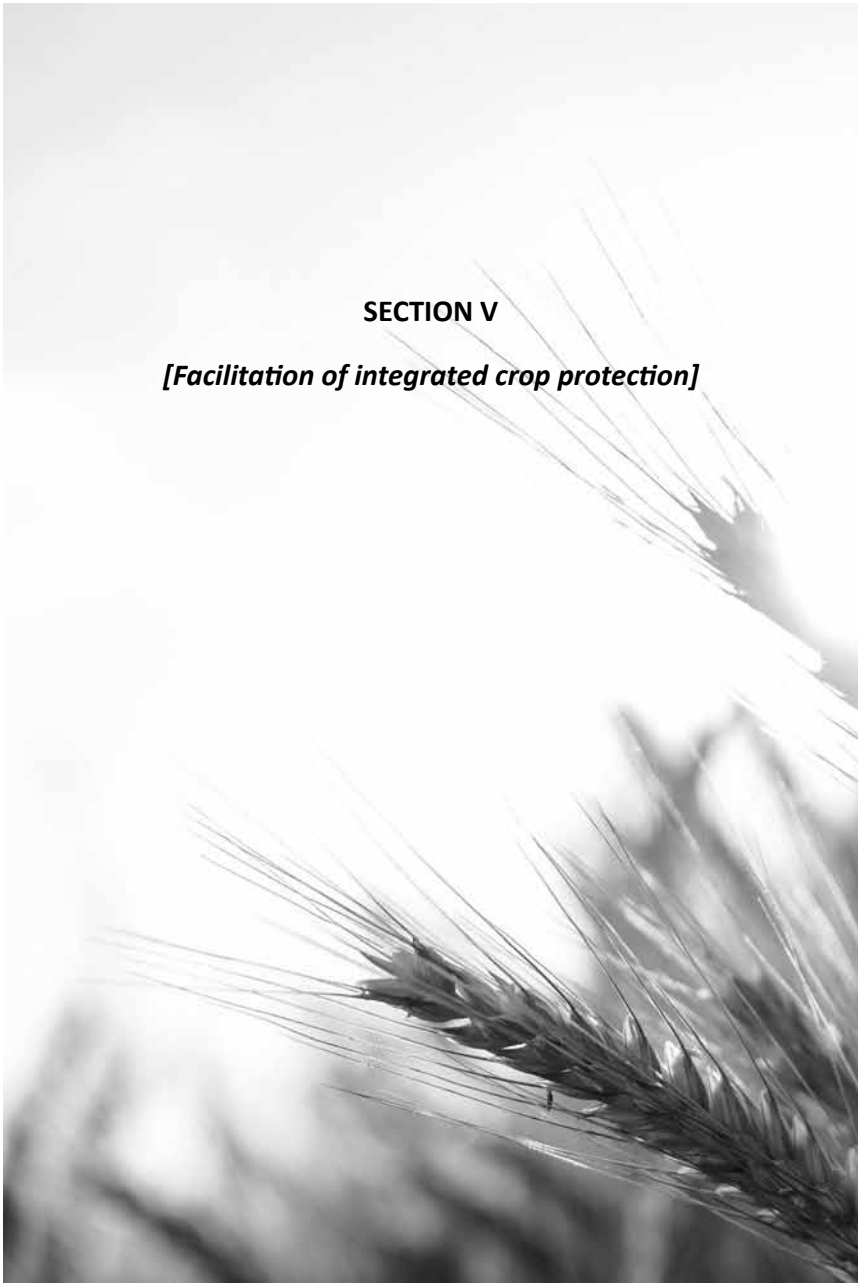

SECTION V

[Facilitation of integrated crop protection]

The impact of tillage and fertilization on wheat grain infection with *Fusarium* spp.

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Various soil tillage systems leave different amount of plant residue on the soil surface and have different effects on diseases. Since many plant pathogens can survive on plant debris the soil tillage system affect the amount of inoculum. The aim of our research was to determine the impact of tillage and nitrogen fertilization treatments on the occurrence of *Fusarium* species on the wheat grain. The field experiment was set at the Magadenovac site from September 2013 to June 2014, having five variants of tillage (CT - conventional tillage treatment, SS - subsoiling, DH- disk harowing, CH - chiseling and NT - no-till treatment) treatments and three variants of nitrogen fertilization treatments (N1 – amount reduced by 50% according recommendation; N2 – according to standard recommendation and N3 – amount increased by 50% according recommendation). The presence of *Fusarium* species was determined in all tested variants of tillage and fertilization treatments. During the fertilization with reduced amount of nitrogen, the infection with *Fusarium* species was statistically reduced in comparison with other nitrogen treatments in almost all variants of tillage treatments (CT, DH and NT). During the fertilization that had an increased amount of nitrogen, the greatest number of grain infection was determined in the disk harowing and subsoiling variants.

Keywords: *soil tillage, nitrogen fertilization, wheat, Fusarium spp.*

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Effects of winter cover crops incorporation on weed infestation in organic popcorn maize production

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Cover crops represents an important component in organic farming. Grown as winter crops in fallow period they bring many benefits to agroecosystem. Weed suppression is one of possible effect of winter cover crops incorporation. The aim of this two year research (2008/09-2010) was to determine the influence of winter cover crops incorporation on weediness in organic popcorn (*Zea mays everta* Sturt) production. The field trial was set up at the lessive soil of the Eastern Croatia (45°38' 46, 52'' N / 18°23' 32, 73'' E) as complete randomized block design in four repetition. The six cover crops treatments were used: Z (zero) - control without cover crop, Wr - winter rye (*Secale cerale* L.), Ww - winter wheat (*Triticum aestivum* L.) and V - hairy vetch (*Vicia Villosa* L.), as single crops, and cover crops mixtures WrV and WwV. Dominant weeds species determined in this trial were *Ambrosia artemisiifolia* L., *Amaranthus retroflexus* L., *Echinochloa crus – galli* (L.) PB. and *Setaria glauca* (L.) PB. Treatments with the highest shoot production were Wr and WrV. The weediness in popcorn maize was higher at cover crops treatments compared to control. Looking at cover crops treatments only, the least weeded was WwV mixture regarding total weed number, and V and Wr treatment showed the lowest weed height, whereas height of the popcorn maize was the lowest at Wr treatment. The highest weed aboveground biomass was recorded on WrV treatment. Results of this experiment indicate increased weed infestation caused by winter cover crops incorporation.

Keywords: *cover crops, weed, organic production, popcorn maize*

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