5th INTERNATIONAL SYMPOSIUM OF SOIL PHYSICS

BOOK OF ABSTRACTS

2022

LITHUANIAN SOIL SCIENCE SOCIETY AT THE DIVISION OF AGRICULTURAL
AND FORESTRY SCIENCES OF THE LITHUANIAN ACADEMY OF SCIENCES

5th INTERNATIONAL SYMPOSIUM OF SOIL PHYSICS

BOOK OF ABSTRACTS

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ORAL PRESENTATIONS

Fertility and sustainability of morainic soils: now days challenge

Virginijus Feiza[a*], Alvyra Šlepetienė[a], Dalia Feizienė[a], Inga Liaudanskienė[a], Irena Deveikytė[a], Simona Pranaitienė[a], Remigija Gaurilčikaitė[a], Kristina Amalevičiūtė-Volungė[a], Agnė Veršulienė[a], Ieva Jokūbauskaitė (Mockevičienė)[a], Lina Bunevičiūtė[a], Mykola Kochiieru[a], Dalia Ambrazaitienė[a], Danutė Karčauskienė[a], Regina Skuodienė[a], Aleksandras Velykis[a], Antanas Satkus[a], Vaclovas Bogužas[b], Aušra Marcinkevičienė[b], Jūratė Aleinikovienė[b], Lina Marija Butkevičienė[b], Aušra Sinkevičienė[b], Rimantas Vaisvalavičius[b], Vaida Steponavičienė[b], Jonas Volungevičius[c]

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Introduction. In Lithuania, there are 12 typological soil groups. Most of them are morainic in origin, glacially formed about 12–10 thousand years ago, and dominate in the country. Unfortunately, the content of humus within the topsoil (0–20 cm) layer of mineral soils rarely exceeds 3–4%. It generally totals around 1% or even less. The low organic matter content in the soil is still one of the most relevant problems to be tackled to improve the productivity of agricultural soils. In addition, another challenge in Lithuania is undulating landscape prevailing in the eastern and western parts of the country. As a rule, mineral soils on hilly land are naturally acidic pH (3.5–5.0) and need to be limed periodically. In addition, a third feature of Lithuanian soils is a low status of plant available macronutrients. Such soils often have a poor and unstable soil structure. They are sensitive to compaction, increases the risk of water logging in the case of excess rainfall, or during rainwater shortage periods when the plant roots cannot reach the ground water through the compacted soil layer.

To get new knowledge about soils in different pedological regions of Lithuania the project titled „The influence of long-term contrasting intensity resources management on genesis of different soils and to other agroecosystems components (AGROTVARA)" has been carried out as a part of the National scientific program "Sustainability of Agro-forest and water ecosystems". The scientists from 3 institutions – Institute of Agriculture of the Lithuanian Research Centre for Agriculture and Forestry (LAMMC), Vytautas Magnus University Agriculture Academy (VDU ŽŪA), and Vilnius University (VU) were involved. The results obtained from long-term field experiments (>10 years) situated at LAMMC and VDU ŽŪA have been involved in the research.

Goal. The aim of the investigations was to reveal the influence of the long-term contrasting intensity agroecosystems sources management to support the physical-chemical sustainability and increase of biodiversity of the soils of different genesis, to secure crop productivity, and to identify the measures to ensure agroecosystems functionality.

Results. The main problems in different agroecosystems of Lithuania were identified:

On morainic and clayey soils of mid-lowland – the bulk density increases within top-soil layer due to natural processes and due to soil compaction occurrence because of heavy machinery usage, soil water logging, organic matter reduction and water erosion occurrence were highlighted in different areas of the region.

On the middle lowland of Lithuania, the main problems are soil compaction and water logging.

In south Lithuania of gently hilly-rolling lowland area – soil compaction, soil moisture problems and soil erosion manifestation.

On heavy soils zone of northern Lithuania – high soil bulk density occurrence promoting water logging risk. Soil organic matter shortage has a negative influence on soil structure stability, soil tillage problems increasing.

On morainic soils of hilly relief – soil acidification increase, organic matter reduction, erosion, soil biodiversity reduction is of great concern.

Conclusions

Due to prevent agroecosystems functionality reduction, it is recommended to implement soil tillage according to local soil and environmental conditions. Deep ploughing may be replaced by shallow tillage or direct drilling on all of soil types investigated. The most suitable for ploughless tillage implementation is *Luvisol, Gleysol* and *Cambisol*. The duration of reduced or no-till application will depend on soil physical properties changes, soil compaction occurrence, soil texture composition in soil horizons of local field conditions. Water logging on soil surface in wet period may signalize about environment problems in top- and/or sub-soil layers.

The use of ploughless tillage on *Retisol* is not identical to the conditions of natural soil formation and soil fertility maintenance.

The decreases in root volume and root length density were dependent on land use and soil depth. The values of root length density and root volume at 0-20 cm depth tended to decrease in the following order: grassland > forest > arable land under conventional tillage.

The negative influence of intensive soil management on physical soil environment can be described in the following increasing order: *Luvisol → Gleysol → Cambisol → Retisol*, while for agrochemical soil environment this order is as follows: *Cambisol → Luvisol → Gleysol → Retisol*.

Long-term reduced and no-till application is responsible for SOC, P and K stratification within Ap soil layer demonstrating 7–19%, 13–28% and 31–43% increase within 0–10 cm soil depth, respectively compared to conventional tillage at the same layer. However, despite of high amounts of nutrients concentrated at top-soil layer, the plant may feel shortage of nutrients availability in dry spells during crop vegetation.

No-tillage and catch cropping for green manure with rotovating compared with conventional ploughing significantly increased the pools of organic carbon by 31.7% to 33.3% in the plots without straw and by 28.9% to 32.7% in the plots with straw applied. Only long-term application of straw increased the quantity of mobile humic acids by 40.6% compared with the plots without straw.

On agrogenically transformed soil profile the amount of soil organic carbon (SOC) was twice as lower as in profile of forest soil.

On all soil types, the organic matter (green fertilizers, straw) incorporation is of great importance. *Retisol* should be limed periodically to maintain Ap soil layer at pH values of 5.8-6.0 in combination with organic fertilizers application.

References

1. Bogužas V., Mikučionienė R., Šlepetienė A., Sinkevičienė A., Feiza V., Steponavičienė V., Adamavičienė A. 2015. Long-term effect of tillage systems, straw, and green manure combinations on soil organic matter. Zemdirbyste-Agriculture, 102 (3): 243–250.
2. Feiziene D., Feiza V., Karklins A., Versuliene A., Janusauskaite D., Antanaitis S. 2018. After-effects of long-term tillage and residue management on topsoil state in Boreal conditions. European Journal of Agronomy, 94: 12–24.
3. Kochiieru M., Lamorski K., Feiza V., Feiziene D., Volungevicius J. 2020. Quantification of the relationship between root parameters and soil macropore parameters under different land use systems in Retisol. International Agrophysics, 34 (3): 301–308.
4. Volungevicius J., Amaleviciute-Volunge K., Versuliene A., Feiziene D., Feiza V., Slepetiene A., Liaudanskiene I., Vaisvalavicius R. 2018. The effects of agrogenic transformation on soil profile morphology, organic carbon, and physico-chemical properties in *Retisols* of Western Lithuania. *Archives of Agronomy and Soil Sciences*, 64 (13): 1910–1923.

Keywords: agroecosystems management, morainic soils, physical-chemical sustainability.

Advanced methods for investigating soil erosion illustrated by the use of a surface scanner to measure the splash phenomenon

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Soil is an important component of many ecosystems providing a habitat for plants and animals and influencing the climate through regulation of e.g., the water cycle. The role of soil in the world highlights the significance of research aimed at protection thereof and understanding the processes that can threaten the soil. An example of such adverse processes is water erosion. The development of such research requires the use of advanced measurement methods.

The splash phenomenon is the first step of water erosion. This dynamic process is caused by the impact of a drop on a soil surface. The modern methods used to analyse the phenomenon include the use of high-speed cameras, computer tomography or, more recently, isotopic analysis. In the context of surface deformation, surface scanners are important instrumentation.

The work aims to present the possibilities of using surface scanners in erosion studies illustrated by splash analysis.

In the present study, loamy sand soil (*Haplic Luvisol*) was used. The samples were prepared in three variants of initial moisture corresponding to a pressure head equal to 0.1 kPa, 1 kPa, and 16 kPa. Drops with a diameter of 4.2 mm were free falling from a height of 1.5m and 7m. The deformation was measured using a Scan3D UNIVERSE 10 Mpix surface scanner.

The use of the scanner helped to determine the depth, diameter, circularity, and volume of craters formed after the impact of the drop. The measurement method posed no risk of deformation damage; additionally, it was fast and precise. The data collected with the use of the scanners may increase the knowledge of the splash phenomenon and help to make further steps in linking the splash to subsequent stages of water erosion.

References

Mazur R., Ryżak M., Sochan A., Beczek M., Polakowski C., Przysucha B., Bieganowski A., 2022. Soil deformation after one water-drop impact – The effect of texture and soil moisture content. *Geoderma* 417, 115838.

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Keywords: soil erosion, splash phenomenon, surface scanning.

Impact of tillage intensity on the main soil physical properties

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Intensive tillage initiates destruction of soil structure, risk of erosions and soil loses, formation of hardpans etc. That problems could be solved using different types of agricultural technique and implements. In 2009–2012, at the Research Station of Aleksandras Stulginskis University, Lithuania, in maize cultivation, five tillage systems were investigated at the basis of long-term experiment (since 1998): deep and shallow ploughing, deep (chiselling) and shallow (disking) cultivation, and no-till. RT and NT systems had no significant effect on the structural composition of soil; however, the stability of the structure of the >1 and >0.25 mm-size fractions was significantly higher in RT and NR compare with conventional tillage-ploughing (CT). The penetration resistance of tilled plots was less at the beginning of vegetative season in spring, while it became similar to the NT plots at the end of the maize growth season. After primary tillage and wintering, the soil moisture content in the upper soil layer (0–5 cm depth) of the NT plots was 17–49 and 16–18% higher than that in CT [1].

On other hand, soil moisture regime regulation is the most important task in surplus humid climate with not even distribution of precipitation (like as in Lithuania). RT may change soil hydrological properties. The objectives of this study were to establish the possibilities to manage soil water regime during the whole tillage system in sugar beet cultivation, which are especially sensitive for water deficit or abundance. Five field experiments were carried out at the Experimental Station of the Lithuanian University of Agriculture (Aleksandras Stulginskis University since 2011) during 1995-2010 in conditions of loam Luvisol. In this study we highlighted the reduction of primary soil tillage from deep annual soil ploughing to shallow ploughing, deep and shallow cultivation and no till, comparison of soil ploughing and subsoiling, pre-sowing ploughed or unploughed soil tillage with different cultivators—S-tine, complex, rotary and others, soil compressing with Cambridge and spur rollers before and after sugar beet sowing investigations. According to the results of experiments, reduction of primary tillage conserved soil water. The highest storage of soil water in spring was observed in RT and NT soil. Subsoiling led higher water infiltration rate, and top layer of subsoiled soil contained less moisture than ploughed. Sugar beet seedbed moisture mostly depended on soil tillage intensity and depth. Pre-sowing rotary tilling was the top tillage method in the case of water capacity in ploughed or unploughed soil. Soil compressing with rollers mostly had negative or low influence on Luvisol moisture content. Rolling with Cambridge roller effected on more rapid water transport from deeper to top sugar beet seedbed layers and higher evaporation rate [2].

So, in our days, the impact of RT or NT on the soil physical properties is well documented worldwide; however, there is still lack of information about the influence of strip-till one-pass

(ST-OP) technology on the soils. This technology became popular in countries with uneven topography. Polish colleagues from UTP University of Science and Technology performed four field experiments to ascertain soil loss on a slope, soil structural proportion and aggregate stability, soil moisture and soil water reserve during crop sowing. After sowing crops in ST-OP, from 62.7 to 82.0% of pre-crop residues remained on the soil surface, depending on the previous crop and row spacing. ST-OP system increased the stability of soil aggregates of 0.25–2.0 mm diameter by 12.7% and moisture content in the soil, decreased soil loss by 2.57–6.36 t ha^{-1} $year^{-1}$ [3].

To summarize, there are plenty methods to solve the problems with soil physical conditions, however we need to establish in detail complex interactions between soil physical, biological, chemical properties, environment, labour and energy consumption's efficiency.

References

1. Romaneckas, Kęstutis; Šarauskis, Egidijus; Avižienytė, Dovilė; Buragienė, Sidona; Arney, David. The main physical properties of planosol in maize (*Zea mays* L.) cultivation under different long-term reduced tillage practices in the Baltic region. *Journal of Integrative Agriculture*. Oxford: Elsevier. ISSN 2095-3119, 2015, vol. 14, iss. 7, p. 1309–1320. doi:10.1016/-3119(14)60962-X.
2. Romaneckas, Kęstutis; Šarauskis, Egidijus; Masilionytė, Laura; Sakalauskas, Antanas; Pilipavičius, Vytautas. Impact of different tillage methods on silty loam luvisol water content in sugar beet (*Beta vulgaris* L.) crop. *Journal of Environmental Protection*. ISSN 2152-2197, 2013, vol. 4, no. 2, p. 219–225. doi:10.4236/.2013.43026.
3. Jaskulska, Iwona; Romaneckas, Kęstutis; Jaskulski, Dariusz; Wojewódzki, Piotr. A strip-till one-pass system as a component of conservation agriculture. *Agronomy-Basel*. Basel : MDPI AG, 2020, vol. 10, iss. 12, 2020, p. 1–18, ISSN 2073-4395. doi:10.3390/agronomy10122015.

Keywords: soil physical properties, tillage intensity impact.

Influence of tillage systems on soil penetration resistance in two organically managed fields

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Tillage is one of the most influential manipulations of the soil. About significant tillage treatments effects on soil physical properties show many studies (Burgos Hernandez, 2015; Steponavičiene et al, 2015) therefore can be considered the minimal disturbance of the soil surface by tillage is one of the main principles of conservation agriculture, which is also emphasized in the scientific literature (Bussari et al, 2015). However, there is still a lack of information on how the effects of the tillage system on soil properties depend on the management system. Within the framework of the EAFRD supported project "Advanced farming system as a basis for environmentally friendly and efficient crop production in Latvia" the effect of minimal soil treatment on soil penetrometric resistance was studied in two organic farms. The soil of the 1st experimental site (BUL) was *Luvisol*, sandy loam with the following agrochemical characteristics (0-20 cm): pH_{KCl} – 6.3, available P_2O_5 – 91.5 mg kg^{-1} and available K_2O – 86.5 mg kg^{-1}, humus content – 32.3 g kg^{-1}. The soil in the field of 2nd farm (KRI) also was *Luvisol*, loamy sand but the corresponding quality indicators were pH_{KCl} – 6.2, available P_2O_5 – 76.2 mg kg^{-1} and available K_2O – 409 mg kg^{-1}, humus content – 29.5 g kg^{-1}. Conventional ploughing 20-22 cm depth in autumn and shallow loosening with disc harrows at 8-10 cm depth was compared. Soil penetration resistance (Mpa) was determined at 15 randomly selected locations per plot in soil layers 0.00–0.25 m with a penetrologger Eijkelkamp in spring and autumn. The hhypothesis we tested was if reduced tillage has a positive effect on the physical properties of the soil also in organically managed fields. The aim of the studies was to evaluate the impact of reduced tillage on soil penetrometric resistance in soils with different texture. Although the hypothesis was confirmed, the yield data did not confirm the benefits of minimal tillage over a two-year period. The penetrometric resistance in the sandy loamy field was 2.5 MPa in the ploughed field and 2.3 MPa in the minimally cultivated field. On the other hand, in the sandy loam field the values were insignificantly ($P>0.05$) higher in both tillage variants. Fluctuations in yield of spring cereals due to the type of tillage were minimal, 5.2% (BUL) and 6.1% (KRI) respectively in sandy loam and loamy sand, with a trend in favor of minimal tillage. Due to the short study period, the results should be considered as indicative.

References

1. Burgos Hernández T.D. (2015). Assessment of Effects of Long Term Tillage Practices on Soil Properties in Ohio. THESIS. Graduate Program in Environment and Natural Resources. The Ohio State University.
2. Busari, M.A., Kukal, S.S., Kaur, A., Bhatt, R., Dulazi, A.A. (2015). Conservation tillage impacts on soil, crop and the environment. Int. Soil Water Conserv. Res. 2015, 3, 119–129.

3. Steponavičienė, V., Bogužas, V., Mikučionienė, R., Sinkevičienė, A., Feiza, V. (2015). Influence of tillage systems and straw incorporation on soil shear strength and penetration resistance. Zinātniski praktiskā konference *LĪDZSVAROTA LAUKSAIMNIECĪBA 2015*, 19.–21.02.2015., LLU, Jelgava, Latvija, 223–225.

Keywords: tillage systems, soil penetration resistance.

Relation between aggregate stability and pedogenetic factors in tropical Andisols, Alfisols, Oxisols and Vertisols

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Aggregate stability is a fundamental physical property of soil associated with factors such as colloid content and type, pedogenetic processes and anthropogenic activities. In addition to contributing extensively to ecosystem services, aggregate stability has been used as an indicator of soil quality to assess vulnerability to degradation and has led to extensive studies on aggregate formation and stability mechanisms. For years, several authors have suggested an association between soil evolution and the development of soil structure, however, there is still limited information available on the stability of soil aggregates from the tropical zone and their relationship with pedogenetic factors.

In this study, soil samples from the endopedons (Bt, Bss, Bo and Bw horizons) of the most characteristic tropical zone soils were collected from the Andean, Caribbean, and Orinoco regions in Colombia, South America. The structural stability index based on the particle size distribution and organic carbon content, aggregate size distribution and stability of these soils were evaluated using the optical microscopy and laser diffractometry methods and the wet sieving method with a single sieve (0.25 mm). The soils studied showed a predominance of fine particles. Correlation between methodologies showed concordance between stability values by Spearman's rank correlation coefficient ($R = 0.8$, $p < 0.001$) and similar values for soils with low structural stability, in addition to a wide heterogeneity in aggregate stability despite the high degree of weathering and pedogenic development.

The results showed that aggregate stability improved with increasing degree of soil weathering, especially for the *Oxisol* and *Vertisols* orders where aggregation was directly related to the type and clay content, while for the *Alfisols* and *Andisol* orders, structural stability was directly determined by organic cementing agents regardless of their degree of evolution. Collectively, both the methodologies and indexes evaluated showed that of the soils studied, the *Vertisols* with the lowest clay contents are the most susceptible to structural degradation.

References

1. Bieganowski, A; Zaleski, T; Kajdas, B; Sochan, A; Józefowska, A; Beczek, M; Lipiec, J; Turski, M; Ryżak, M. (2018). An improved method for determination of aggregate stability using laser diffraction. *Land Degradation & Development* 29. 1376–1384.
2. Pulido Moncada, M., Gabriels, D., Cornelis, W. y Lobo, D. (2015). Comparing aggregate stability tests for soil physical quality indicators. *Land Degradation & Development* 26(8), 843–852.
3. Bronick, C. J., & Lal, R. (2005). Soil structure and management: a review. *Geoderma*, 124(1–2), 3–22.
4. E. Amézketa (1999). Soil Aggregate Stability: A Review, Journal of Sustainable Agriculture, 14:2-3, 83-151, DOI: 10.1300/J064v14n02_08

Keywords: tropical soil, laser diffractometry method, wet aggregate stability.

The Applied Innovation Research and Results Information System (TITRIS)

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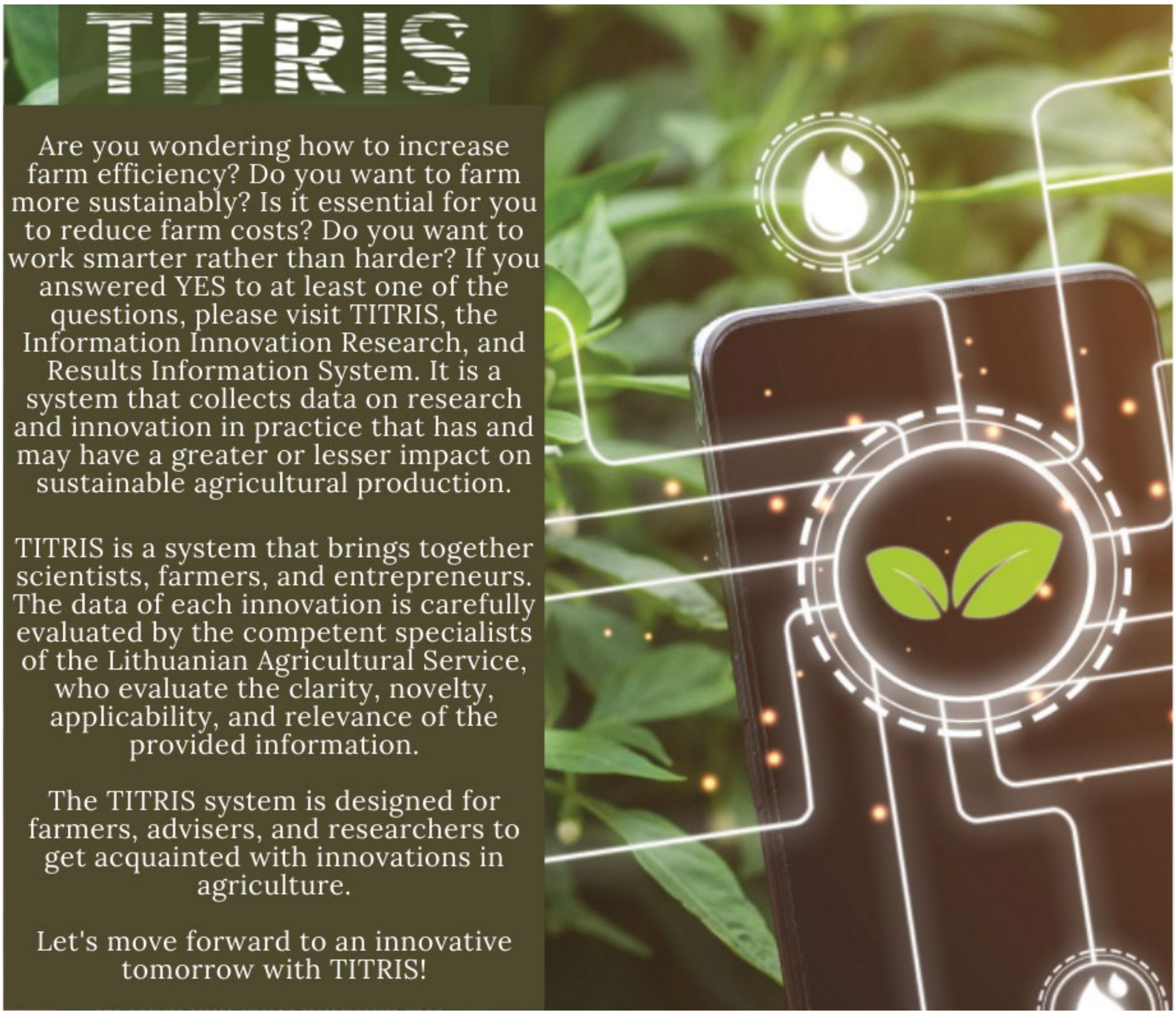

The Applied Innovation Research and Results Information System (TITRIS) (http://titris/en/) is a part of the project “Gate of Innovations” – the center for knowledge accumulation, transfer, development of agricultural technologies and their demonstration (Contract No. 35BV-KK-15-1-07868/16/6874, 19 December 2016). The TITRIS system is designed for farmers, advisers, and researchers to get acquainted with innovations in agriculture. It collects, publicizes, and compiles data on applied innovation research and results that can potentially contribute to more efficient, sustainable, and environmentally friendly farming. The object of TITRIS is research and innovations created in practice that have and can have a lower or higher significance in the development of sustainable agricultural production.

Innovation is understood as a technological and/or organizational improvement of an agricultural and forestry product, process, technology, production and/or service method that can be tested, demonstrated, and adapted to production conditions.

Data on the results of applied research and innovation are provided to TITRIS by scientific institutions, farms, and other producers of specialized activities. Before publicizing innovations in TITRIS, all data is carefully evaluated by a competent specialist of the Lithuanian Agricultural Advisory Service. The purpose of this evaluation is clarification, novelty, adaptability, and relevance of the publicized information.

At this moment at TITRIS system are published 29 innovations in the system: 8 are scientific and 21 are practical. Innovations provide written information and include photos, videos, or links to interjections. The information provided is read not only by Lithuanian farmers. People from abroad visit the site as well. Since 2019, the site has been visited more than 84,000 times.

Keywords: applied innovation research, results information systems.

Splash phenomenon on slope – measurement methods for the characteristics of ejected material

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Soil, i.e., the natural outer layer of the lithosphere and an important component of ecosystems, may be subjected to various types of degradation depending on different factors. One of the forms of physical degradation is water erosion, which is associated with the splash phenomenon caused by water drops hitting the soil surface during rainfall. This process causes the detachment and ejection of splashed material and, in consequence, its transport over different distances. The magnitude of soil splash is influenced by many factors, i.e. soil properties, rainfall parameters, or external factors, such as the incline of the surface (slope). The aim of this study was to present the possibilities of using splash cup measurements and high-speed imaging for characterization of the splash phenomenon on the slope. The research was intended to relate to the mass and proportions of the ejected material, taking into account its division into solid and liquid phases, i.e., soil or water, and to the quantities of the ejected particles.

The splash experiments were performed with the single-drop impact methodology. The drops of water with a diameter of 4.2 mm were dispensed using a water dosing system and fell freely from a height of 1.5 m. The measurements were conducted on three types of soil (differentiated in terms of texture) in moistened conditions, i.e., pressure head corresponding to -1.0 kPa. Three slope inclines were investigated: 5°, 15°, and 30°.

The modified splash cup divided into upslope and downslope parts was used for the mass measurements. The ejected material was collected after the drop impact and weighed using laboratory scale (two times, i.e. immediately after the impact and then again after drying of the material). Based on this, the following quantities were measured: the total ejected mass, the mass of the ejected solid phase, and the mass of the ejected liquid phase. The distribution and proportions of the splashed material (soil/water) were analyzed in both the upslope and downslope directions. The results showed that the change in the slope had a variable influence on the measured quantities for different soils and, with the increase in the slope, the splashed material was mostly ejected in the downslope direction. What is more, the ejected material consisted mostly of water, which was observed for material ejected both upslope and downslope.

In separate splash experiments, a set of three high-speed cameras was used to register the phenomenon. Based on the graphically processed images, the total number of ejected particles was determined. Next, the processed images were implemented in the 3D particle-tracking module (Volumetric PTV) for detailed identification of particles and determination of flight trajectories for each of the ejected particles. Based on this, it was possible to calculate the velocity and angle of ejection for each particle, the distance to which the particle was displaced, and the maximal altitude (height) of particle flight. The results showed that the increasing slope had an influence on the measured quantities.

In conclusion, the methods presented above are useful tools for investigation of splash on the slope in the aspect of ejection of particles. They help to elucidate the effect of this factor on the course of the phenomenon.

Acknowledgements

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References

Beczek M., Ryżak M., Mazur R., Sochan A., Polakowski C., Bieganowski A.: Influence of slope incline on the ejection of two-phase soil splashed material. PLOS ONE 17(1): e0262203, 2022.

Keywords: splash phenomenon, soil properties, measurement methods.

Tillage and cover crop management impact on soil quality and pest pressure

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Low intensity tillage is economically beneficial and minimizes soil erosion, but it is often facing some problems: such as soil compaction and higher pest and weed pressure (Suproniene et al., 2011; Velykis and Satkus, 2018, Kadziene et al, 2020). A cereal-based crop rotation, which is common practice in Lithuania, increases the occurrence of some specific weeds: like grass weeds, which are difficult to control in cereals due to lack of herbicides and resistance problem. The same host of some pathogens also provoke a specific diseases infestation, especially when low intensity tillage technologies are applied.

This study explored the effect of white mustard Sinapis alba L. and white clover Trifolium repens L. as cover crops on soil physical properties, weed pressure, and Fusarium infestation in spring wheat and spring barley grain under different tillage, and finally the effect on nutrient content and organic carbon, after 8 years of tillage–cover crop management.

Five tillage practices: deep ploughing (22–24 cm), shallow ploughing (16–18 cm), harrowing (8–10 cm), harrowing (14–16 cm) and direct drilling, with and without cover crop, were investigated in a loam soil in long term tillage experiment in Dotnuva in 2013–2021. Crop sequence consisted of five crop extended in time: spring wheat + cover crop (white mustard); spring barley + cover crop (white mustard); field pea; winter wheat; winter oilseed rape + cover crop (white clover). Cover crops were established using fertilizer spreader: white mustard seed were spread before harvest of the spring wheat and spring barley and white clover – at the beginning of vegetation of winter oilseed rape in early spring.

Both cover crops resulted in lower weed pressure for a post – harvest period under different tillage practises (Fig. 1). White mustard, grown as cover crop, reduced weed biomass at post-harvest period, from 2 up to 3.5 times and white clover – from 6 up to 18 times, depending on the tillage technology.

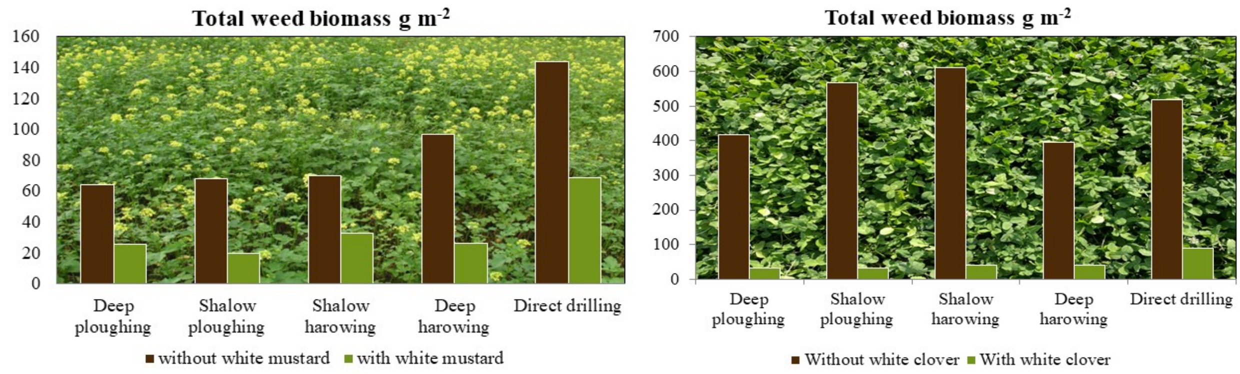

Figure 1. Air-dry weed biomass at post-harvest period as influenced by tillage and cover crop

White mustard and white clover positively affected top-soil physical properties decreasing soil compaction (Fig. 2). White mustard, significantly reduced soil bulk density and increased total soil porosity, for the arable layer, down to 20 cm, for both ploughing treatments as well as for other tillage treatments the tendences were similar. White clover, tended to reduce soil bulk density and increase the total porosity for arable layer, for all tillage technologies and for shallow ploughing the results were statistically significant.

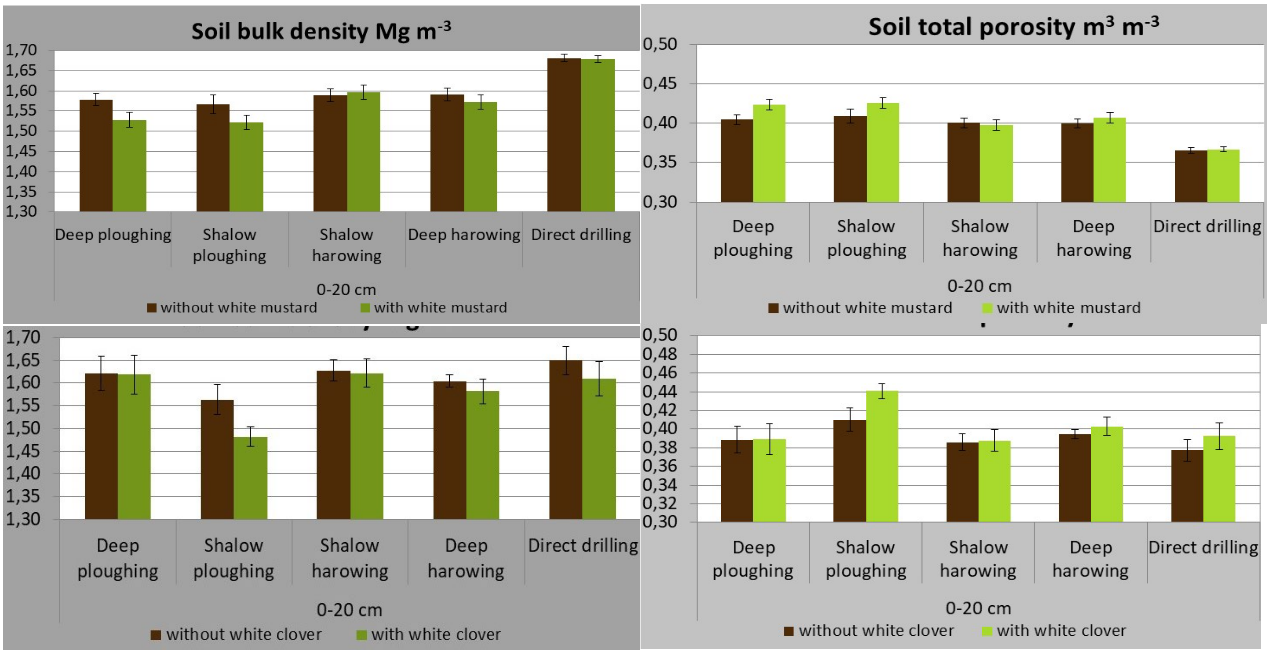

Figure 2. Soil dry bulk density and total porosity for arable layer as affected by tillage and cover crop

The residues of white mustard as well as white clover have influenced lower grain contamination by *Fusarium* fungi (Fig. 3).

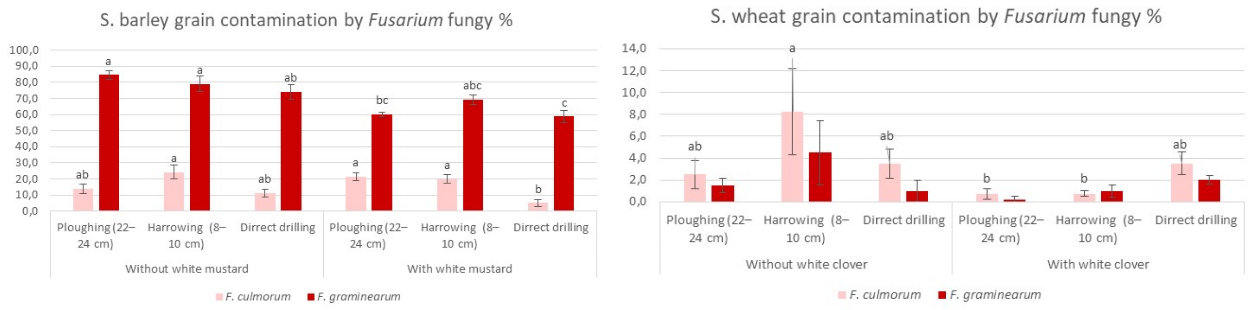

Figure 3. Grain contamination by *Fusarium* fungi as influenced by tillage and cover crop

After 8 years of tillage – cover crop management, some positive results were obtained on nutrient content as well as on organic carbon sequestration (Fig. 4). The use of the cover crop significantly increased phosphorus content for the arable layer for both ploughing treatments and tended to increase for all other tillage. Potassium was significantly higher at the arable layer after the use of the cover crop in both ploughing treatments, deep harrowing, and direct drilling. Cover crop management also positively affected organic carbon sequestration in arable layer and significantly increased its content for no-tillage treatment.

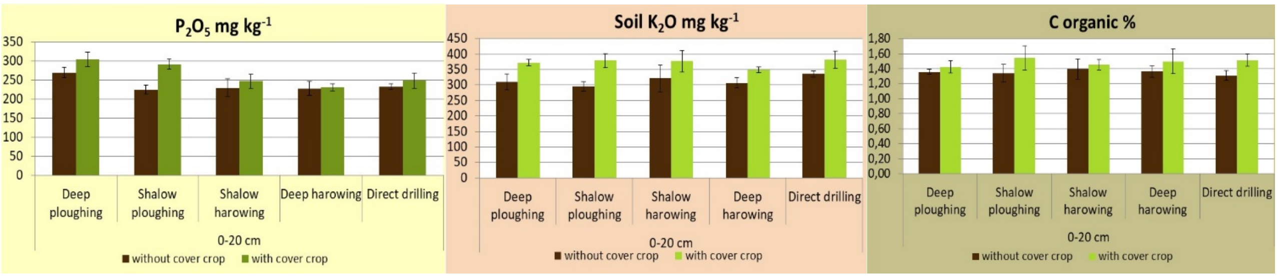

Figure 4. Soil nutrient and organic carbon content for arable layer as affected by tillage and cover crop

Long term tillage–cover crop experiment showed that the use of cover crops positively affected soil quality of arable layer by decreasing soil compaction, increasing nutrients and organic carbon content. It also clearly reduced weed pressure at post-harvest period in all tillage treatments. The residues of white mustard as well as white clover have influenced lower grain contamination by *Fusarium* fungi.

Our results suggest that white mustard and white clover as a cover crop are a promising tool for extensive tillage and especially no-tillage technologies.

Acknowledgement

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References

1. Kadziene G., Suproniene S., Auskalniene O., Pranaitiene S., Svegzda P., Versuliene A., Ceseviciene J., Janusauskaite D., Feiza V. 2020. Tillage and cover crop influence on weed pressure and *Fusarium* infection in spring cereals. Crop Protection, 127, 104966.

2. Suproniene, S., Mankeviciene, A., Kadziene, G., Feiziene, D., Feiza, V., Semaskiene, R., Dabkevicius, Z., 2011. The effect of different tillage-fertilization practices on the mycoflora of wheat grains. Agric. Food Sci., 20, 316–326. https://doi.org/10.23986/afsci.6028.
3. Velykis, A., Satkus, A., 2018. The impact of tillage, Ca-amendent and cover crop on the physical state of clay loam soil. Zemdirbyste-Agriculture, 105, 3–10. https://doi.org/10.13080/z-a.2018.105.001.

Keywords: no-tillage, service crop, soil physical properties, soil nutrients, organic carbon, integrated crop management.

Influence of the type of tillage on the topsoil texture

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In current research the traditional ploughing system and the reverse power harrow system (Forigo G45-400) for tillage are being studied. Tillage comparing was carried out in particularly stony soils formed on the moraine bedrock in Northern Latvia (N57°13' E26°04') The presence of stones of different sizes in the upper layers of the soil increases the possibility of breaking the tillage equipment. In turn, stone removal takes up a lot of human resources. Using a power harrow system, it is possible to transfer the coarse soil fraction below the root zone, using the top, finer texture layer of the soil for sowing perennial grasses. In this tillage system, potential complications can be caused by a coarser textured area beneath the root zone, which can disrupt the capillary system in the soil, thus reducing the water supply to the roots. The aim of the study is to determine whether the amount of fine soil fraction in the root zone is not critically reduced using reverse power harrow system. The topsoil is compared by analyzing every three centimeters to a depth of thirty-one centimeter. The obtained data are shown in Figure 1 and Figure 2.

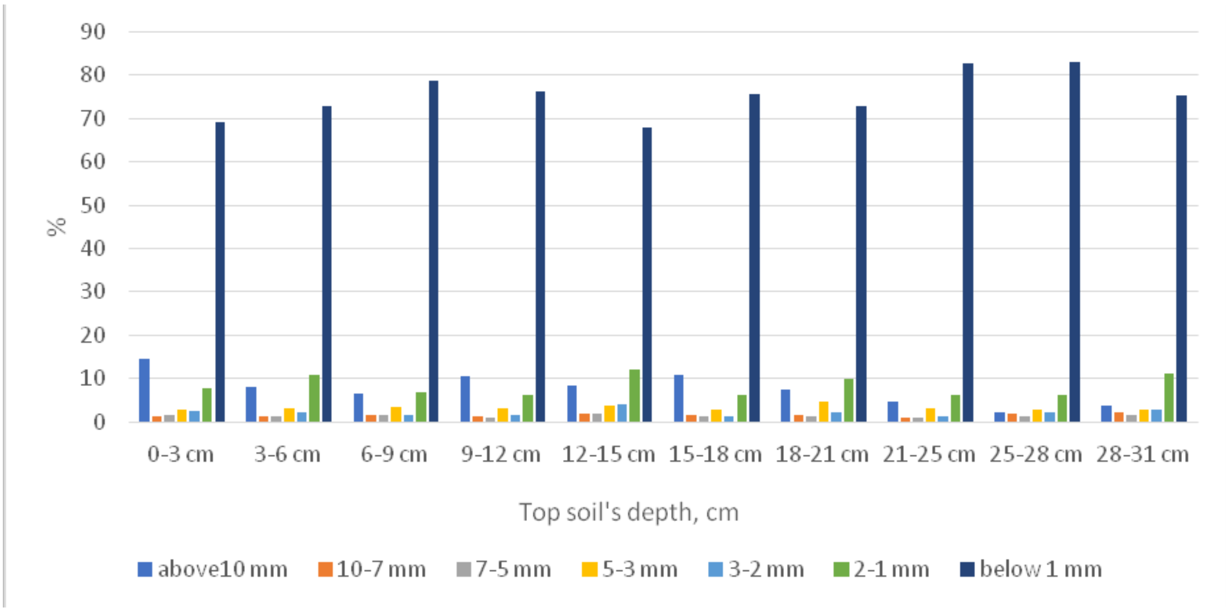

Figure 1. Soil texture in the topsoil plowing system, %

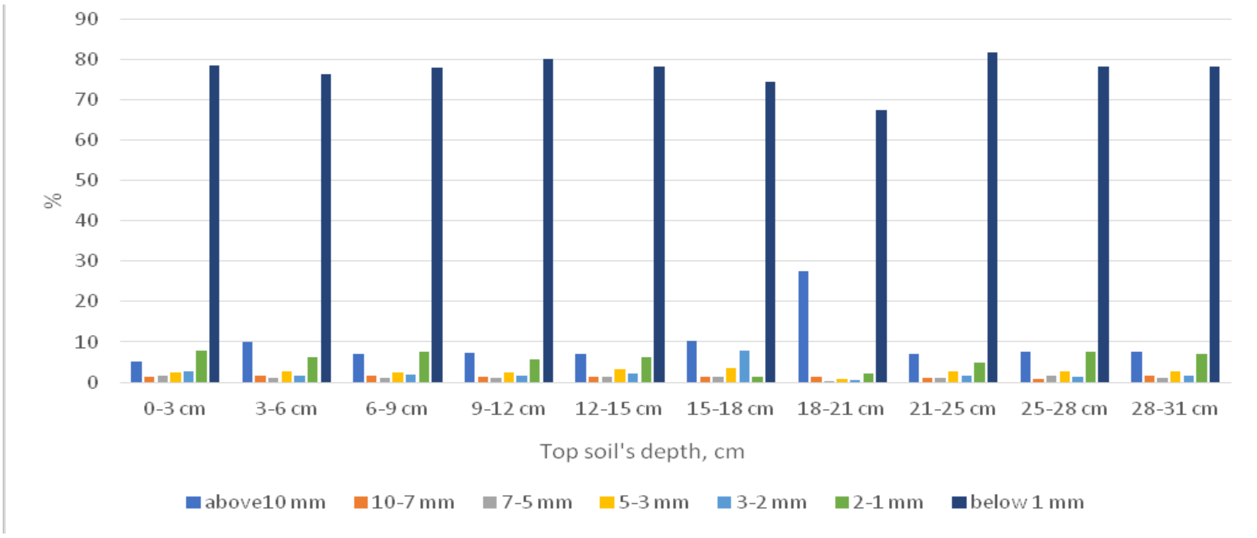

Figure 2. Soil texture in the topsoil using reserve harrow system, %

The obtained data show that the percentage of fine soil in the upper 18 cm of the soil is much more even when treating the soil with reverse power harrow system compared to the ploughing system. Most of the coarse texture fraction has fallen below 18 cm. The fine-grained fraction has decreased in this zone, but this is not critical (67.5 %). These data show that the reverse power harrow system allows to successfully rearrange the topsoil to provide more favorable conditions for root development.

Keywords: soil texture, tillage, reverse power harrow.

Relationship between soil agrochemical properties, macropores and water-stable aggregates under different tillage

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Contrasting management practices often results in differences of soil chemical and physical properties which in turn affects the functional ability of the soil. The research aimed to quantify the relationships among soil agrochemical properties (soil organic carbon (SOC), total nitrogen (Ntotal), total phosphorus (Ptotal), total potassium (Ktotal), macropore parameters and water-stable aggregates (WSA) in topsoil layer under contrasting tillage (CT – conventional tillage and NT – no-tillage) in combination with different rates of mineral fertilizers and plant residue management from long-term field experiment.

Type of the soil classified according to WRB (2015) as *Cambisol* (loam, drained, *Endocalcaric, Endogleyic*) at a study site of the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry (LAMMC), Central Lithuania. The content of SOC established photometrically using glucose standards (Jankauskas et al., 2006). Ntotal content was determined by the Kjeldahl method. The content of Ktotal was determined using atomic absorption spectrometry measurement of Analyst (Perkin Elmer) after wet digestion procedure with sulphuric acid. The content of Ptotal was quantified spectrophotometrically at a wavelength of 430 nm on a Cary 50 UV-Vis (Varian Inc., USA) spectrophotometer. The study of soil macropores was performed using a GE Nanotom 180S device (GE Sensing & Inspection Technologies GmbH, Germany) at the Institute of Agrophysics of the Polish Academy of Sciences in the laboratory of X-ray computed tomography (Lamorski, 2017). Macropores was determined according to Brewer (1964) classification: coarse >5 mm, medium 2-5 mm, fine 1-2 mm, and very fine 0.075-1 mm. Water-stable aggregates were determined for the 5-10 cm soil depth by using a wet sieving apparatus (Eijkelkamp Agrisearch Equipment, the Netherlands).

Effect of tillage for WSA was statistically significant at $p < 0.0001$, except for residues ($p < 0.98$) and fertilization ($p < 0.42$) which were not significant. WSA content, averaged across residues and fertilizations, was 48% lower in CT than in NT. SOC content within the tillage amounted from 7.55 to 8.72 g kg^{-1} in CT, from 9.04 to 9.46 g kg^{-1} in NT. SOC, averaged across residues and fertilizations was 10% higher in NT than in CT. Content WSA and macroporosity tended to decrease in the following order: NT (returned residues) > NT (removed residues) > CT (removed residues) > CT (returned residues) in both fertilizations (not fertilized and fertilized with mineral NPK fertilizers). This shows that residues and tillage had effect on macroporosity and WSA differently. Intensive anthropogenic activity causes a decrease WSA and thereby reduces the macroporosity in 0-10 cm soil depth. The correlations WSA with medium size macropores ($r = 0.72$, $p < 0.05$), fine size macropores ($r = 0.83$, $p < 0.01$) and volume of total macroporosity ($r = 0.91$, $p < 0.01$) were statistically significant, while the correlations with coarse and very fine size macropores were not. The highest influence of SOC increase was demonstrated under presence of fine size macropores ($r = 0.70$, $p < 0.05$) and volume of total macroporosity ($r = 0.73$, $p < 0.01$). The content of Ntotal significantly and positively correlated with many soil factors investigated: SOC ($r = 0.65$, $p < 0.05$), Ptotal ($r = 0.65$, $p < 0.05$), fine size macropores ($r = 0.75$, $p < 0.01$) and macroporosity ($r = 0.71$, $p < 0.05$), whereas the relationship of Ktotal with SOC was negative. Within the 0-10 cm soil depth, the SOC and Ntotal positively correlated with WSA ($r = 0.81$, $p < 0.01$ and $r = 0.68$, $p < 0.05$, respectively). The accumulation of Ptotal in *Cambisol* positively responded to increase the volume of fine size macropores ($r = 0.58$, $p < 0.05$) and total volume of macropores ($r = 0.74$, $p < 0.01$). The content of Ptotal positively correlated with WSA ($r = 0.62$, $p < 0.05$).

Soil agrochemical properties, soil macropore network and water-stable aggregates, averaged across residues and fertilizations were higher in no-tillage than in conventional tillage. Soil organic carbon, total nitrogen, total phosphorus had a positive direct effect on the formation of macropore network and water-stable aggregates in different tillage management in *Cambisol*.

References

1. Brewer R. 1964. Fabric and mineral analysis of soils. John Wiley and Sons, 482 p.
2. Jankauskas B., Jankauskiene G., Slepetiene A., Fullen M.A., & Booth C.A. (2006) International Comparison of Analytical Methods of Determining the Soil Organic Matter Content of Lithuanian Eutric Albeluvisols, Communications in Soil Science and Plant Analysis, 37(05–06): 707–720.
3. Lamorski K. 2017. X-ray computational tomography facility. Institute of Agrophysics PAS. (WWW Document) URL http://tomography.ipan.lublin.pl (accessed 4.19.18)

Keywords: soil, agrochemical properties, macropores, water-stable aggregates, contrasting tillage.

Instrumental possibilities in determination some key properties of soil cover

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The research aim. The aim is to identify the soil key properties that determine the fertility of the soil using UAV technology in distance.

More than 30 years ago in Lithuania, most of the soils of agrarian territories were investigated by surface. Based on these studies, the Dirv_DR10LT GIS database has been created. Nevertheless, after assessing the level of soil science in the context of existing scientific technologies and the needs of precision agriculture, existing soil GIS databases used by farmers no longer meet the precision requirements. Due to the intensive agriculture use the soil properties has changed: significantly increased area of eroded soils and agricultural land that has been waterlogged for a shorter or longer period of time (J. Volungevičius, LAMMC, 2017).

Surface analyzes of soil properties are expensive, so it is not popular to investigate them in Lithuania. Only 0.1 per cent of land is investigated in Lithuania every year (G. Staugaitis, LAMMC, 2013), therefore the need for cheaper and larger-area surveys is increasing. The growing popularity of precision agriculture has increased the need for aero distant research in recent years. One of the most pressing challenges of this time in precision farming is to rationalize and to reduce the price of precision farming (research, their use, economic return) so that they optimize the resources managed: sustainability (finding solutions whose value would bring benefits for more than one year), time-saving time) and economic efficiency.

Study area. 9 farms areas were selected for the research, which are localized in different Lithuanian agroclimatic and geomorphological conditions: undulating moraine plateau: Lyduokiai (LD) (Ukmergė dist. mun., 24 ° 54'54 "E, 55 ° 16'26.4" N); undulating moraine lowlands: Dotnuva (DT) (Kėdainiai dist. mun.) 23 ° 51'58,074 "E, 55 ° 26'20,815" N; slope of the valley: Upytė (UP) (Panevėžys dist. mun.) 24 ° 11'1,512 "E, 55 ° 36'11,205" N; Daugėlaičiai (DE) (Radviliškis dist. mun.) 23 ° 29'8,741 "E, 55 ° 44'15.567" N; Ažytėnai (AZ) (Kėdainiai dist. mun.) 23 ° 35'4,814 "E, 55 ° 26'47.1" N; moraine plain: Liepalotai (LP) (Šakiai dist. mun.) 22 ° 54'43,362 "E, 54 ° 56'39,685" N; Pavartyčiai (PV) (Radviliškis dist. mun.) 23 ° 43'9,617 "E, 55 ° 45'48.652" N; Daugalaičiai (DA) (Joniškis dist. mun.) 23 ° 35'59,299 "E, 56 ° 5'14,721" N; moraine hilly upland: Vievininkai (VV) (Elektrėnai mun.) 24 ° 47'1,272 "E, 54 ° 45'4,332" N.

Soil description, sampling and analyses. Soil typological units were not identified during the study. Samples were taken in September–October and May 2019–2020 from topsoil to a depth of 0–5 cm, forming a pooled sample from a three–point radius of 1 m. Sampling and field measurements were performed in conjunction with drone orthophoto fixation with visible spectrum (RGB) and thermal (NIR) cameras. The position in space was recorded with an accuracy of 1–2 m using a Trimble Juno T41 / 5 GPS receiver with ArcPad 10.2 software. 78 samples were taken from agricultural land areas with two replicates in time. The soil samples were air-dried, visible roots and plant residues were manually removed. Than samples were crushed and sieved through a 2 mm sieve, and homogeneously mixed. For the analysis of soil organic carbon (SOC) and humic substances an aliquot of the samples was passed through a 0.25 mm sieve.

The soil organic carbon (C) content was determined by a spectrophotometric measure procedure at the wavelength of 590 nm using glucose as a standard after wet combustion according to Tyurin method modified by Nikitin (1999). SOC converted to humus according to the formula: Humus (%) = Soil organic carbon (%) x 1.72. Water extractable organic carbon (WEOC) was measured by IR-detection method after UV-catalysed persulphate oxidation.

The particle size determination of the soil granulometric composition in the range of 0.02–2000 µm was performed by the laser diffraction method (Mastersizer 2000); particle-size classes are identified by WRB 2015 and textural classes are defined by Fere.

Soil moisture content and temperature under field conditions were measured at a depth of 0–10 cm according to the electrical conductivity of the soil surface with the HH2 sensor. The aggregate composition and durability of the aggregates were determined using a dry screening machine Retsch and a wet screening machine Eijkelkamp. Soil density and moisture were measured and extracted by sorption (pF) under laboratory conditions. Undamaged soil samples were taken in 100 cm3 steel cylinders from 5–10 cm layers (3 samples from each layer at all measuring points)

Spatial and statistical analysis. Spatial analysis was performed using ArcGIS 10.7 and Spatial Analyst tools for raster analysis: Iso Claster, Likelihood Classification, generalization, raster analysis. The correlation method was used for statistical analysis.

Results. The results obtained during the study are ambiguous and do not allow to make more meaningful generalizations about the relationships between individual soil properties and RGB spectral values. Two data samples were formed for analysis: 1 – a total sample of all study fields and 2 – a sample of each field separately. The relationship between the humus materials, moisture (determined by weight method in the laboratory), aggregates, density and sand content of the topsoil (0–10 cm) layer and the red (R), green (G) and blue (B) spectral bands was chosen for further investigated in detail analysis.

The relationship between the humus materials and RGB. Analysis of a pooled data sample showed (Table 1.) no correlation between humus and RGB (R2 (R) = -0.4; R2 (G) = -0.2; R2 (B) = -0.2). Very different correlations were obtained by analyzing different fields. In the area of Daugelaičiai (DE) the correlation was very strong in the whole RGB spectrum (R2 = -0.9), in the area of Upytė (UP) the correlation was strong, but in the G and B spectral bands it weakened. In the Dotnuva (DT) area, a strong correlation (R2 (R) = -0.9) was found only in the R part of the spectrum. Meanwhile, no correlation was found or was weak in other study areas.

The study also found that the reliability of the correlation between laboratory-determined humus content and RGB values differs between spring measurements (2019, hummus1), and autumn (2019 10, hummus2). Nevertheless, the correlation trends remained.

Table 1. Correlations between hummus materials (2019 04) and RGB spectrum bands

	Joint	VV	DT	PV	DE	UP	AZ	LD	LP	DA
hummus1/b1 (R)	-0,4	-0,5	-0,9	-0,6	-0,9	-0,9	-0,7	-0,5	-0,6	-0,7
hummus1/b2 (G)	-0,2	0,5	-0,1	-0,5	-0,9	-0,8	-0,7	-0,4	0,0	-0,5
hummus1/b3 (B)	-0,2	0,0	-0,7	-0,6	-0,9	-0,7	-0,6	-0,2	0,0	-0,4

Table 2. Correlations between hummus materials (2019 10) and RGB spectrum bands

	Joint	VV	DT	PV	DE	UP	AZ	LD	LP	DA
hummus2/b1 (R)	-0,4	-0,6	-0,8	-0,7	-0,9	-1,0	-0,8	-0,5	-	-0,8
hummus2/b2 (G)	-0,2	0,5	0,2	-0,6	-0,9	-0,9	-0,7	-0,4	-	-0,7
hummus2/b3 (B)	-0,1	0,0	-0,6	-0,7	-0,8	-0,9	-0,7	-0,2	-	-0,6

Table 3. Correlations between soil moisture and RGB spectrum bands

	Joint	VV	DT	PV	DE	UP	AZ	LD	LP	DA
Moisture_L1/b1 (R)	-0,6	-0,5	-0,7	-0,7	-0,8	-0,9	-0,6	-0,1	-0,2	-0,8
Moisture_L1/b2 (G)	-0,2	-0,2	0,2	-0,6	-0,7	-0,9	-0,6	0,1	-0,1	-0,6
Moisture_L1/b3 (B)	-0,2	0,0	-0,4	-0,7	-0,9	-0,9	-0,4	0,3	-0,1	-0,4

The relationship between the moisture and RGB. It was found that the data on the moisture content measured by the laboratory condition by weight method are more accurate than the measurements performed by the in-situ method (HH2 sensor). Therefore, only these data were used for correlation analysis.

This analysis showed (Table 3) that there is a weak correlation (R2 (R) = -0.6) between the RGB spectrum and the field moisture in the R band. The values of correlation were unevenly distributed in the study areas. The most significant relationship was found in the UP area (R2 (RGB) = -0.9) and in the DE area ranged from -0.9 in the blue band to -0.7 in the green band. A sufficiently strong correlation was also found in the area of Daugalaičiai (DA) in the R spectrum band (-0.8). The correlation was weak or absent in other study areas.

The relationship between the aggregates and RGB. Aggregate data obtained after wet sieving were selected for correlation analysis. This analysis did not allow the identification of significant results. Only in the DT and UP areas was a reliable correlation found in the R band of the RGB spectrum. The correlation was weak or absent in other study areas.

Table 4. Correlations between aggregates and RGB spectrum bands

	Joint	VV	DT	PV	DE	UP	AZ	LD	LP	DA
Aggregates_DL1/b1 (R)	-0,4	-0,7	-0,8	-0,6	0,0	-0,8	0,3	-0,1	-0,7	0,2
Aggregates_DL1/b2 (G)	-0,2	-0,6	0,0	-0,5	-0,2	-0,7	0,2	0,0	-0,2	0,4
Aggregates_DL1/b3 (B)	0,0	-0,4	-0,7	-0,5	-0,1	-0,7	0,4	0,1	0,2	0,6

The relationship between the bulk density and RGB. The correlation between bulk density and RGB (Table 5) is weak or non-existent. A weak relationship (R2 (R) = -0.6) was found between the bulk density and the R band of the RGB spectrum. Areas such as VV, AZ, and DA have a weak correlation with the R and G spectral bands. Meanwhile, a weak correlation was found in the PV, DE, and UP areas in the G and B spectral bands and at the same time a strong correlation in the R spectral band.

Table 5. Correlations between bulk density and RGB spectrum bands

	Joint	VV	DT	PV	DE	UP	AZ	LD	LP	DA
Bulk density/b1 (R)	0,6	0,6	0,9	0,8	0,8	0,8	0,6	0,4	-0,1	0,7
Bulk density/b2 (G)	0,4	-0,7	0,3	0,7	0,6	0,7	0,6	0,2	-0,4	0,4
Bulk density/b3 (B)	0,3	0,0	0,3	0,8	0,6	0,6	0,5	0,0	0,0	0,2

The relationship between the sand particles and RGB. No general correlation was found between sand and RGB (Table 6), however, the different study areas differed greatly in their results. The AZ area was strongly correlated in all bands of the RGB spectrum, while DT correlated only with the B band and DA correlated only with the R band.

Table 6. Correlations between sand particles and RGB spectrum bands

	Joint	VV	DT	PV	DE	UP	AZ	LD	LP	DA
Sand/b1 (R)	0,3	-0,2	0,4	0,5	0,7	-0,2	0,9	0,5	0,0	0,8
Sand/b2 (G)	0,2	0,1	-0,3	0,5	0,5	-0,4	0,9	0,3	0,2	0,7
Sand/b3 (B)	0,3	0,1	0,8	0,5	-0,5	-0,5	0,8	0,1	0,3	0,6

Discussion. The main question for discussion is why the results of the analysis of the relationships between RGB and soil properties are so different? Why do cardinal differences in the analysis of the same property occur at different study sites? The study was conducted on the assumption that the moisture and humus content of the soil should be strongly correlated, and this correlation should be found in many study sites, especially those with large differences in humus content, with a pronounced relief. However, this hypothesis was not confirmed. Nevertheless, the results are reasonable and explanatory. The strongest humus correlations were obtained in the DE and UP areas. The results may have led to the contrast of these areas in terms of SOC distribution, expressive relief, and same surface treatment.

These properties of the area also resulted in quite good results in terms of moisture correlation. The UP area also differed according to the correlation of the aggregates. This was also due to the characteristics discussed above. The PV area was stood out by its moisture and density correlation results. The PV area was covered with perennial meadow. Therefore, the correlations of bulk density and moisture were most pronounced in it.

The conditions of the study in performing such analysis were the most important in the LP and LD areas. The LD area is cultivated without tillage, therefore the surface structure is homogenized and covered with plant residues and inflorescence. Such tillage does not allow the differences in surface structure to be properly highlighted and therefore cannot be applied to the tasks addressed in the report. LP area is characterized by high intensity use in agriculture, so although we have a flat surface and loamy soil, low humus content, manure fertilization is also applied, surface homogenization makes unfavorable conditions for such an analysis.

The results show that the RGB reflection of the study area depends not only on many factors, but also on their different degree of expression and individual interaction, different time and day of data collection, as well as the microclimate and meteorological situation before and during the study. The results of the research may also lead to excessive sensitivity of the RGB sensors used and the detail of the obtained images. Therefore, optimizing the sensitivity of the sensor would allow different results to be obtained and different generalizations to be made.

An interesting situation is with the correlation between sand and RGB. The results between the AZ and VV areas are very contrasting. The VV area was the most pronounced in the whole study in terms of surface color and particle size distribution, but no correlation could be established between soil properties and RGB spectrum. However, the AZ area was distinguished by an exceptionally strong correlation in all bands of the RGB spectrum, although the orthophoto image of this area was not the most characteristic. This situation could probably be explained by the unevenness (plowing) of the cultivation of the VV area. Meanwhile, the AZ area was cultivated evenly and had the contrasting granulometric composition of the soil.

Carrying out such studies under controlled conditions (multiannual tests) and the results obtained must be evaluated with caution.

Conclusions

- The study was conducted under real conditions that reflect a wide variety of not only land cover conditions but also applied agrotechnical conditions. The study showed that the results obtained under controlled conditions (e.g. perennial tests, etc.) should be treated with caution as they may not correspond to the real conditions.
- Regional summaries of the results of such experimental work are not possible because there are too many variables determining the topsoil properties of the soil, such as moisture, humus content, density, and so on.
- The methodology used in the study can be used for mapping of local areas ant to identify selected topsoil properties, but the results that are obtained can only be interpreted within the study area.

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Keywords: soil key properties, fertility, UAV technology application.

ProbeField: A novel protocol for robust in field monitoring of carbon stock and soil fertility based on proximal sensors and existing soil spectral libraries

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Quick and simple soil analyses directly in the field through proximal sensing has the potential to substantially gear up the number of samples analyzed. With focus on visible and near infrared spectroscopy (Vis-NIRS) ProbeField will work to make this happen. The Vis-NIR technique has many advantages required for field analyses of soil properties. There are, however, drawbacks to be overcome. In contrast to spectroscopy in the lab on prepared samples, variable moisture and structure in the field will hamper reliability of analyses. ProbeField will test and suggest physical and mathematical procedure to manage these problems. A wide range of soil properties will be analyzed and 3D mapping will be performed to estimate for example carbon stocks. A best practice protocol will be produced.

Keywords: carbon stock monitoring, soil fertility, novel protocol, proximal sensors.

POSTER PRESENTATIONS

Some methodological aspects of macro-aggregate stability measurements

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Introduction

Although there is no objective or universally applicable method to quantify soil structure, there is a common agreement that soil macro-aggregate stability (MaAS) can be its good indicator. It is not yet known how edaphic and environmental parameters affect structural properties and how soil physical properties depend on these properties. In this study we have measured the aggregate stability with wet sieving apparatus (Eijkelkamp) by testing the effects of different water quality (tap water, distilled water) as well as dispersing agent (Na-pyrophosphate, Calgon and diluted Calgon). We have also determined the MaAS from clayey samples with half of the required sample amount to find out whether sample amount has effect on the results.

Materials and Methods

The soil samples represent the main Hungarian soil types, with different texture, calcium carbonate and humus content, quality and quantity of clay minerals, and land use.

The rate of stable macroaggregates (MaAS) was measured by wet sieving apparatus (Eijkelkamp), when we used 4 g from the 1–2 mm size aggregates, with not less than four replicate measurements. After carefully pre-moistening, samples were placed on 0.25 mm mesh size sieves, immersed into containers filled with distilled water, and moved up and downward for 3 minutes (about 34 times min^{-1}; f_{nd}). After changing the containers, sieves were immersed into a second vessel and moved up and down for 8 minutes (f_d). Both sets of containers were evaporated and oven dried (24 h; 105 ºC) prior to mass measurements. The percentage of the stable fraction was calculated as a ratio of the weight of soil obtained in the distilled water divided by the sum of the weights obtained in the dispersing solution and distilled water:

$$MaAS=fdfnd+fd\times100(\%)$$

We tested different dispersing solutions on 5 soil samples:

1. 2 g/L Na-pyrophosphate – suggested by the manual;

2. cc. Calgon (33 g Na-hexametaphosphate and 7 g of anhydrous Na-carbonate per 1 L) – because this solution is used in particle size distribution measurements via laser diffraction method;
3. diluted Calgon – to have the same Sodium content in the dispersing solution as in Na-pyrophosphate;
4. distilled water – to check the effect of immersion;
5. tap water – as suggested by Dvoracsek (1952).

In case of 27 samples with higher clay content (above 35%), we determined the macro-aggregate stability, with 2 g/L Na- pyrophosphate dispersing solution.

Results and Discussion

We found that the most effective dispersing agent was the 2 g/L sodium-pyrophosphate solution (Fig. 1). Cc Calgon caused salt-crystallization in the oven-dried vessels, as it contains too much dispersing agent for this measurement. Diluted Calgon might not dispersed the swelling clay minerals (Goethit) in case of Luvisol_2 sample. Measurements with distilled water had the highest standard deviation, while the quality of tap water was not consistent, and its Ca-carbonate content can cause discrepancy in the measured values.

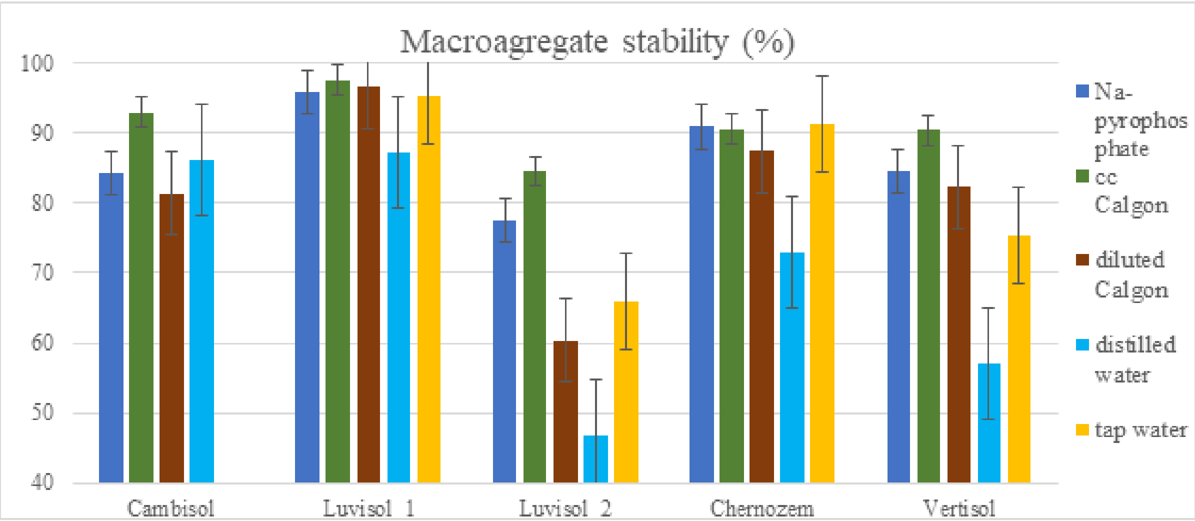

Figure 1. Comparison of MaAS determined with different dispersing solutions

From the 27 samples with high clay content 17 samples showed significant differences between the results measured with 4 g and 2 g. Decreasing sample weight during analysis provided definitely larger aggregate stability for a Chernozem soil, but a definitely smaller aggregate stability for a Solonchak soil. The measured difference of aggregate stability between 2 versus 4 g sample weight showed positive correlation with soil organic matter content and negative correlation with soil $CaCO_3$ and exchangeable potassium contents. These two soils also showed different salinity, alkalinity and sodicity values. We explain the differences of the two sample weights on the basis of the effect soil organic matter for Chernozem, and on the effect of soil salinity/sodicity/alkalinity in the case of Solonchak soil.

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References

Dvoracsek M., 1952. Adatok a talajszerkezet vízállóságának fiziko-kémiai alapjai-hoz. In: Agrokémiai Kutató Intézet 1950-es évkönyve. Mezőgazdasági Kiadó. Budapest. 141–158. (In Hungarian).

Keywords: soil structure, macro-aggregate stability.

Prediction of ^{137}Cs retention by forest Arenosol

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Forest ecosystems retain dust, gases and aerosols from atmosphere and hold potentially harmful elements safe for a longer time in comparison with agroecosystems. Pollutant retention capacity by soils is determined by soil physical, chemical and biological properties and it depends on pollutant nature. Artificial radionuclide's entered the environment from global fallout following the nuclear weapons tests in the atmosphere in the period between 1945 and 1980 and after the accidents of the Chernobyl NPP in April 1986 and the Fukushima Daiichi NPP in March 2011.

The aim of the investigation is to determine the residue of artificial radionuclide ^{137}Cs in 30 km radius of Bel NPP before the start of the operation (1–8 and BAL) and in control sites close to Ignalina NPP (SMA, forest ecosystem) and remote from operating NPP (MAR, fallow ecosystem). The conventional methods were used for determination of main soil properties and activity of radionuclides. PCA analysis revealed *arenosol* features which are the most significant for ^{137}Cs sorption capacity. ^{137}Cs activity is positively interrelated with soil organic matter properties: degree of decomposition and bacterium to fungi ratio. Higher cation exchange capacity, sulphur and phosphorous is related with lower ^{137}Cs activity. Albeit the highest activity of ^{137}Cs occurs in organic soil horizons the highest inventory of ^{137}Cs was determined in A horizon. The human impact on forest ecosystems causes favourable conditions for the highest ^{137}Cs inventories in deeper soil horizons. ^{137}Cs retention in the case of possible new pollution event is the most probable in moss and organic soil horizons. Deeper mineral soil horizons must be investigated for determination of long-term effects and especially for agroecosystems.

Keywords: forest ecosystem, soil properties, ^{137}Cs retention.

Comparison of soil texture on moraine bedrock in the region of Northern Latvia

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In the recent years, an arising problem of soil erosion has been detected. The importance of understanding soil physics is a way of dealing with problems caused by conventional farming and natural erosion. To better the knowledge of soil physical characteristics, two soil profiles have been analyzed.

The first soil profile was located in northern part of Latvia in Valkas region (coordinates: 57.83555540323298, 25.82677572651651), the profile was located on top of a hill and approximately 15 years ago this location was used as a garden, but afterwards grass was sown there and no further fertilization or spraying of pesticides was done. In this profile it was clearly visible that there are signs of erosion, which could have been caused by agricultural activities in that place and even though there has been a meadow for more than 15 years the top layer of soil had visibly low amount of organic matter. When looking at the profile it was noticeable that there was a line of redoximorphic signs that had been accompanied by some podzol processes, because there was a horizon of whiteish matter and the top layers were slightly acidic until this horizon of gley and podzol mix. While testing the pH_{KCl} on the top layer carbonates were established right beneath this dividing line which also correlated with pH_{KCl} of the lower horizons which peaked at the most bottom horizon of about 7.04. This profile also contained a large number of moraines sediments starting at 30 cm interesting discovery was made when in the horizon of the gleyic and podzol properties the rocks were starting to degrade creating saprolites. The soil in the profile was mostly sandy clay which became heavier the lower in the profile we went, with the exception of the bottom horizon, which was notably gravellier than the horizon above that had noticeably fewer sand particles and was mostly clay. After gathering all of the data it was determined that this soil will be classified as *Endocalcaric Stagnic Luvisol* (Loamic, Cutanic) (Fig. 1), because of the horizon with high clay particles below the depth of 100 cm, the carbonate presence below 50 cm, and the stagnic properties in the redoximorphic horizon.

The second profile was located near Ranka (Coordinates: 57.13353, 26.04234). This profile was located on a field. In this case, the soil is formed on a leached moraine. As in the first case, the formation of saprolites is observed in the unwashed part of the moraine. The pH levels were very different, because it ranged from 8 up to 9, as carbonates were discovered on the very top of the profile. The interesting part of this profile was that it had developed on 2 different bedrock material, the top part contained high amount of sand particles (0–79 cm) and the bottom part of the profile was heavy clay (79–200 cm), and the bottom part showed signs that a part of the bedrock material was present within these 2 meters from the soil surface.

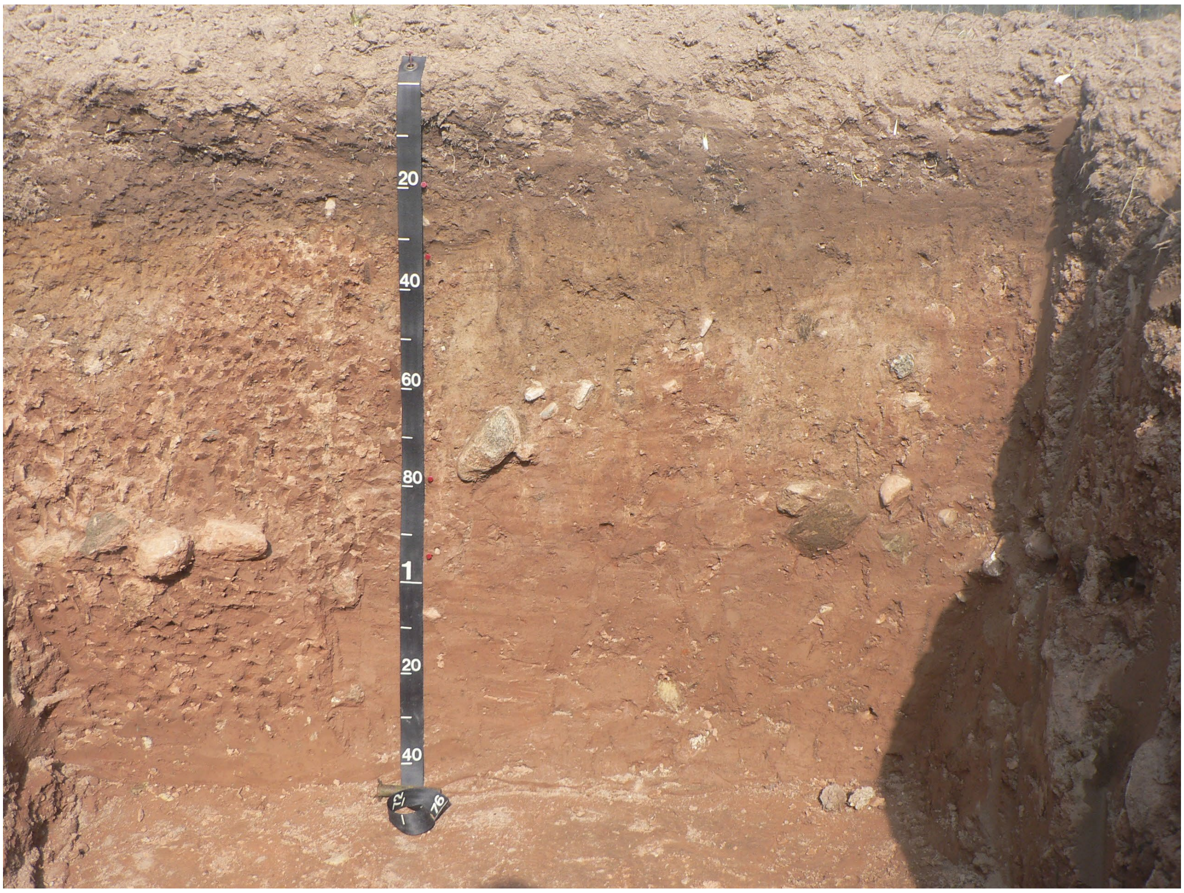

Figure 1. *Endocalcaric Stagnic Luvisol (Loamic, Cutanic)*

The soil near Ranka varies from the first profile by these changes in bedrock material and that is why this soil was classified as Argic *Mollic Raptic Arenosol (Calcalric)* (Fig. 2), because of the high amount of sand in the horizons. Mollic meaning the medium amount of organic matter on the soil surface, and Calcaric because of the high pH which suggest a high concentration of carbonates which also was proved by the use of HCl on the field.

Figure 2. *Argic Mollic Raptic Arenosol* (*Calcalric*)

Keywords: soil texture, *Luvisol, Arenosol*.

Effect of Biological Products and Nitrogen Fertilization on soil physical properties of Winter Wheat crop

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Introduction. The yield of plants and soil quality are determined by many environmental factors. However, abundant, good quality crops are grown only when they are brought as close as possible to their optimal growth, development, wintering, nutrition, formation of crop structure elements and other conditions that very depending on soil characteristics, agrotechnical measures, natural and climatic factors or plant growing technologies used. With the intensification of agricultural production, the use of plant protection products, mineral fertilizers and less organic is increasing. Due to poor farming, intensive land use reduces the potential of the soil, which is partly determined by humus. The physical, agrochemical and biological properties of the soil are closely related to the amount of humus and its qualitative composition, therefore one of the most important tasks is the preservation and restoration of humus. It is also very important to direct the processes of destruction of organic matter in the direction of humification by agricultural means and to maintain their appropriate balance. This is especially relevant in low natural yields, ecologically vulnerable soils of light granulometric composition, where soil fertility is constantly decreasing due to low organic matter content, rapid mineralization processes, low soil sorption capacity and intensive leaching of plant nutrients. One of the most effective measures to support soil structure, stability, hardness and fertility is fertilization with organic fertilizers. In the recent period, with the decline in the use of organic fertilizers, a partial solution to the problem may be fertilizers enriched with humic, amino acids, seaweed extracts, etc. use of plant nutrition activators. Biological products thanks to strengthen the root system, accelerating the process of photosynthesis, increased resistance to adverse environmental factors, improving soil structure, strengthen the immune system of the plant. A distinctive feature of microbiological products is that they are produced by natural fermentation and do not contain chemically synthesized substances. Use of these products reduces the number of pathogenic micro-organisms in the root zone of the plant, improve digestion of organic matter and humus formation process, increases of nutrients (in particular phosphorus) absorption coefficient. Physical soil properties generally have a slow response to management changes, which can make it more difficult to detect changes after changes in soil management.

Methodology. The experiment was conducted in 2019–2020 in the Experimental Station of Vytautas Magnus University Agriculture Academy, in *Calcari-Endohypogleyic Luvisol*, a semi-neutral (pH_{KCl} 6.8), highly phosphorous (226.6 mg kg^{-1} P_2O_5), mid-potassium-level (105.0 mg kg^{-1} K_2O), mid-humus-level (2.33 %) soil. The experiment was carried out in four replications in a winter wheat crop. Experiment treatments: Factor A – biological products: 1) biological products were not used (control), 2) complex of fulvic and humic acids with microorganisms (biopreparation

A) was sprayed (norm 1 l ha^{-1}) in autumn, 3) complex of industrial biological waste (molasses) with microorganisms (biopreparation B) was sprayed (norm 2 l ha^{-1}) in autumn. Factor B – nitrogen rates: 1) fertilized with N_{105}, 2) fertilized with N_{165}. Treatments were arranged randomly. The size of the initial field was 140 m^2, the size of accounting field was 100 m^2.

Results. The soil was treated with Biopreparation B and showed a significant (P<0.05) reduction in microstructural aggregates (Fig. 1). Biopreparation B tended to increase the amount of macrostructural aggregates in the soil. This effect was observed in soils where wheat was fertilized with both rate of nitrogen N_{105} and N_{165}.

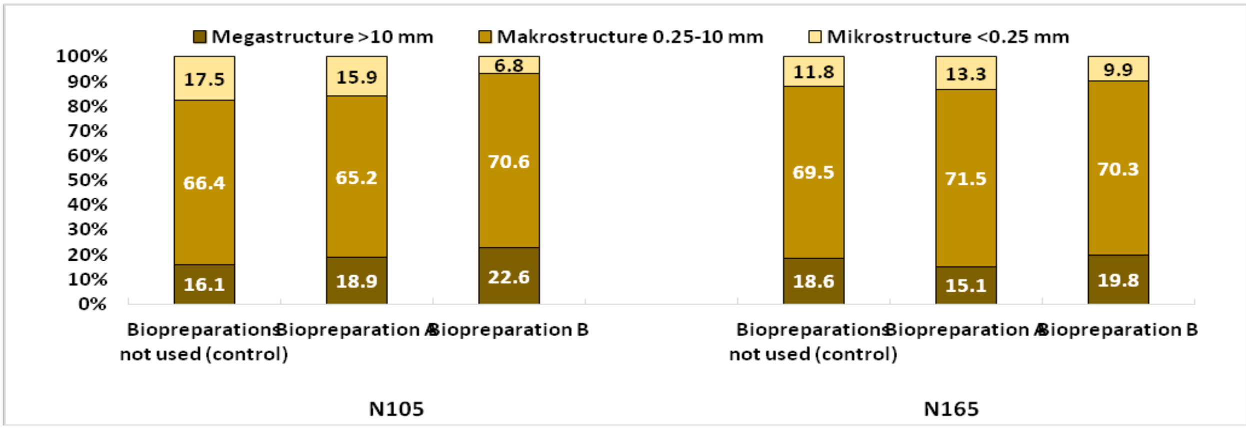


Figure 1. Effect of biological products and nitrogen fertilization on soil structure after harvest

Biological preparation A also tended to increase the amount of macrostructural aggregates in the soil when wheat was fertilized with N_{165}, but did not have a significant effect on the soil structure. Soils with 40–60 % water-resistant aggregates (>0.25 mm) are the most suitable for cultivation. Both studied biological products had a positive effect on the stability of soil structure (Fig. 2). The highest values stability of soil structure was found in the soils treated with biopreparation A were winter wheat fertilized with nitrogen N_{105} rate, while soil stability was 0.4 % lower in the soil were winter wheat fertilized with nitrogen N_{165} rate. Compared to the stability of the soil not sprayed with biological products, product A increased the stability of the soil structure by 48 % on average.

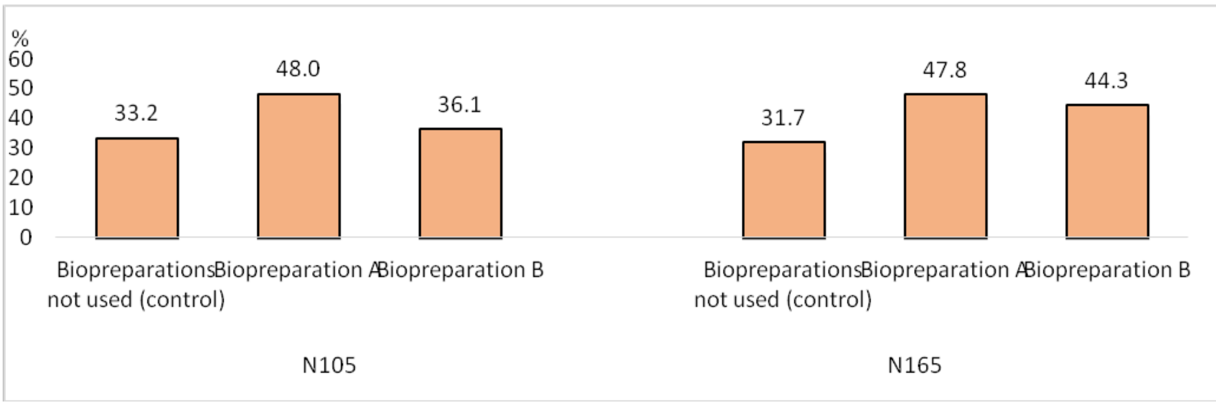
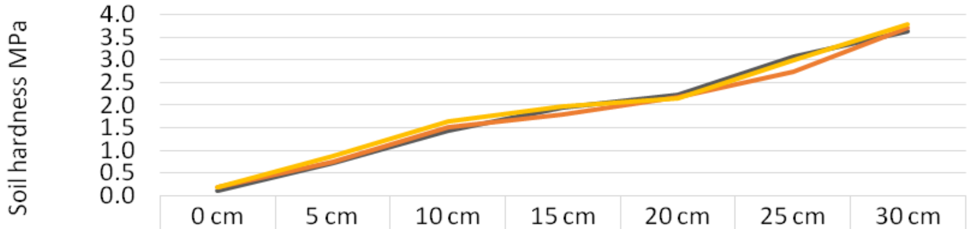


Figure 2. Effect of biological products and nitrogen fertilization on soil stability after harvest

The higher N165 nitrogen rate and biological product B gave significantly higher (23 %) stability of the soil structure than this product at the lower N105 nitrogen rate, although here too the structure was 9 % more stable than the structure of the not sprayed soil.

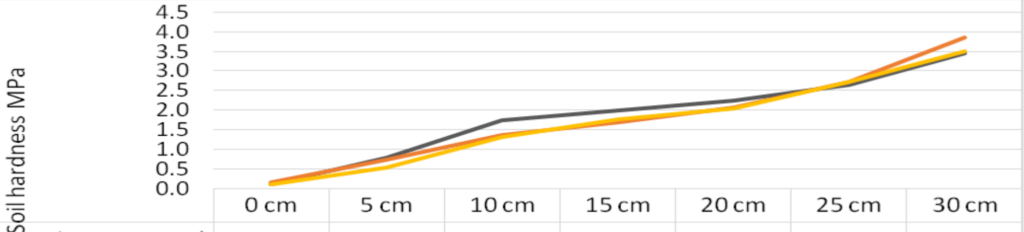
Both biological products tested tended to reduce soil hardness at 20 and 25 cm depth in a wheat crop fertilised with N105 but did not have a significant effect on soil hardness (Fig. 3).



	0 cm	5 cm	10 cm	15 cm	20 cm	25 cm	30 cm
Biopreparations not used (control)	0.12	0.73	1.44	1.94	2.24	3.08	3.64
Biopreparation A	0.18	0.74	1.52	1.80	2.16	2.74	3.70
Biopreparation B	0.19	0.88	1.63	1.96	2.14	3.00	3.78

Figure 3. Effect of biological products and nitrogen fertilization N105 on soil hardness after harvest

At the higher nitrogen rate of N165 in the winter wheat technology, product B showed a significant reduction in soil hardness at 5 and 10 cm depths, which was respectively 32 and 24 % lower than the hardness of the unsprayed soil (Fig. 4). This product also tended to reduce soil hardness in the deeper soil layers of 15 and 20 cm. When wheat was fertilized with N165 at the nitrogen rate, biopreparation A also tended to reduce soil hardness in the layer between 5 and 25 cm but did not have a significant effect on soil hardness.



	0 cm	5 cm	10 cm	15 cm	20 cm	25 cm	30 cm
Biopreparations not used (control)	0.09	0.78 a	1.74 a	1.98	2.25	2.65	3.45
Biopreparation A	0.15	0.73 a	1.37 a	1.69	2.07	2.73	3.86
Biopreparation B	0.10	0.53 b	1.32 b	1.76	2.03	2.71	3.51

Figure 4. Effect of biological products and nitrogen fertilization N165 on soil hardness after harvest

Means, marked with the different letters indicate statistically significant differences (P<0.05)

Biopreparation B and N105 fertilizations significantly (*P*<0.05) increased soil moisture content after winter wheat harvest. Here, the soil was 4,5 percentage points wetter than the soil not sprayed with biopreparations and fertilized with N105 (Fig. 5). Both studied products tended to increase soil moisture when wheat was fertilized with N165 nitrogen.

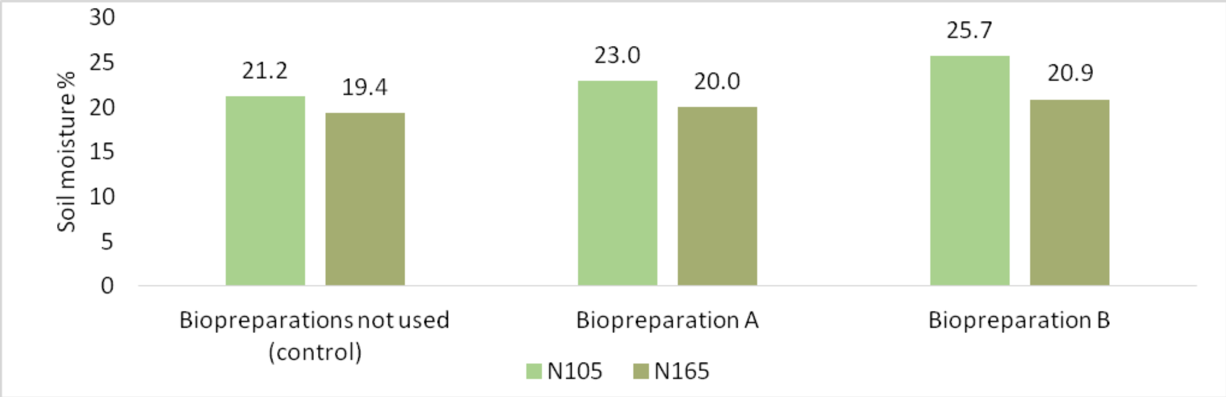


Figure 5. Effect of biological products and nitrogen fertilization on soil moisture after harvest

Main conclusions. Biological product B significantly (P<0.05) reduce the microstructure of the soil by nitrogen fertilization with N_{105}. However, the amount of other soil particles (macro and mega structure) was not significantly affected. Meanwhile, product A significantly increased the amount of soil microstructure by fertilizing winter wheat with N_{165}. Studied products significantly increased the stability of the soil structure in both fertilization rates. The use of biological products in the winter wheat crop increased soil moisture due to increased humus content and reduced soil hardness.

Keywords: biological products, fertilization, nitrogen, winter wheat.

Peculiarities of the physical characteristics of the ordinary chernozem from the village of Negrea, Republic of Moldova

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The diversity of the natural conditions of solification and their interaction with the anthropic factors led to the formation of the territory of Negrea village of a variable and complex soil cover of the Republic of Moldova (Cojocaru et al., 2013). A special feature of the soil cover of the researched area is the absolute predominance of ordinary chernozems in its structure (Cerbari et al., 2002). The main components are the ordinary semicarbonate and weakly carbonate chernozems, which have been eroded by various degrees of erosion. The arable lands occupy 87.3%, the landslides – 12.7% of the total surface of the reception basin in the researched area. Erosion by runoff covers 70–80 percent of the field area. Leaks formed by heavy rainfall destroy the soil, exposing the root system of plants. The annual loss of fertile soil is tens of tons per hectare. The aim of the investigations carried out in the village of Negrea, Hincesti district is to highlight the physical properties of the ordinary chernozem subjected to the erosion process that influences the production capacity of the soil (Cojocaru at al., 2013). At the foot of the slopes, diluvial soils formed. The research methods used are the classical ones. Field research was carried out in early spring and the soil moisture practically corresponded to the field capacity for water (CC). The main results of the research highlight the complexity of the structure of the ordinary chernozem cover, due to the destructive influence of natural factors (Canarache, 1990; Jigau et al., 2002; Jigau, 2008), as well as the intensity of anthropogenic activity that determined the wide manifestation of degradation processes on agricultural lands. The main degradation factor of the ordinary chernozem in the researched area is soil erosion – by runoff at the surface and depth (Cerbari et al., 2010; Cojocaru at al., 2013).

The granulometric composition depends on the production capacity of the soil, its agronomic and ameliorating characteristics, the superior capitalization technology. As the texture is a virtually unchangeable feature, agricultural and improvement technologies must adapt to the textural specificity of the soils (Canarache, 1990). A specific feature of the texture for the researched territory is the high summary content of fine sand and coarse dust which for the soils in the upper part of the reception basin varies in the limits of 20–30%, and for the soils in the middle part – in the limits of 15–17%. This confirms the formation of parent rocks from a mixture of dusty global subaerial loess deposits and local post-alluvial wind deposits with high fine sand content. The highest sand content fin is characteristic of the not eroded ordinary chernozem (Atlas, 1978) located in the upper part of the reception basin on the primary denudation surface of Pliocene age (Pliocene river meadow occupying the whole territory of Moldova). The dusty-sandy loam-clay texture is a main feature of the ordinary chernozem of the reception basin in the hilly area of the Middle Prut, which influences all properties, their suitability for different use, and their production capacity. The high content of fine sand in combination with the low clay content (predominantly 28–34%), ensures a medium cohesion between the elementary soil particles, which determines the comparatively low hydrostability of the structural elements and a medium and low anti-erosion resistance of the soils. On the other hand, the soils of the reception basin, in terms of texture, are suitable for vineyards and orchards. This peculiarity and the favourable climatic conditions determined their unclogging and their use under fruit crops.

According to the dry sieve data, the researched soils are characterized by a favourable agronomic structure, mostly satisfactory, and low hydrostability. Their structure, according to the data of dry sieving, is appreciated as good, and the hydrostability of their structure, according to the data of wet sieving, is classified as satisfactory. This physical property of the soil plays a particularly important role in determining most of the other physical properties. At the humidity corresponding to the physical maturity these soils work comparatively easily, which gives the possibility to form a good germination bed for the agricultural crops. At the same time, this type of texture causes a rather high vulnerability of the soils to the erosion process (Cojocaru, 2014).

The values of the hygroscopicity coefficient (CH) for the researched soils vary in the limits of 8–9% g/g in the upper humiferous horizons and 7–8% g/g in the underlying horizons. The magnitude of the wilting coefficient, calculated with the ratio CO = 1.5*CH, is estimated as medium to high.

Density values increase from 2.63–2.64 g/cm^3 in the horizons from the surface to 2.68–2.72 g/cm^3 in the underlying horizons.

Apparent density is an integral index of the physical quality of soils (Florea et al., 1987). In the 0–20 cm layer of the ordinary chernozems researched, the values of this index vary in spring in optimal limits for arable soils (1.10–1.30 g/cm^3). Under the recently arable layer (0–20 cm) in the soil profiles there is a compact post-arable layer with an apparent density value higher than 1.40 g/cm^3, which negatively influences the water permeability of the soil and increases the risk of erosion. The apparent density for the weakly humiferous underlying horizons of the reception basin soils varies in the range of 1.40–1.55 g/cm^3, characteristic values for chernozems.

The value of the total porosity of the genetic horizons of the researched soils depends mainly on the size of their apparent density. In spring, after autumn ploughing, the surface layer of the researched soils is characterized by comparatively high values of total porosity (54–56% v/v). This index for the post arable underlying horizons (20–35 cm) varies in the range of 46–47% v/v. The soil of this horizon is classified as moderately compacted. Knowing capacity for water (CC) it was possible to determine the aeration porosity. In the spring until sowing, the values of aeration porosity for the genetic horizons of the soils are classified as follows: arable layers – high aeration porosity; post arable layers (20–35 cm) – low aeration porosity; the underlying layers – very low aeration porosity for heavily eroded soil.

In the process of pedological research, the humidity on the 0–100 cm layer of the main soil profiles was determined. According to the results obtained by determination and calculation, the values of water reserves in the 0–100 cm layer of the soils researched in spring to sowing are medium to large and practically identical for all soil units, which is explained by the homogeneity of their texture. The possibility of accumulation of comparatively large amounts of rainwater in the soil is a positive factor that contributes to reducing the risk of soil erosion.

The penetration resistance to field humidity, practically corresponding to CC, is low for the arable layer (5–10 kgf/cm^2) and medium for the underlying layers and horizons of the researched ordinary chernozems (11–20 kgf/cm^2). At the humidity corresponding to the physical maturity, these soils are relatively easy to work, the quality of the basic work being appreciated as good.

In the process of conducting the pedological study, it was found that the soil cover of the receiving basin in the village of Negrea is an example of the indestructible unity between the interaction of soil, vegetation (life), environment and man in a hilly region. Erosion on the territory of the reception basin has become the main factor in the irretrievable destruction of the profile of agricultural soils and the decrease of their production capacity (Cojocaru, 2014).

In general, the climatic conditions and the physical properties of the researched ordinary chernozem are favorable for the growth of crop plants, especially for the founding of vineyards and orchards; their limiting feature is the predominantly high vulnerability of soils to erosion processes.

The main anthropogenic causes of degradation of the soil cover of the researched area are: maximum entrainment of the plowed territory, unfavorable condition of the forest strips, agricultural work along the slope, incorrect location of the road network, insufficient protection of landslides with vegetal carpet, exaggerated share of weeding crops in crop rotations located on slopes after deforestation of perennial plantations, compaction of soils with heavy mechanisms, non-compliance with anti-erosion agrotechnics. The agricultural activity, without taking into account the physical particularities of the soils, the relief, the climatic conditions, leads to the continuous decrease of their fertility and their degradation.

References

1. Atlas of the Moldavian SSR, 1978. pp. 37–44.
2. Canarache, A. 1990. Physics of agricultural soils. Bucharest: Ceres, 268 p.
3. Cerbari, V., Leah, Tamara. 2002. Processes of soil degradation in Moldavia and principal actions intended to prevent soil degradations and environmental aggravations of agriculture. In: Soil under Global Change – a Challenge for the 21st Century. Volume 1. Constanta, Romania, pp. 121–133.
4. Cerbari, V., Constantinov, I., Dobrovolschii, Gr. 2010. Recommendations on combating soil erosion on agricultural land. In: Monitoring the soil quality of the Republic of Moldova (database, conclusions, forecasts, recommendations). Ch.: Pontos, pp. 300–318.
5. Cojocaru, Olesea, Cerbari, V. 2013. Comparative characterization of the properties of not eroded and eroded chernozems from the reception basin of the Middle Prut Plain. In: Agricultural Science, no. 1. UASM. pp. 12–16. ISSN 1857-0003.
6. Cojocaru, Olesea. 2014. The peculiarities of the soils of the reception basin in the village of Negrea and their influence on the erosion processes. In: Agricultural Science, No. 1, State Agrarian University of Moldova, pp. 3–9. ISSN 1857-0003.
7. Florea, N. et al. 1987. Methodology for elaborating pedological studies. Part II. Elaboration of pedological studies for different purposes. Bucharest, 349 p.

8. Jigau, G. et al. 2002. The role of modern processes in the evolution of soil fertility in the Republic of Moldova. In: Materials International. Scientific conference. Part 2. Kiev, pp. 182–184.
9. Zhigeu, G. 2008. Evaluation of factors and systematization of modern processes of evolution of chernozems of the Danube region. In: Agrochemistry and Soil Science. Interdepartmental thematic scientific collection. Problems of classification and diagnosis of soils. Kharkiv, pp. 112–121.

Keywords: ordinary chernozem, physical characteristics.

Influence of biopesticides and intercropping on soil properties in organically grown spring oilseed rape agrocenosis

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One of the main reasons for the slow growth of oilseed rape on organic farms is the problem of plant nutrition, weed, disease and pest control.

Under organic farming, biopesticides should play an important role in the absence of synthetic pesticides. Intercropping intercrops of different botanical families in oilseed rape cover crop would help to address the problems of crop weediness, reducing the spread of diseases and pests, and increasing soil and plant fertility.

The field experiment was carried out in 2020 at the VMU Academy of Agriculture Experimental Station. The soil is a carbonate stagnant leached soil (*Endocalcaric Amphistagnic Luvisol*). Soil agrochemical properties: pH: 6,51–6,92, humus: 2,14–2,67 %, mobile nutrients: P_2O_5: 226–305 mg kg^{-1}, K_2O: 109–118 mg kg^{-1}. The aim of the study was to determine the effect of biopesticides and intercrops of different botanical families on soil structure and shear resistance under organic farming conditions.

The two-factor field experiment is set up using the field splitting method. Experiment options: Factor A: biopesticides: 1) not used; 2) used. Factor B: cover crop: 1) no cover crop; 2) purple (incarnate) clover *(Trifolium incarnatum Broth.)* 'Kardinal' (10 kg ha^{-1}); 3) rye (winter) vetch *(Vicia villosa Roth.)* 'Rea' (50 kg ha^{-1}); (4) perennial ryegrass *(Lolium perenne L.)* 'Merkem' (10 kg ha^{-1}); (5) winter rye *(Secale cereale L.)* 'Elias' (50 kg ha^{-1}).

Soil structure was determined using a Retsch sieving machine. In each field, a soil sample of about 300 g was taken with a shovel from at least 5 locations in the 0–20 cm ploughsoil layer of each field after the rape harvest. A 200 g sample was taken, sieved for 2 min and sieving amplitude was 60%.

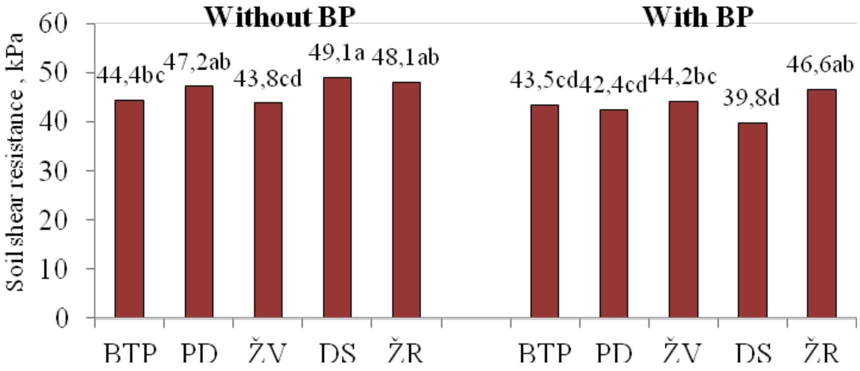

Figure 1. Soil shear resistance in agrocenosis of spring oilseed rape, 2020

Note. The means of the variants not marked with the same letters (a, b, c, d) are significant (P <0.05). Under-sown cover crops: BTP – without under-sown cover crop, PD – crimson clover, ZV – winter vetch, DS – perennial ryegrass; ŽR – winter rye; BP – biopesticides.

In 2020, soil shear resistance was found to be significantly lower by between 7.2 and 10.8% in fields with winter vetch in spring oilseed rape and no biopesticide application compared to fields with purple clover, perennial ryegrass and winter rye.

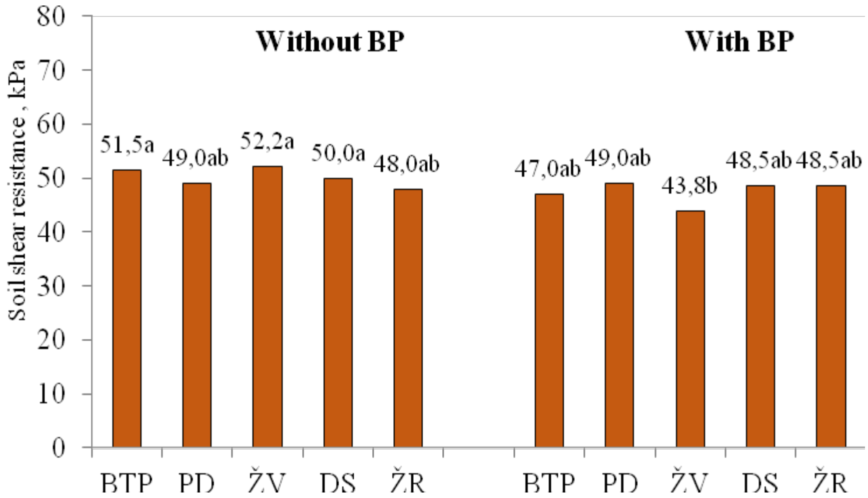

Figure 2. Soil shear resistance in agrocenosis of spring oilseed rape, 2021

Note. The means of the variants not marked with the same letters (a, b, c, d) are significant (P <0.05). Under-sown cover crops: BTP – without under-sown cover crop, PD – crimson clover, ZV – winter vetch, DS – perennial ryegrass; ŽR – winter rye; BP – biopesticides.

In 2021, the soil shear resistance in the winter vetch cover crop after the application of biopesticides was significantly 16.1% lower than in the plots without biopesticide application.

Table 1. Percentage of structural aggregates in spring rape agrocenosis, 2020

Under-sown cover crops (factor B)	*Biopesticides (factor A)*	*Soil Structure*		
		Mega >10 mm	Makro 0.25–10 mm	Mikro <0.25 mm
1. Without under-sown cover crop	-	68.5a	29.0b	2.44a
	+	59.4ab	38.0ab	2.54a
2. Crimson clover	-	66.6ab	30.6ab	2.86a
	+	52.4b	44.5a	3.15a
3. Winter vetch	-	66.8ab	30.9ab	2.25a
	+	59.3ab	37.7ab	2.96a
4. Perennial ryegrass	-	60.9ab	36.7ab	2.36a
	+	51.8b	44.7a	3.44a
5. Winter rye	-	60.0ab	37.1ab	2.91a
	+	64.4ab	32.5ab	3.13a

Note. The means of the variants not marked with the same letters (a, b) are significant (P<0.05). Biopesticides not used, + - biopesticides used.

In 2020, mega-aggregates were the most abundant in all fields tested. This is probably due to the lack of moisture in the autumn months. The highest levels of mega-aggregates (68,5 %) were found in the fields without cover crop and without the use of biopesticides.

Table 2. Percentage of structural aggregates in spring rape agrocenosis, 2021

Under-sown cover crops (factor B)	*Biopesticides (factor A)*	*Soil Structure*		
		Mega >10 mm	Makro 0.25–10 mm	Mikro <0.25 mm
1. Without under-sown cover crop	-	36,0a	59,8c	4,20b
	+	19,0b	76,4a	4,60b
2. Crimson clover	-	36,3a	57,9c	5,80ab
	+	23,7b	71,3ab	5,00ab
3. Winter vetch	-	35,9a	60,5bc	3,60b
	+	20,9b	71,3ab	7,80a
4. Perennial ryegrass	-	25,6ab	68,2abc	6,20ab
	+	28,6ab	66,7abc	4,70ab
5. Winter rye	-	27,4ab	67,1abc	5,50ab
	+	21,0b	72,8a	6,20ab

Note. The means of the variants not marked with the same letters (a, b) are significant (P<0.05). Biopesticides not used, + - biopesticides used.

In 2021, the highest share of macro-aggregates ranged from 57.9% to 72.8%. In fields without cover crop and without biopesticide use, a significantly higher content of mega-aggregates was found by a factor of 1.9 compared to fields with biopesticide use.

Keywords: biopesticides, intercropping, soil properties, spring rape agrocenosis.

Changes in soil organic matter in apple orchards as a result of long-term herbicide use

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As concerns about the impact of the agricultural footprint on GHG emissions increase, it is important to develop an in-depth understanding of the impact of agricultural technologies on soil organic matter change. In a study in three apple orchards in Latvia (Dobele, Bauska, Saldus,), where technogenic fallows is used, with a duration of herbicide use of at least 10 years, in the spring of 2021, an average sample of arable land was randomly collected. Using the Wokley-Black method, the easily oxidizable carbon, the total carbon and the percentage of organic matter in the air-dry mass of the sample were determined in four replicates. The row between the fallows of each apple orchard (lawn) was used as a control. The study found that with a significance level of 0.05, the location of the apple orchard has no significant effect on the amount of organic matter in the soil. The use of herbicides has had a significant effect on changes in soil organic matter on all farms. Easily oxidizable carbon in the Dobele grass band is on average 1.64±0.01%, in the furrow 1.33±0.004%, in the Bauska grassland: 1.77±0.02%, in the furrow 1.38±0.00001%, in the Saldus grassland 1.69±0.008%, in the furrow 1.42±0.0006%. The total soil carbon in the Dobele grassland is on average 2.14±0.02%, in the soil 1.72±0.007%, in the Bauska grassland: 2.30±0.04%, in the soil 1.79±0.0002%, in the Saldus grassland 2.19±0.01%, in the soil 1.84±0.001%. The amount of soil organic matter in the grassland zone in Dobele is on average 6.33±0.16%, in the soil in 5.11±0.06%, in Bauska grassland: 6.81±0.32%, in the soil 5.31±0.001%, in Saldus grassland 6.50±0.12%, in the soil 5.46±0.008%. Soil organic matter levels in all farms are significantly lower than in the grassland. Soil organic matter and carbon decreased in Dobele by 19.29%, in Bauska by 22.01% and in Saldus by 15.95%. These rates correlate with the duration of herbicide application. Bauska has historically the highest number of herbicide applications and Saldus the lowest.

Keywords: soil, organic matter, GHG, herbicides.

Modification of soil water and thermal regimes, and soil properties due to various surface covers in urban areas

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Different modifications of the soil surfaces, which are found in the urban environment, significantly affect the soil water and temperature regimes. Alternations of these regimes due to modifications of soil covers may lead to changes in soil properties. Therefore, the goal of this study was to find out how soil properties, particularly soil structure and soil hydraulic properties changed during our experiment, which has been mainly focused on the monitoring of soil water and thermal regimes under five different surface covers (bare soil, bark chips, concrete, mown grass, and unmown grass). The surface of a Haplic Chernozem (which was originally covered by grass) was modified in the autumn 2012. Since then, climatic conditions are monitored, and soil water contents and temperatures are measured at the depths of 10, 20, 30, 40, 60, and 80 cm. In the summer 2020, after removal of the surface over, intact soil samples were taken, on which the hydraulic properties were measured using the multistep outflow method. Another set of the undisturbed soil samples was used to study soil structure using the X-Ray computer tomography. In addition, these samples were next used to prepare thin soil slides for micromorphological analyses. Along with soil sampling, the measurement of some characteristics took place directly in the field. The mini disk tension infiltrometer with a disk radius of 2.22 cm was used to measure unsaturated hydraulic conductivities for pressure head of –2 cm. The net CO_2 and net H_2O efflux were measured using the LCi-SD portable photosynthesis system with a Soil Respiration Chamber. The CT and micromorphological analyzes showed that while the soil under the bare surface showed small aggregates and small interaggregate pores, the soil under the grass cover was formed by large aggregates with large pores formed by roots and organisms living in soils. Soil structure under concrete or bark chips was compact with thin fractures and few pores created by organisms living in soils. However, porosity under bark chips was larger than that under concrete likely due to better conditions, i.e., larger amount of the organic matter content due to the decomposition of organic mulch. Measured soil properties reflected character of soil structure.

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Keywords: soil water, thermal regimes, soil properties, urban areas.

Soil quality as recovery indicator in an Andean Colombian nature reserve

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Soils provide essential ecosystem services that support the existence of ecosystems and biodiversity. It is critical to understand soil quality and thus to evaluate ecological processes related to vegetation. Few studies have considered soil quality as an indicator of the effectiveness of ecosystem restoration in tropical mountain areas. This study evaluates soil quality criteria for land uses in conservation, restoration, crops, degraded regions, and ecological succession; and assesses physical, chemical, and biological properties. It focuses on preliminary results of properties such as texture, bulk density, aggregate stability, infiltration, saturated hydraulic conductivity, soil penetration resistance and soil organic matter as quality indicators concerning land use and actual restoration conditions. Descriptive classes with values between 1 and 10 were used to evaluate the different items. Those between 8 and 10 indicate an improvement in soil conditions and the success of the restoration process. These results allow understanding of soil quality changes under different uses and provide a practical basis for evaluating ecological restoration methods in the Colombian Andes conditions.

Keywords: soil physics, soil degradation, soil quality, tropical mountains, ecosystem services.

Impact of different land management on soil structure and organic matter qualitative indicators

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Enhancement of soil organic carbon (SOC) sequestration and soil structure stabilization are targeted goals in agroecosystems to increase crop yield, reduce erosion, and mitigate climate change (Zang et al., 2018; Cooper et al., 2020). Generally, organic matter is occluded by soil aggregates physically that hinder microbial degradation of plant and microbial residues (Abiven et al., 2009), thereby holding a fundamental keystone in soil C sequestration (Six et al., 2002). The sequestration of SOC and its response to different soil management practices are largely related to physical properties of soil (Zhu et al., 2015), which comprised different sizes of aggregates. The size distribution of water-stable aggregates reflects the physical structure properties of soil and influences soil function, such as storing SOC, providing physical defense against SOC loss, and constructing soil pore structure for nutrient supply (Cotrufo et al., 2015). As such an understanding of soil aggregate stability and subsequent C sequestration is imperative for sustainable management of agroecosystems. Studying the impact of tillage and fertilization on soil SOC content and aggregate is essential to define better strategies for improving soil structure and SOC sequestration. The aim of this study was to investigate the influence of tillage of different intensities (deep ploughing, shallow ploughing and shallow ploughless tillage) and their combinations with organic fertilizers on the soil aggregate composition, aggregate stability and organic carbon accumulation in *Retisol.*

The field experiment was carried out at the Vežaičiai Branch of Lithuanian Research Centre for Agriculture and Forestry during the period between the years 2012 and 2019. The soil of the experimental site is *Dystric Bathygleyic Glossic Retisol* with a texture of moraine loam (clay content 13–15%). The experiment consisted of three tillage methods – deep ploughing (22–25 cm), shallow ploughing (12–15 cm) and shallow ploughless tillage (8–10 cm). As organic fertilizer, farmyard manure (40 t ha^{-1}) was incorporated into soil. Soil samples were taken from the three layers of the soil profile: the upper 0–10 cm, middle 10–20 cm and the lower 20–30 cm.

The study revealed that shallow ploughing created the better conditions for chemical moraine loam soil properties (pH, organic carbon, organic carbon qualitative indicators) in arable and deeper layers (up to 30 cm depth), while long-term shallow ploughless tillage influences the differentiation of the arable layer into two layers: carbon-rich 0–20 cm and these elements substantially less rich 20–30 cm layers. Shallow ploughless tillage exerted the transformation of carbon compounds changes in the direction of polymerization of humic acids, which creates more favorable conditions for carbon sequestration. The incorporation of organic fertilizers (FYM) has reduced soil acidification and increased the accumulation of organic carbon and nutrients in the soil. In the humid and warm climate of Western Lithuania, the replacement of traditional deep plowing with less intensive tillage – shallow ploughing and shallow ploughless tillage had a positive effect on the aggregate composition of moraine loam soil and the amount of water stable aggregates. In the case of long-term shallow ploughless tillage, the soil with better structures remains only in the upper 0–10 cm arable layer, and in the deeper layers, water-stable aggregates, especially >0.25 mm, tended to decrease. This indicated that the lower SOC contents in the treatment, where shallow ploughless tillage was applied, have hastened the decomposition of humus and the deterioration of soil aggregates while in shallow ploughless tillage with application of FYM might be responsible for increased not only for SOC content and the stabilization of aggregates as well as higher mean weight diameter of soil aggregates. These experimental results showed that great opportunities exist to change deep ploughing with alternative and more environmentally friendly techniques.

References

1. Zhang, D. B., Yao, Z. Y., Chen, J., Yao, P. W., Zhao, N., He, W. X., Li, Y. Y., Zhang, S. Q., Zhai, B. N., Wang, Z. H., Huang, D. L., Cao, W. D., Gao, Y. J., 2019. Improving soil aggregation, aggregate-associated C and N, and enzyme activities by green manure crops in the loess plateau of China. *Eur. J. Soil Sci.* 70, 1267–1279.
2. Cooper, J., Greenberg, I., Ludwig, B., Hippich, L., Fischer, D., Glaser, B., Kaiser, M., 2020. Effect of biochar and compost on soil properties and organic matter in aggregate size fractions under field conditions. *Agric. Ecosyst. Environ.* 295, 106882
3. Abiven, S., Menasseri, S., Chenu, C., 2009. The effects of organic inputs over time on soil aggregate stability – a literature analysis. *Soil Biol. Biochem*. 41, 1–12.
4. Six, J., Conant, R., Paul, E .A., Paustian, K., 2002. Stabilization mechanisms of soil organic matter: implications for C-saturation of soils. *Plant Soil* 241, 155–176
5. Zhu, L., Hu, N., Zhang, Z., Xu, J., Tao, B., Meng, Y., 2015. Short-term responses of soil organic carbon and carbon pool management index to different annual straw return rates in a rice–wheat cropping system. *Catena* 135, 283–289.
6. Cotrufo, M. F., Soong, J. L., Horton, A.J., Campbell, E. E., Haddix, M. L., Wall, D. H., Parton, W. J., 2015. Formation of soil organic matter via biochemical and physical pathways of litter mass loss. *Nat. Geosci.* 8.

Keywords: land management, soil structure, organic matter, qualitative indicators.

Influence of environmental factors and root network on CO_2 efflux in grassland and forest land of Western Lithuania

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Due to climate changes the question of CO_2 efflux from the soil became of great importance. The effects of root network, soil temperature, and volumetric water content on soil CO_2 efflux were investigated in three (2017–2019) years experiment on *Retisol* near Bijotai, Šilalė district, Western Lithuania.

The temporal dynamic changes of CO_2 efflux from the soil surface using a closed chamber method (LI-COR LI-8100A) have been investigated 6 times per growing season in 2017, 2018 and 2019 under grassland and forest land. Soil temperature and volumetric water content changes were investigated during CO_2 efflux measurement at 5 cm soil depth by a portable sensor HH2 WET. For the root network investigations soil samples were collected from topsoil (0–10 cm) at the flowering stage of plants. Analysis of root volume, root length density and mean root diameter were done using the PC software *WinRhizo* (Bouma et al., 2000).

Results and discussion. The soil CO_2 efflux under different land use during growing season varied from 0.67 to 2.25 µmol CO_2 m^{-2} s^{-1} in 2017, from 0.88 to 2.69 µmol CO_2 m^{-2} s^{-1} in 2018, from 0.67 to 2.99 µmol CO_2 m^{-2} s^{-1} in 2019. The average soil CO_2 efflux in 2017 was 12% lower than in 2018 and 14% lower than in 2019.

Soil temperature during growing season varied from 11.9°C to 20.4°C in 2017, from 11.9°C to 25.5°C in 2018, from 7.6°C to 25.1°C in 2019, with averages of 16.2°C, 19.6°C and 17.1°C at 0–5 cm soil depth in 2017, 2018 and 2019, respectively. Soil temperature averaged, in 2017 was 17% lower than in 2018 and 5% lower than in 2019. Soil temperature averaged across years, in the grassland was 3% higher than in the forest land.

Volumetric water content of the soil during growing season varied from 14.4% to 40.5% in 2017, from 8.7 to 45.6% in 2018, from 11.6 to 31.2% in 2019, with averages of 26.6%, 26.4% and 20.4% in 2017, 2018 and 2019, correspondently. Volumetric water content averaged, in 2017 was 1% higher than in 2018 and 23% higher than in 2019. Volumetric water content averaged across years, in the forest was 1% lower than in the grassland.

The root parameters' investigation had shown that the effect of land use was significant ($P < 0.01$) for root volume and length root density, but not significant for mean root diameter. The effect of year was not significant ($P > 0.05$) for all root parameters. The root volume in the forest was 2.2-fold lower than in the grassland in *Retisol* and the length root density in the grassland was 7.3-fold higher than in the forest, also the grassland had the 1.1-fold higher mean root diameter, what confirms that the reduction in parameters of the root depended on land-use. Was revealed that the soil CO_2 efflux has a positive linear relationship with root volume (R^2=0.44, P <0.05) at the 0–10 cm depth and with length root density (R^2=0.92, P <0.01) at the same depth.

Conclusions. The study confirmed that the root network development, soil temperature, volumetric water content and a type of a land-use contributed significantly to the soil-atmosphere exchange of CO_2 efflux. Was determined that the average soil CO_2 efflux in grassland was 32% higher than in forest land. The CO_2 efflux, average across land-use, tended to increase in the following: 2017<2018<2019. Due to dry and high-temperature meteorological conditions, the CO_2 efflux of soil increased by 14%. Also, soil temperature (up to 20°C) and volumetric water content (up to 23–25%) had a positive influence on the soil CO_2 efflux. We established that the root's activity plays one of the main roles in the production CO_2 rate – in both land-use the soil CO_2 efflux was influenced by length root density and root volume.

References

Bouma T.J., Nielsen K.L., and Koutstaal B., 2000. Sample preparation and scanning protocol for computerized analysis of root length and diameter. *Plant Soil,* 218(2), 185–196.

Keywords: environmental factors, root network, CO_2 efflux.

Leaching of micropollutants from beds irrigated with wastewater or amended by biosolids, and their uptake by planted vegetables and maize

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Various micropollutants (including pharmaceuticals, UV filters, cosmetics, cleansers, etc.), are increasingly being detected in the environment because of their partial or incomplete removal from wastewater in wastewater treatment plants (WWTPs). These compounds can leach towards the groundwater or can be taken up by plants if treated wastewater is used for irrigation or if biosolids are used for soil amendment. The aim of this study was to evaluate a behaviour of selected compounds from these sources in two soil types. Experiment was carried out directly in the wastewater treatment plant, where nine raised beds were installed, which contained soils taken from topsoil of two soil types *Arenosol* (two beds) and *Cambisol* (seven beds). Either maize or a mixture of different vegetables (lettuce, carrot and onion) was grown in these beds. Of the seven beds with the *Cambisol*, one of the beds containing either maize or vegetables was irrigated with tap water and other pair of beds (maize or vegetables) was irrigated with treated wastewater (i.e., WWTP effluent). In another pair of beds (maize or vegetables), composted sludge from WWTP Three beds containing both types of biosolids were irrigated with tap water. Only vegetables were grown in the beds with the *Arenosol*, which were irrigated with either tap water or treated wastewater. Selected compounds concentrations were measured in WWTP effluent, both biosolids, solution drained from the beds, soils, and plant tissues. Fifty five of 77 analyzed compounds were quantified in WWTP effluent. Interestingly larger spectrum of compounds was quantified in solution leached from the *Cambisol* beds (10) in comparison to that from the *Arenosol* beds (6). Ten and eleven compounds were quantified in the sewage sludge and composted sludge, respectively, and 2 compounds were quantified in solution leached from the beds. Uptake of selected compounds was observed mainly for vegetables planted in the beds irrigated by effluent.

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Keywords: micropollutants, leaching, uptake, vegetables, maize.

Long-term soil tillage systems and cover crop management effects on soil physical properties and plant root growth

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Root length, diameter and volume are very important measures to understand plant and soil functions. Root growth and development of agriculture crops depend on the plant species, soil texture and properties, agronomic practices. Soil and crop management practices such as tillage and CC can influence soil physical properties like the bulk density, water content, pore size distribution and water infiltration, and these may in turn influence the plant root growth. The main purpose of this study was to assess the effects of long-term tillage and cover crop management on the soil physical conditions, and it's influence on soil plant root growth.

The investigations were performed in a long-term experiment established in 2012 of the Institute of Agriculture (55°23′50``N and 23°51′40``E) of Lithuanian Research Centre for Agriculture and Forestry (LAMMC) in Dotnuva, Kedainiai district, Central Lithuania. According to World Reference Base the soil was classified as an *Endocalcari – Epihypogleyic Cambisol*, of a loam texture. The experiment was of two factors: tillage (ploughing (DD), harrowing (DH) and direct drilling (DD)) as main plot and cover crop (with cover crop (CC) and without cover crop (NC)) as sub-plot. Cover crop seeds were spread out using a fertilizer spreader: white mustard (*Sinapis alba* L.) approximately 3 weeks before the planned harvest of spring barley.

Soil physical parameters were determined by a laboratory sorption method. Undisturbed soil samples were taken with steel cylinders (diameter 5 cm, volume 100 cm^3) from 5–10 and 15–20 cm layers from eight replications when the soil moisture content was close to field capacity. The laboratory research results obtained by his method were used to calculate total soil porosity, soil pore–size distribution and bulk soil density in the soil. Soil samples for root investigation were taken from spring barley stand at crop flowering (BBCH 63–65) stage at three replications from 0–10 and 10–20 cm soil depths. Root length and root diameter image analysis was done with the software WinRHIZO. Statistical analysis was performed with the statistical software package SAS 7.1 to assess the statistical significance of the differences between the mean values using Duncan's multiple range tests at the probability level of $P < 0.05$. Correlation-regression analysis was also implemented. The standard error values were used to construct error bars.

Significantly higher total porosity and microporosity, in 0–20 cm layer, was identified in the DP treatment, with and without CC The DD contributed to significantly lower total porosity and macroporosity, but did not change meso- and microporosity, compared to DP. The soil layer significantly increases total porosity, which was higher in 0–10 cm soil depth for all tillage treatments in both CC backgrounds. The CC significantly increased soil micropores and decreased mesopores for all tillage treatments in both depths. The influence of the cover crop – tillage handling interaction was significant for total and meso-porosity.

Significantly higher soil bulk density of the topsoil, was determined in DD tillage, without CC. In DP and DD with CC background soil bulk density was lower than NC. Soil bulk density increased with soil depth in all tillage systems. In 10–20 cm soil layer the significantly higher bulk density was determination in DH and DD tillage with CC. In DP soil with CC background tended to decrease bulk density.

Soil bulk density in the upper profile under DD (1.64 g m^{-3}) system was higher than that under DH (1.58 g m^{-3}) and DP (1.54 g m^{-3}) tillage, leading to a decrease in root length but root diameter was significantly higher under a DD (0.35 mm) treatment than DP (0.31 mm) and DH (0.31 mm) tillage. Application of CC tended to decrease soil bulk density and increase root diameter and volume for all tillage treatments in 0–20 cm depth. The influence of the cover crop – tillage handling interaction was significant for soil bulk density and root diameter.

Root development of spring barley depended on the soil and crop management practices. The tested root development parameters – length and diameter – depended also on the plant species. Our research data showed that the root length of spring barley positively correlated with soil total porosity ($r = 0.38$, $P < 0.05$), while with bulk density ($r = –0.38$, $P < 0.05$) correlation was negative. Root volume positively correlated with soil macroporosity ($r = 0.40$, $P < 0.05$) and with total porosity ($r = 0.41$, $P < 0.05$) and the correlation with bulk density ($r = –0.41$, $P < 0.05$) was negative.

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Keywords: ploughing, harrowing, no-tillage, cover crop, soil physical properties, root growth.

Can Munsell colour indices be used for identification of sandy post-boggy soils?

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Munsell soil colour charts are widely used for soil classification, especially to define diagnostic properties in many soil classification systems. Soil colour is used for estimation of organic matter content and other soil components (Jorge et al., 2021). Munsell colour seems to be useful to identify sandy post-boggy soils, which differ markedly in organic matter content. In soil landscape they constitute a transition zone between organic soils (murshic soils) and humose sands (*Arenosols*). Polish Soil Classification (PSC) 2019 (Kabała et al., 2019) distinguishes semimurshic soils (Polish – gleby murszowate) and postmurshic soils (Polish – *gleby murszaste*). Sandy post-boggy soils are the result of intensive dewatering of shallow peat deposits underlined by sands or originate directly from dewatering of *Gleysols*. Such soils occur on peatlands borders but are especially common on outwash plains where they cover vast areas. Enhanced (in comparison to typical peat soils) content of mineral matter (sand and silt fractions) is due to the following processes: i) deposition by river floods, ii) pedoturbations (mixing of surface layers with mineral subsoil, iii) aeolian deposition from surrounding sandy areas.

This study was conducted to answer the following questions: (1) can soil colour be a reliable proxy for organic matter, organic carbon and total nitrogen content in sandy post-boggy soils?, (2) whether Munsell colour can be helpful in identification of the following soil materials: mursh, semimurshic, postmurshic?, (3) whether colour indices can be used to determine boundary between soil materials containing 6% $C_{org.}$ and 12% $C_{org.}$?

Sandy post-boggy soils belonging to the following units (subtypes) of Polish Soil Classification (PSC, 2019): thin murshic soils (WRB, 2015: *Murshic Histosols; Histic Gleysols*), typical semimurshic soils (*Mollic/Umbric Gleysols* (*Arenic, Humic*), and to postmurshic soils (Umbric *Gleysols (Arenic, Nechic*) were studied. Collected samples were air-dried, visible roots and other living plant remnants were removed manually, the soil was gently crushed with a rolling pin, and sieved through a 2 mm steel sieve. In air-dried soil samples loss-on-ignition (LOI) after ashing during 6 hours at a temperature of 550 ºC, which approximates the amount of soil organic matter (SOM). Total organic carbon ($C_{org.}$) and total nitrogen ($N_{tot.}$) contents were measured with a Vario Max Cube CN Elementar analyser. All analyses were performed in duplicate. All results were expressed on the oven-dry soil weight basis (the temperature of drying 105°C). According to the location in soil profile, samples were divided into surface (187) and sub-surface ones (139). Based on $C_{org.}$ content, surface soil samples were divided according to diagnostic criteria of PSC (2019) into three groups: ≥12.0% $C_{org.}$ – murshic; ≥6,0 – <12.0% $C_{org.}$ – semimurshic; ≥0,6 – <6.0% $C_{org.}$ – postmurshic. Dry soil colour was determined in natural diffuse light conditions by applying Munsell colour charts (Munsell Colour Company, 1994). The following colour indices, found in the literature, were correlated with soil organic matter variables (SOM, $C_{org.}$, $N_{tot.}$): value of dry soil (V); chroma of dry soil (Ch); V+Ch; V+½Ch; V×Ch; V/Ch.

Among tested Munsell colour parameters, V displayed the strongest correlation with SOM variables. It is possible to estimate SOM as well $C_{org.}$ and $N_{tot.}$ content in the soils studied using value component of the Munsell colour system. Both surface and subsurface soil materials differ significantly in respect of Munsell value, therefore it is possible to identify them using this color parameter. Median value for murshes averaged 2.5, for semimurshic materials 3.0, and for postmurshic ones 4.5. The interquartile ranges (25%–75%) of Munsell value among distinguished soil materials do not overlap each other (Fig. 1).

Classification and Regression Trees (C&RT) analysis (Breiman et al., 1984; Ripley, 1996) demonstrated that all soil materials studied (surface and subsurface) can be successfully divided based only on Munsell value. Soil materials having <6,0% $C_{org.}$ displayed value >3.125. On the contrary, soil materials having ≥12.0% $C_{org.}$ displayed value ≤2.625 (Fig. 2). However, for surface soil materials C&RT analysis proved that the best classification can be obtained using summation V+Ch. For murshes this index is ≤4.875, and for postmurshic materials >5.125. V/Ch quotient demonstrated significant correlation with SOM, $C_{org.}$ and $N_{tot.}$ contents but only in surface soil materials. This quotient is within 1–2 in the group of murshes and semimurshic soil materials but is within broader range (1–5) in the group of postmurshic materials.

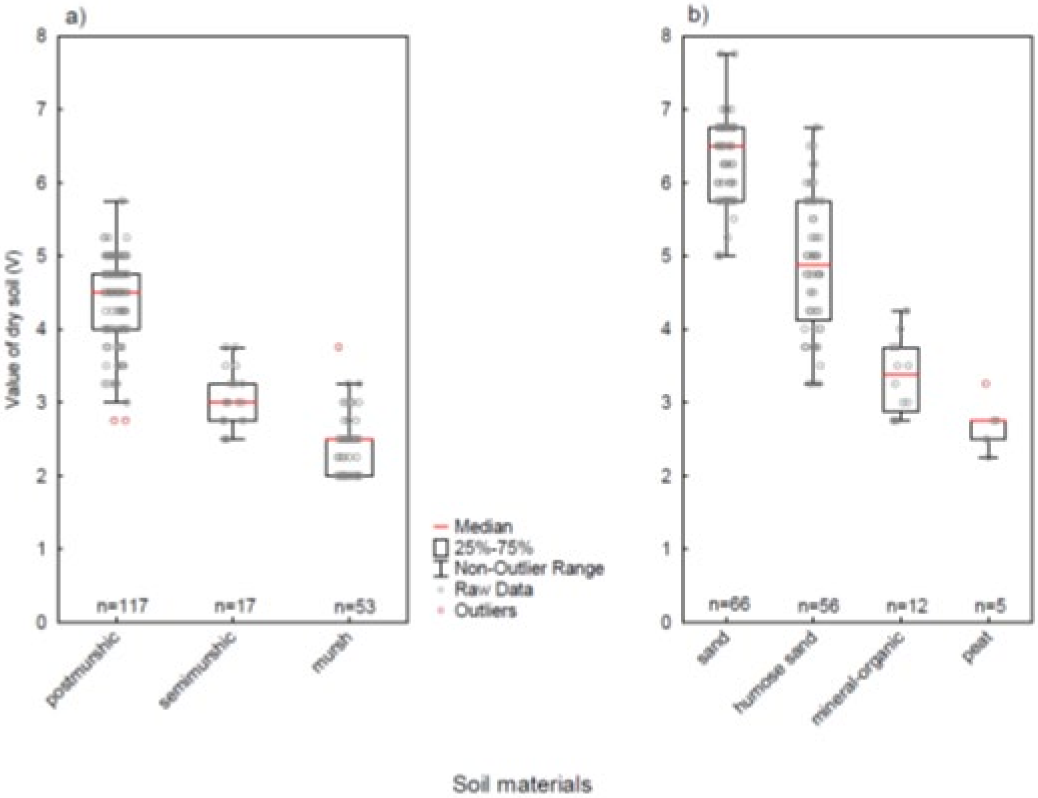

Figure 1. Munsell value of surface (a) and sub-surface (b) soil materials

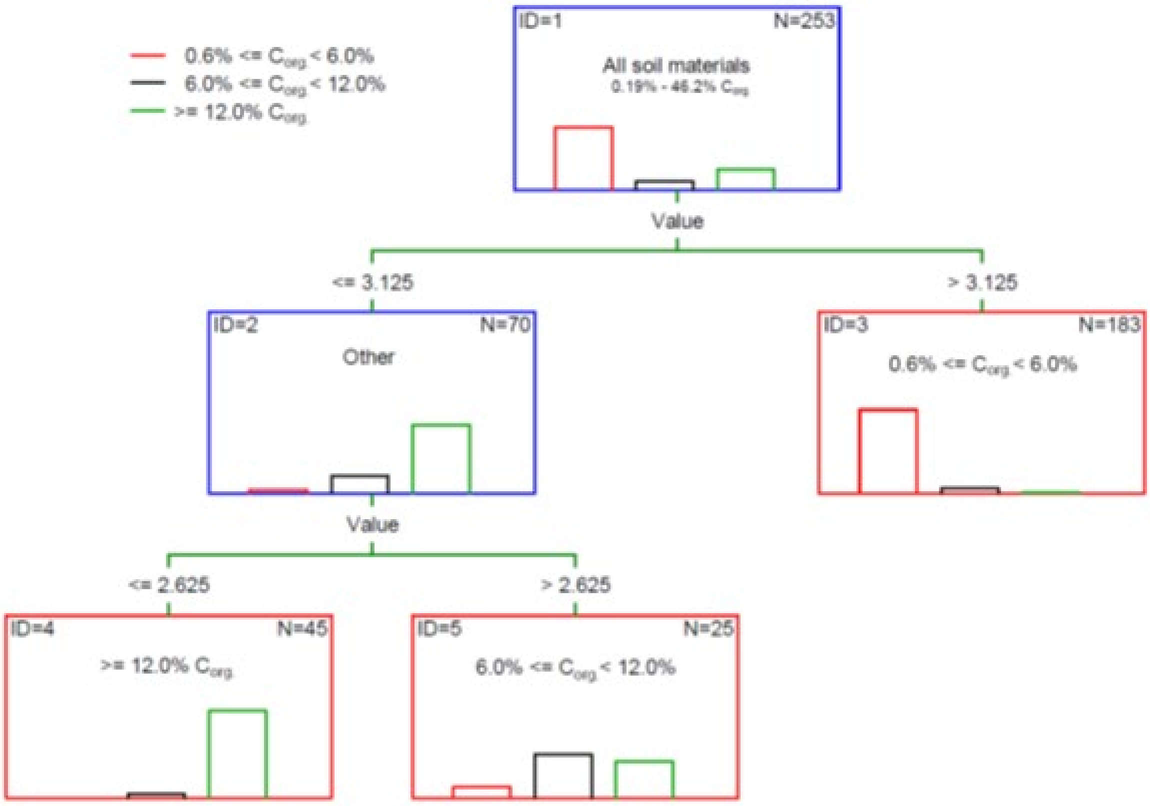

Figure 2. Classification and regression tree for all soil materials distinguished on organic carbon content

Conclusions

1. Among the tested Munsell colour parameters (V, Ch, V+Ch, V+0.5Ch, V×Ch, V/Ch), the strongest correlation with soil organic matter displayed value. In investigated soils it is possible to estimate SOM, as well as $C_{org.}$ and $N_{tot.}$ content using Munsell value. In surface soil materials Munsell chroma is without greater predictive importance in respect of SOM, because these soil materials do not contain (except murshes) considerable amounts of colourful iron oxides.
2. Both surface and subsurface soil materials differ significantly in respect of Munsell value, therefore it is possible to identify them using this colour parameter.
3. Classification and Regression Trees (C&RT) analysis demonstrated that all soil materials studied can be successfully divided based only on Munsell value. Soil materials having <6.0% $C_{org.}$ displayed value >3.125.

References

1. Breiman, L., Friedman, J. H., Olshen, R. A., Stone, C. J., 1984. Classification and regression trees. Wadsworth & Brooks/Cole Advanced Books & Software, Monterey, CA: 358 pp.
2. IUSS Working Group WRB, 2015. World Reference Base for Soil Resources 2014, update 2015. World Soil Resources Report No. 106, FAO, Rome: 212 pp.

3. Jorge, N.F., Clark, J., Cárdenas, M.L., Geoghegan, H., Shannon V., 2021. Measuring soil colour to estimate soil organic carbon using a large-scale citizen science-based approach. Sustainability 13, 11029. https://doi.org/10.3390/su131911029
4. Kabała, C., et al., 2019. Polish Soil Classification, 6th edition – principles, classification scheme and correlations. Soil Science Annual 70(2), 71–97. https://doi.org/10.2478/ssa-2019-0009
5. Munsell Color Company, 1994. Munsell Soil Color Charts, Revised Edition. Macbeth Division of Kollmorgen, New Windsor, NY.
6. Ripley, B. D., 1996. Pattern Recognition and Neural Networks. Cambridge University Press, Cambridge, UK: 416 pp. https://doi.org/10.1017/CBO9780511812651.

Keywords: Munsell colour indices, sandy post-boggy soils.

Comparison of the results of liquid retention measurements to assess aggregate stability of soils

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Aggregate stability indicates mechanical stability of soil. Most frequently the destructive action of water is measured with wet sieving or simulated rainfall. Comparative particle size distribution analysis for measuring the stability of microaggregates belongs to this group, as well. Aggregate stability can be assessed also by comparing water permeability or retention of soils with air or non-polar liquid permeability or retention.

In the course of our research work, we explored 31 soil profiles that are representative of the Hungarian soil conditions, sampled the different genetic horizons of the profiles (107) and determined the most important soil properties of the collected samples. Soils of these profiles represent large heterogeneity in their organic matter and carbonate content, texture, morphology and aggregate stability, respectively.

Undisturbed samples (100 cm^3 in three replicates) were used to determine NAPL (Nonaqueous Phase Liquid) retention from saturation to 1,480 hPa and water retention from saturation to 15,540 hPa pressure range. Water retention measurements were carried out with suction plate method. NAPL retention measurements were carried out with modified pressure plate extractors (Figure 1), using a non-polar model fluid, namely Dunasol 180/220 (Hungarian Gas and Oil Company Plc. - MOL Rt., Százhalombatta), which does not contain aromatic components.

Macroaggregate stability (MaAS %) was measured by wet sieving apparatus (Eijkelkamp), using 1–2 mm size aggregates (usually repeated eight times), after careful pre-wetting through filter paper.

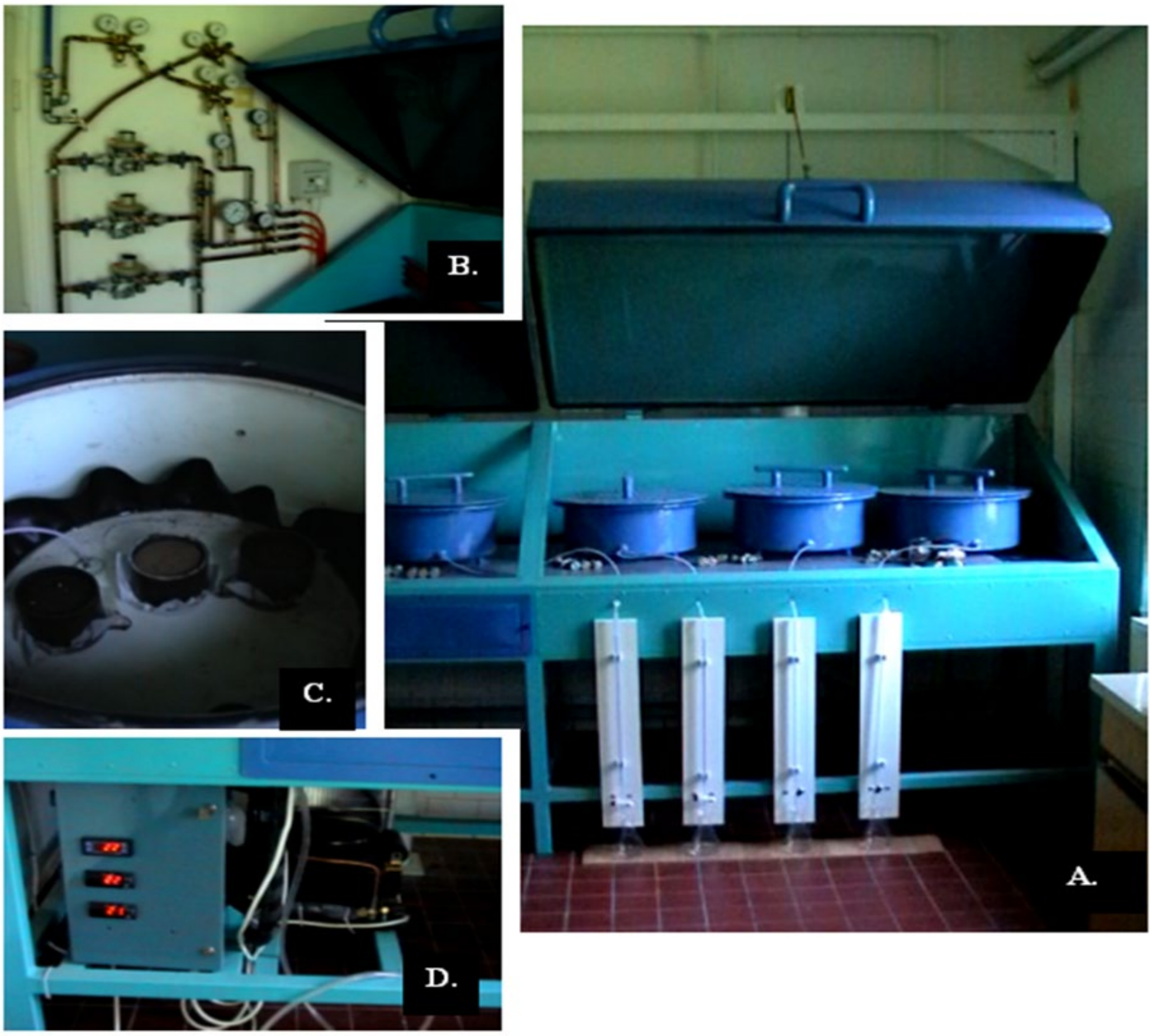

Figure 1. Modified version of the pressure plate extractors

Note: Soil moisture Equipment Corporation LAB 23: (A) – isolated work-bench with a built-in heater and refrigerator and extractors connected to burets; (B) – pressure regulator; (C) – porous plate with NAPL saturated samples; (D) – temperature regulator.

Our results verified that significant differences might be found between NAPL and water retention curves of soil samples, and differences between total porosity and pore size distribution of soils calculated on the basis of NAPL and water retention exists as well. Structure might undergo remarkable changes in the case of water saturation of the soil samples (by the action of disaggregation or swelling processes), but no significant structural changes were experienced in the case of NAPL saturation. Ratio of pore size classes (especially the proportion of macropores) measured with different liquids can be used as an indicator of soil aggregate stability (Figure 2).

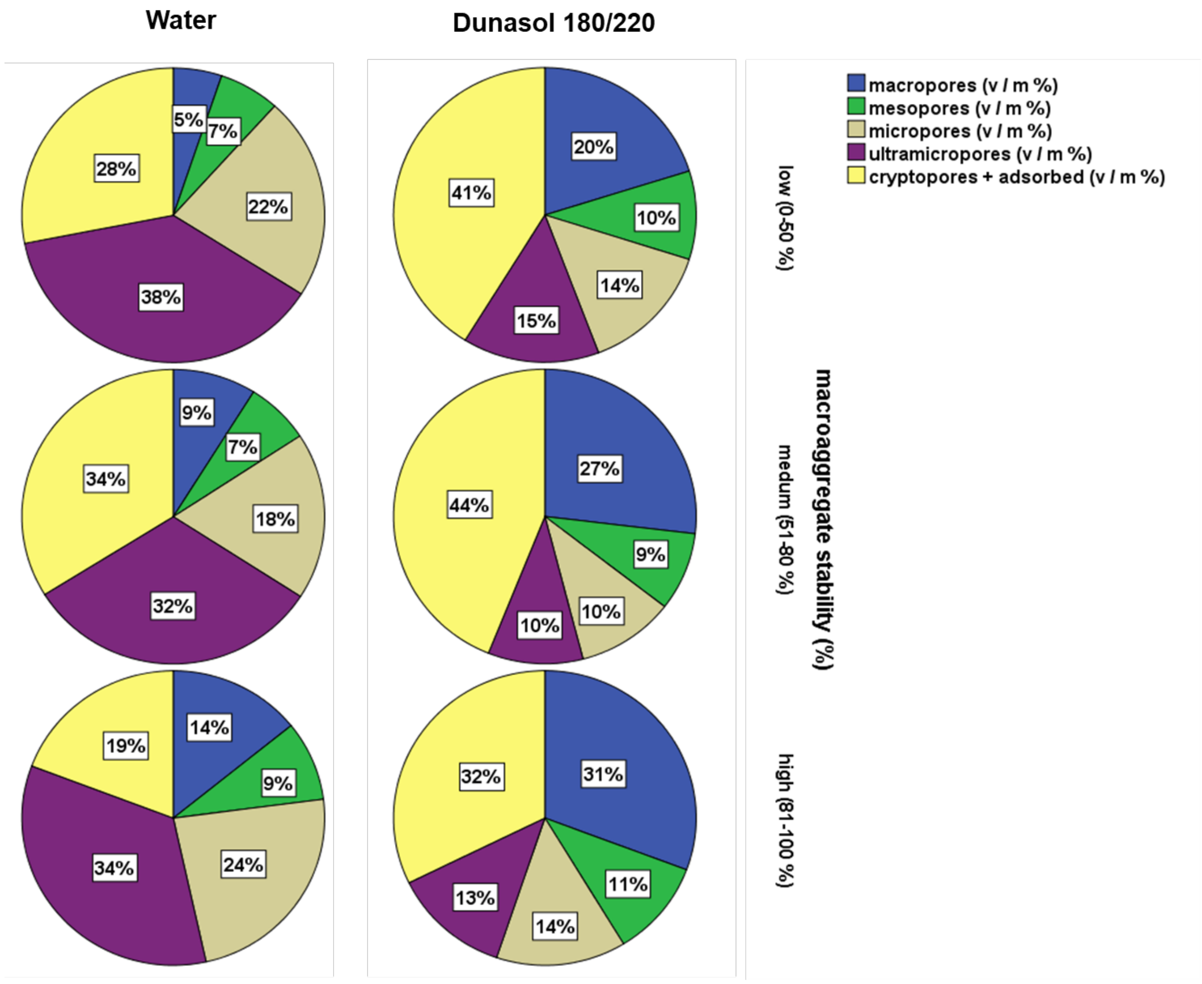

Figure 2. Presentation of pore size distributions calculated from the liquid retention curves of soils, grouped according to the macroaggregate stability of soils

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Keywords: soil aggregate stability, liquid retention measurements.

Determination of the critical wetting surface tension of fen peat soils

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Peatlands provide many important ecosystem services, including water regulation, carbon sequestration and storage. Soils of peatlands are commonly known as peat and contains substantial amount of organic matter. Soil wettability depends on several factors, which are principally related to the characteristics of soil organic matter. Soil water repellency has several hydrological and geomorphological implications, which include reduced infiltration capacity, enhanced overland flow and caused unstable wetting front, increased erosion rates, and reduced plant establishment and growth. The phenomenon of soil water repellency in mineral soils is relatively well documented, whereas soil water repellency in peat soils has been studied less often. Therefore, the aim of the research was to determine water repellency severity of peat soils.

Soil samples were collected from four soil profiles (18 soil layer with different botanical composition) located in the Biebrza Valley. The severity of soil water repellency was assessed based on measured values of wetting contact angle (sessile drop method), critical and ninety degree surface tensions. For this purpose contact angle measurements of the solid phase wetted by water-ethanol mixtures were used and data were analysed using Zisman approach.

The critical values of the surface tension (surface free energy) of the studied soil samples were ranged from 30.8 to 33.7 mN m^{-1}, while the ninety-degree surface tensions were within the range 40.4 to 49.8 mN m^{-1}.

Keywords: fen peat soils, wetting surface tension.

Autonomous quasi-distributed optical fiber temperature sensor for ground temperature measurements

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Aim of the project. This projects' aim is to develop an autonomous optical fibre based system for distributed ground temperature measurements that will enable remote sensing of this parameter with unprecedented precision, resolution and range.

Innovative fiber design will provide better temperature sensitivity and measurement precision. Tasks proposed in this project also include designing and verification of the installation process, shields and safeguards against influence of unwanted environmental factors (strain, water ingression etc.), as well as formulation of measurements methodology and data analysis algorithms for proper description of ground's thermal dynamics.

Impact of the project. Success of this project will allow the Leader of the consortium to carry out necessary development works leading to expansion of InPhoTech's commercial portfolio of fiber-based sensors by offering of a novel device for ground temperature measurements.

Perspectives. The device under consideration will find its use in climate change and ground properties' research conducted by scientific and meteorological institutes. They will be equipped with live, high resolution data with large coverage of the ground (incl. permafrost, glaciers etc.) that will allow them to create more accurate climate and weather change predictions influencing regions spanning from polar circles to farmlands. Another anticipated group of clients will be farmers themselves, who are genuinely interested in low-emission, high efficiency farming techniques that can be optimised in response to daily and yearly changes of local ground conditions. Considerable market is also envisaged in form of private companies providing soil science services.

Consortium members:

1. InPhoTech Sp. z o.o. (Leader);

2. Maria Curie-Skłodowska University, Faculty of Earth Sciences and Spatial Management;

3. Institute of Agrophysics Polish Academy of Sciences.

Funding

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Keywords: fiber temperature sensor, ground temperature measurements.

Biofortified and climate resilient food and fodder production on marginal soils

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In line with the decreasing surface of arable soils and progressive climate changes, will increase demand to develop new options to sustainably increase both yield and quality of food and feed crops and climate change-resilience of agroecosystems in EU. There is a chance to activate idle and marginal land for food and non-food crops. High amounts of quality biomass can be produced on marginal soils by improving their physico-chemical properties using amendments made from agricultural by-products and biofortification of food/fodder crops (e.g., Se). The application of various fertilizer in marginal soils can have a positive effect if the environmental conditions are favourable for the plant productivity realization. Also, the different types of fertilisers and fertilisation intensity could affect the diversity and viability of the soil microorganisms.

With this goal being carried out the project involve partners from six different Europe countries – Estonia, Lithuania, Poland, Germany, Belgium, and France. The aim of this project is to assess possible changes in crop yields in marginal soils by supplementing crop production technologies with biofertilizers or various additives of organic origin, such as silicon. It is believed that the addition of silicon fertilization to agricultural crop production technologies will increase crop resistance to biotic and abiotic stresses and achieve higher plant productivity levels. The field experiments are conducted in four countries and include different climatic conditions – Germany, Poland, Lithuania and Estonia. There are grown the same variety of spring barley, according the same agrotechnology in all countries. For fertilization are use the compost pellets and mineral fertilisers, also applied silicon (Si) and selenium (Se) foliar fertilisers

The organic fertilisers are important factor to increase the productivity of crops and improves properties of marginal soils. Meteorological conditions also determine the productivity of crops and effectiveness of the applied measures. The soil moisture is very important in light soils, especially during crop vegetation. In Lithuania, the prevailing soil in field trial is sandy soil and the moisture of such soil is varied during crop vegetation (figure 1).

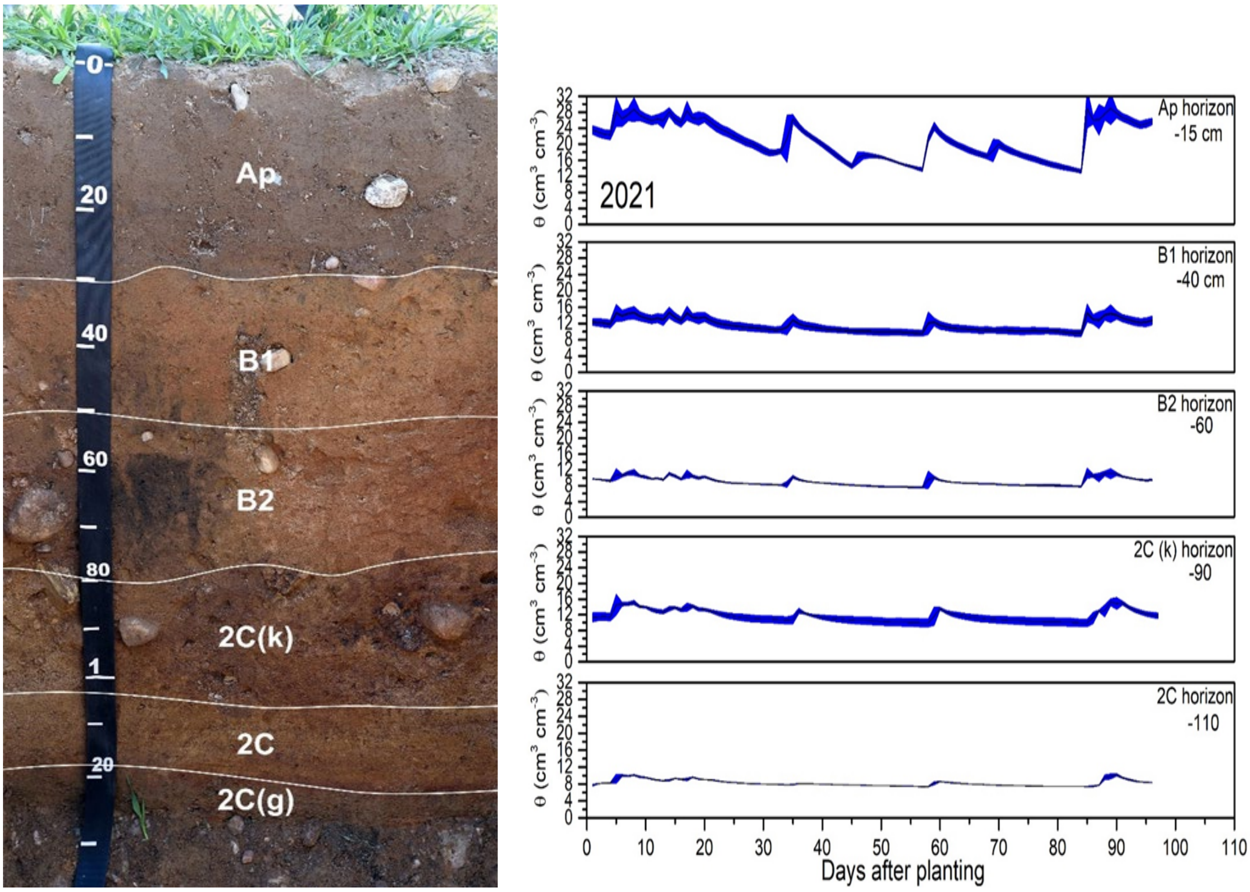

Figure 1. Sandy soil (SDp-b) soil profile and the variation of soil moisture at different genetic horizons in 2021, at Vokė experimental site

The "Biolog" ecoplate method was used to assess the functional diversity of microorganisms. In 2020, soil samples were taken during the vegetation period to evaluate the indicators reflecting the activity of microorganisms - AWCD, R and H. The evaluation of soil microorganism activity in soil showed that check treatment and treatment with mineral fertilisers with applied additionally with foliar silicone fertiliser have the highest abundance of microorganisms.

Spring barley uses both mineral fertilizers and organic or organic and mineral fertilizer complexes in a sufficiently efficient way to realize its productivity potential in marginal soils, but the uptake of phosphorus and potassium was lower. Therefore, when planning fertilization technology in marginal soils, it is important to take into account the natural properties of the soil in order to use resources more efficiently.

Acknowledgment. All authors are partners in the BioFoodOnMars Project funded by the EU-FACCE-SURPLUS within the FACCE-JPI. Authors are grateful for the financial support obtained from the national funding organizations, and for the support by the FACCE-office.

Keywords: marginal soils, crop production, biofertilizers, organic additives.

Pesticide residue determination in the soil samples in different crops at the end of the 2020 season and start of the 2021 season

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At the end of the growing season 2020 the study on the composition and quantity of PPP (plant protection products) residues in soil in different depths (0–20 cm, 20–40 cm) in the winter wheat crop with different soil treatment technologies where carried out. Samples were collected from two farms. One was the commercial farm, and the other one was a scientific institute demonstrating the good practice of growing the crop.

Samples were taken during the harvest of winter wheat in the first two decades of August. Repeatedly samples were taken again in spring 2021 before the start of the active season in first two decades of April to determine how the composition and concentrations of the substances had changed after winter. Additional determination of the active substance herbicides – glyphosate was carried out in samples during the spring 2021 sampling.

The soil samples have identified eight different PPP residues, five of them are currently in the PPP Register, epoxiconazole is already under restriction form the year 2021, and two substances DDT and its metabolite 4,4 '- DDE have not been registered for decades. It should be noted, that in the MPS Peterlauki fields with the same spraying scheme (Table 1) and same tillage system is maintained for more than 10 years.

If we speak about scientific institute demonstration field at LLU Peterlauki, then it can be seen, that 4 active substances in the spring: *boscalid* (F), pendimethalin (H) and very old active substance, which was banned more than 40 years ago, DDT (I) and it's metabolite 4,4 '- DDE were found in the soil samples for the 0-20 cm depth. In the depth 20-40 cm only *Boscalid* was found at the minimal tillage field. In the literature we can find the data about possibility to find these substance after more than 40 years in Poland and other EU countries, and it means, that DDT has the ability not to dissipate for many years, especially in clay soils, such it was on this field. Based on the history of spraying data, the presence of pendimethalin in the soil can be explained by the use of the herbicide *Stomp CS* to limit weeds in field bean volumes in the previous year 2019, the half-life DT50 for pendimethalin is relatively long – 1000 days. Fungicides containing *boscalid* have been registered to limit diseases in both cereal and bean crops. According to field history data, fungicides containing *boscalid* have not been used during the season 2020. It means, that PPP with *boscalid* have been used previously in the year 2019. Half-life in the soil DT50 for *boscalid* is 254 days in the field, and 484.4 in the laboratory conditions. Getting laboratory analysis results it is seen, that plateau concentrations still are met in soils for much longer, that DT50 period.

The other tendency is clearly seen, that amount of pesticide residues at the field, were the ploughing technology was applied, are less comparing to the field concentrations, where minimal tillage technology was applied (Fig. 1.).

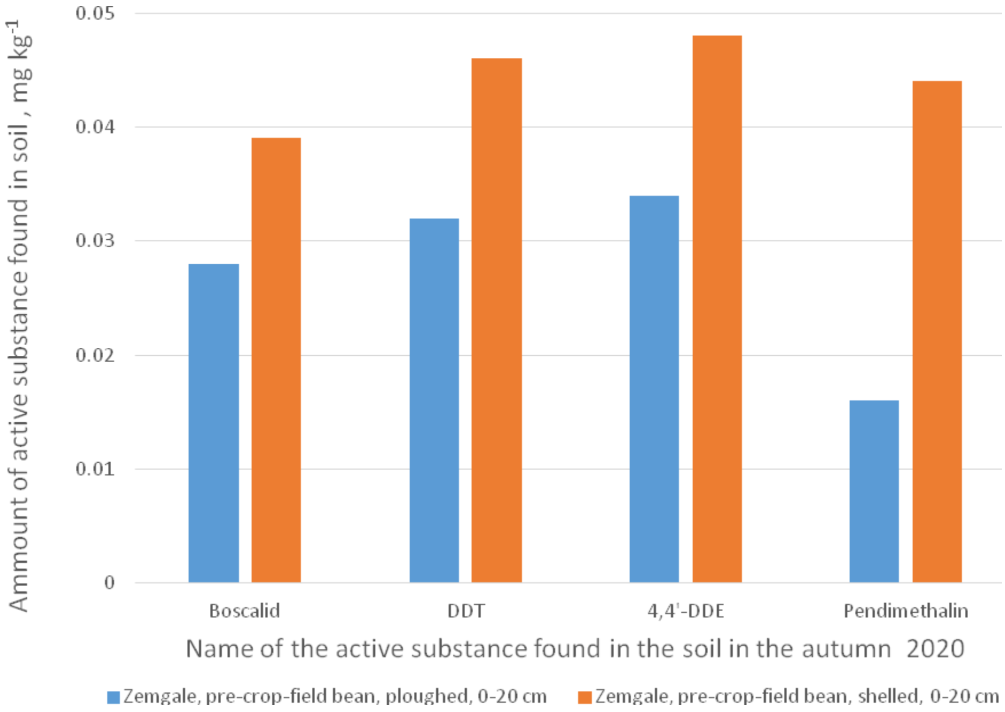

Figure 1. The active substance residues found in the autumn 2020 in the winter wheat field at the LLU demonstration field Peterlauki

Table 1. Investigation site characteristics and treatment

Farm	*Crop*	*Pre-crop/soil treatment technology*	*Relief*	*Soil type*	*Granulo-metric composi-tion*	*Plow layer thickness, cm*	*Plow layer pH_{KCl}*	*Under plow layer pH_{KCl}*
LLU farm Peterlauki	Winter wheat	Field beans/ploughed	plain	Leached sod carbonate soil	Heavy silty clay	30	6.33	6.71
		Field beans/minimale tillage						
Farm in Zemgale	Winter wheat	Winter wheat/ploughed	plain	Typical sod carbonate soil	Light clay	34	6.98	7.25
		Winter wheat/minimal tillage				34	6.98	7.25

In a result (Fig.1) in the field, were winter wheat during the season 2020 was grown, with the previous culture field beans (Table 1), all found pesticide residues are less in average for 4 samples for 38%. Of course, number of data samples is not statistically representative, but nevertheless the tendency can be seen. If we compare autumn samples to the spring samples, then it is also seen, that pesticide dissipate better in the field, where the ploughing was applied. *Pendimetalin* was found repeatedly in the field with the minimal tillage technology, but in the field with ploughing it was not found. During the spring sampling analyses for the glyphosate group pesticides was made additionally, comparing to the autumn samples, and glyphosate in a quite big amount was found. *Diflunican, fluxapyroxad* was also found for the first time, comparing to the autumn 2020 samples, here the situation of the correct sampling appears, were on the producing field it is impossible to take the sample from exactly the same place. The glyphosate was sprayed in the first decade of September 2020, according to the *glyphosate* half time in the soil DT50 is 23.79 days in laboratory and 15 days for field conditions, but it still present after 8 months, again the plateau value still is present. Although it has a high solubility in water, it tends to adsorb and accumulate in agricultural soils. The fact, that *glyphosate* is present in higher amounts coincide with the scientists from Argentina, where it was found, that in no till soils *glyphosate* dissipates more slowly, during 6 months period. *Pendimethalin* with DT50 in soils with 1000 days in the spring samples was not found any more in ploughed field at all, and at the minimal tillage field it dropped down dramatically. Again, maybe some factors of collecting samples influenced the not presence of pendimethalin, but still in both cases the concentration had the positive tendency to reduction in the ploughed fields.

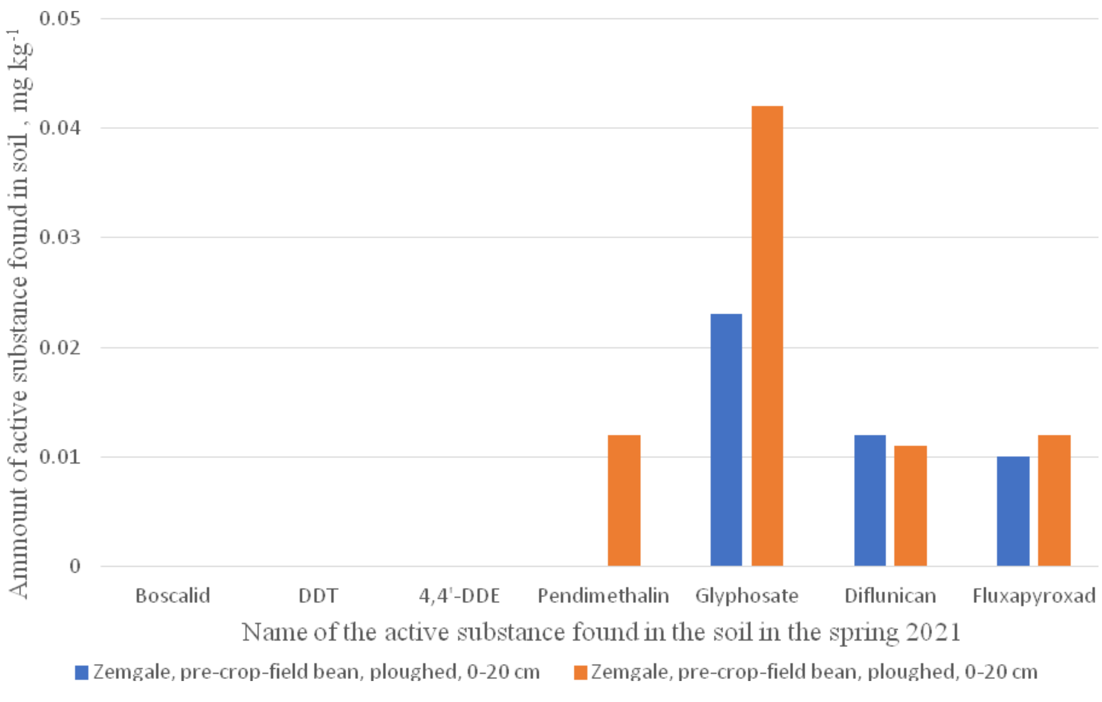

Figure 2. The active substance residues found in the spring 2021 in the winter wheat field at the LLU demonstration field Peterlauki

The same situation happens in the other winter wheat field at the commercial farm in Zemgale (Table 1), were in the field with ploughing concentration is less, than in the field with minimal tillage for the more than 50%. Only two active substances were found, nevertheless the fact, that about 10 active substances were used. When making the analysis in the spring 2021 the fluxapyroxad was found in the minimal tillage field at concentration 0.012 mk kg^{-1}, and glyphosate in concentration of the 0.031 mg kg^{-1} in the minimal tillage field as well, but no residues were found at the ploughed field.

It can be explained with more rapid oxidation process, which happens during the ploughing in contrary to minimal tillage technology, therefore in a ploughed field the concentration and diversity of PPP residues is found is less amounts.

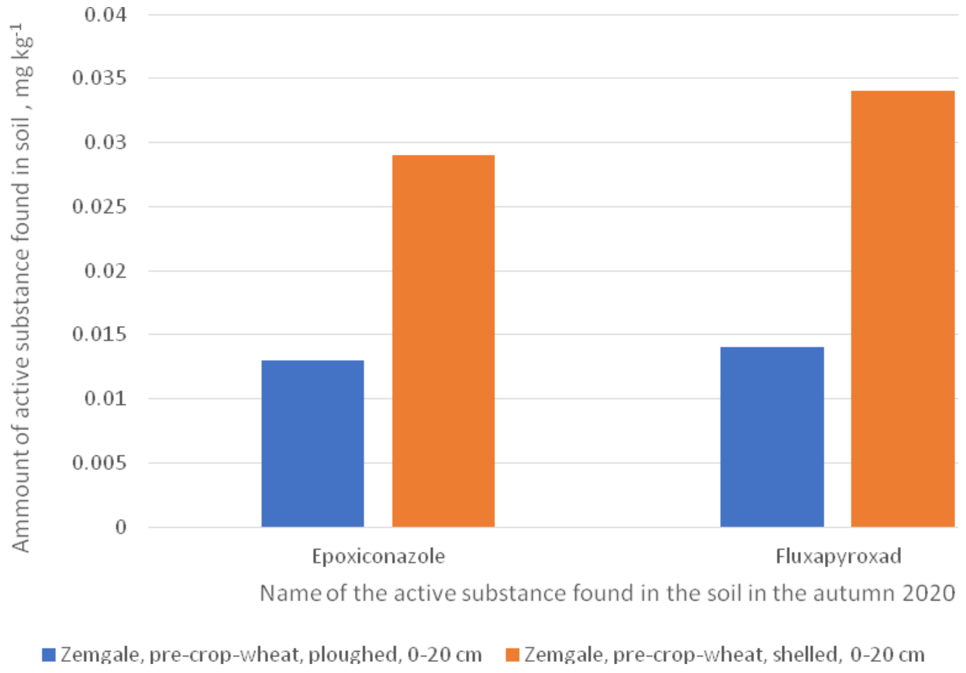

Figure 3. The active substance residues found in the autumn 2020 in the winter wheat field at the commercial farm in Zemgale region

Highlights

Residues of the active substances used in plant protection product in growing winter wheat technology were analysed.

There were found a tendency of lower amount of residues in the ploughed fields.

The concentration and diversity of the pesticide residues was not very high, mostly at the plateau concentration levels.

Keywords: soil, winter wheat, pesticide residue.

The comparison of soil agrophysical properties in the multi-cropping farming system

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Introduction. Over the last few decades, advanced agriculture has made it possible to meet the food and feed needs of the world's human population (Hertel, 2011; Hemathilake, Gunathilake, 2022). However, sustaining the needs of an ever-growing population is challenging due to urbanisation, severe land degradation and climate change (Arora et al., 2018). Moreover, to successfully adapt to and mitigate climate change through agricultural management, simple, cost-effective, and largely scalable approaches must be developed. An agricultural management strategy is therefore essential for adapting to and mitigating climate change (Naulleau et al., 2021). The solution to these challenges is to achieve long-term sustainable use of resources, considering the environmental and economic aspects of sustainability. Eco-efficiency and means producing more agricultural output with fewer resources (Keating et al., 2010). This eco-efficiency is also reflected in the multi-cropping farming system.

The formation of stable soil aggregates plays an important role in the sustainable use of agroecosystems. The formation of stable soil aggregates is important for hydraulic conductivity and root respiration, gas diffusion in the soil and plant growth (Alagöz, Yilmaz, 2009). The aggregate structure of the soil is also strongly influenced by the intensity of cultivation. Tillage mechanically disrupts persistent soil aggregates, changes soil properties, and accelerates the decomposition of organic matter (Balesdent et al., 2000), reducing the number of persistent aggregates (>0.25 mm).

Soil shear resistance is another indicator of healthy soil. Soil shear resistance depends on humus content, soil grain size composition, hardness, density, porosity, as well as frost and thaw processes. Growing multi-cropping system is one way to mitigate soil degradation and increase crop yields and economic benefits (Nasar et al., 2019).

Materials and Methods. Field experiment was carried at Experimental Station of Vytautas Magnus University Agriculture Academy in 2017–2019. The soil was Endocalcaric Amphistagnic Luvisol (WRB, 2015). Agrochemical properties of soil: pH – 6,70, humus – 1,57–1,86%, mobile nutrients in the soil: P_2O_5 – 213–318 mg kg^{-1}, K_2O – 103–125 mg kg^{-1}. A single factor field experiment was set up in 2017–2019 using a randomized block design with ten treatments.

Research object – agrophysical properties of soil covered with multi-cropping system crops. **Research aim:** to compare soil properties and caraway seed yield in the sole, binary and trinary crops. Objectives: 1. To determine the agrophysical properties of soil covered with multi-cropping system crops; 2. To evaluate the yield of caraway seeds grown in multi-cropping system.

The soil shear resistance was determined by harddrive Geonor 72407 in the first and second cultivation year. The soil structure was determined by a Retsch sieve apparatus. Caraway seed yield was calculated with standard moisture content of 12 % and amount of absolutely clean seed (t ha^{-1}).

Results

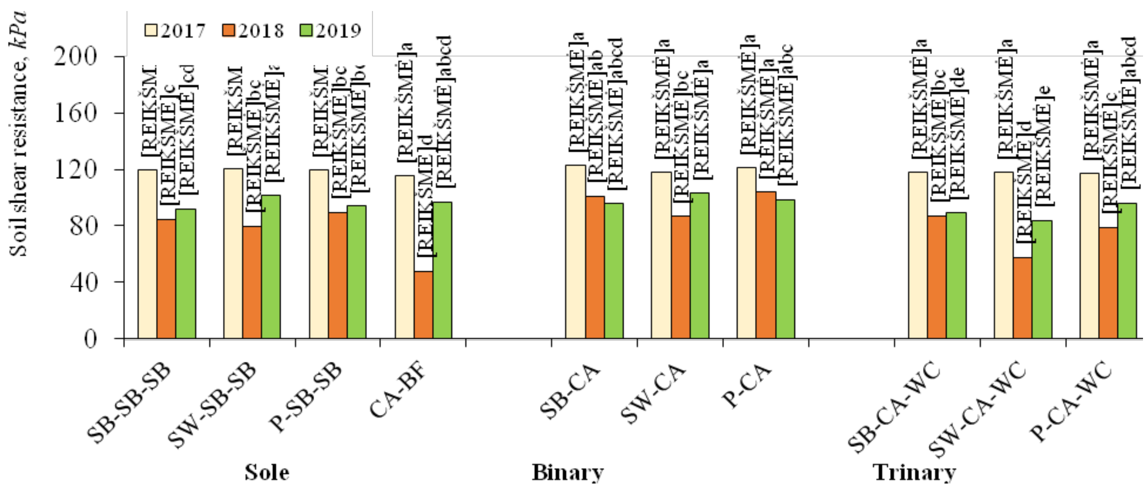

Figure 1. Soil shear resistance in the multi-cropping system crops, 2017–2019

Note: SB – spring barley, SW – spring wheat, P – peas, CA – caraway; WC – white clover, BF – black fallow. Differences between the averages of treatments marked with different letters (a, b, c, d, e) are significant (P <0.05).

In the first year of (2017). The high rainfall in 2017 during the autumn growing season contributed to high soil shear resistance (115.5 to 122.7 kPa) in all experimental plots (Figure 1).

Table 1. Soil structural aggregates % in the multi-cropping system crops, 2017–2019

Multi-cropping system crops	*Soil structural aggregates %*								
	mega >10 mm			makro 0.25–10 mm			mikro <0.25 mm		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Sole									
SB-SB-SB	68.8ab	49.1ab	31.6bc	30.1bc	45.6bc	53.5ab	1.10b	5.30ab	14.9b
SW-SB-SB	73.0a	57.3a	15.9c	25.9c	39.0c	62.9a	1.10b	3.70b	21.2a
P-SB-SB	68.5ab	50.5ab	29.8bc	30.0bc	44.1bc	54.1ab	1.50ab	5.50ab	16.1b
CA-BF	53.9c	42.1bc	55.2a	44.8a	51.7ab	36.0b	1.30b	6.22ab	8.80c
Binary									
SB-CA	53.4c	40.6bc	18.7bc	44.2a	60.6a	74.3a	2.40a	4.90ab	7.10c
SW-CA	63.4abc	36.4c	34.8bc	35.4ab	54.6ab	58.5a	1.20b	4.85ab	6.60c
P-CA	61.6abc	34.5c	26.6bc	36.9ab	60.1a	66.8a	1.50ab	5.25ab	6.70c
Trinary									
SB-CA-WC	59.7c	32.6c	33.2bc	38.8ab	61.9a	60.8a	1.50ab	5.50ab	6.10c
SW-CA-WC	71.7a	39.8bc	28.8bc	27.0c	53.3ab	63.5a	1.30b	6.90a	7.70c
P-CA-WC	56.7c	32.2c	38.6b	41.8a	69.0a	56.6a	1.50ab	4.78ab	4.90c

Note: SB – spring barley, SW – spring wheat, P – peas, CA – caraway; WC – white clover, BF – black fallow. Differences between the averages of treatments marked with different letters (a, b, c) are significant (P <0.05).

In the second year (2018). The soil shear resistance was found to be significantly higher in the sole caraway crop by between 3.70% and 12.3% than in the binary and trinary crops.

In the third year (2019). At the resumption of vegetation in spring 2019, soil shear resistance was significantly lower by a factor of 2.1 to 3.0 in black fallow left after caraway harvest compared to other crops (Figure 1).

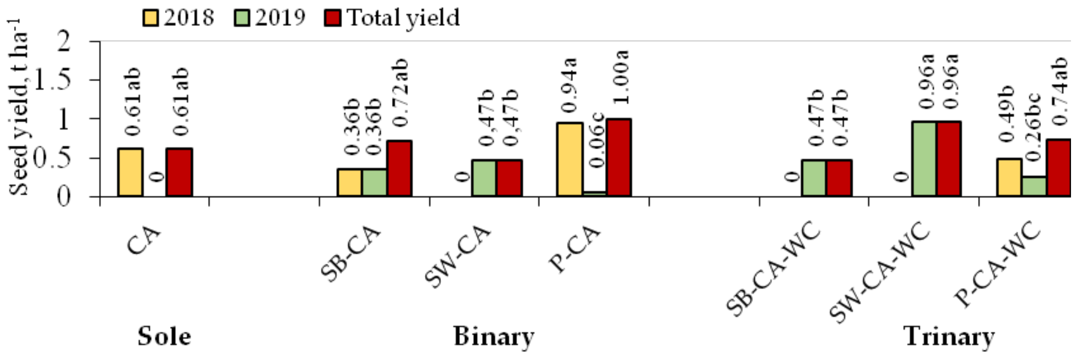

Figure 2. Caraway seed yield in the multi-cropping system, 2018–2019

Note. CA – caraway, SB – spring barley, SW – spring wheat, P – pea, WC – white clover. Differences between the averages of treatments marked with different letters (a, b, c), are significant (P < 0.05).

Conclusions. In the second year the soil shear resistance was found to be significantly higher in the sole caraway crop by between 3.70% and 12.3% than in the binary and trinary crops.

In the binary and trinary crops, the amount of macro-structure aggregates increased compared to sole crops.

In the second year, the highest yield of caraway seeds was formed, when they were grown as binary crop after pea without white clover (0.94 t ha^{-1}), and in the third year – when they were grown as trinary crop after wheat with white clover (0.96 t ha^{-1}).

References

1. Hertel, T. W. (2011). The global supply and demand for agricultural land in 2050: a perfect storm in the making? *American journal of Agricultural Economics*, Vol. 93, p. 259–275.
2. Hemathilake, D. M. K. S.; Gunathilake, D. M. C. C. (2022). Agricultural productivity and food supply to meet increased demands. In: Future Foods. Academic Press, p. 539–553.
3. Arora, N. K., Fatima, T., Mishra, I., Verma, M., Mishra, J., Mishra, V. (2018). Environmental sustainability: challenges and viable solutions. *Environmental Sustainability*, Vol. 1, p. 309–340.
4. Naulleau, A., Gary, C., Prévot, L., Hossard, L. (2021). Evaluating strategies for adaptation to climate change in grapevine production–A systematic review. *Frontiers in Plant Science*, Vol. 11, p. 2154.

5. Keating, B. A., Carberry, P. S., Bindraban, P. S., Asseng, S., Meinke, H., Dixon, J. (2010). Eco-efficient agriculture: Concepts, challenges, and opportunities. *Crop Science*, Vol. 50, p. 109–119.
6. Alagöz, Z., Yilmaz, E. (2009). Effects of different sources of organic matter on soil aggregate formation and stability: A laboratory study on a Lithic Rhodoxeralf from Turkey. *Soil and Tillage Research*, Vol. 103, p. 419–424.
7. Balesdent, J., Chenu, C., Balagane, M. (2000). Relationship of soil orgnic matter dynamics to physical protection and tillage. *Soil and Tillage Research*, Vol. 53, p. 215–230.
8. Nasar, J., Alam, A., Nasar, A., Khan, M. Z. (2019). Intercropping induce changes in above and below ground plant compartments in mixed cropping system. *Biomedical Journal of Scientific & Technical Research*, Vol. 17, 13043–13050.
9. IUSS Working Group WRB, (2015). World Reference Base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps. Update 2015. World Soil Resources Report 106. FAO, Rome: p. 18.

Keywords: multi-cropping farming system, caraway, soil agrophysical properties, soil shear, soil structure.

Agrophysical properties as influenced by soil tillage and crop residue incorporation systems

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Since 1999, a long-term field experiment has been done at the Experimental Station of Vytautas Magnus University Agriculture Academy at 54º52′50 N latitude and 23º49′41 E longitude. According to the latest edition of the International Soil Classification System, the soil in the experimental field was classified as Endocalcaric Stagnosol (Aric, Drainic, Ruptic, and Amphisiltic), texture at 0–20 cm depth is silty medium loam (33.7% sand, 50.3% silt, 16.0% clay), at 20–40 cm depth – silty light loam (35.4% sand, 51.1% silt, 13.5% clay). The objective of our investigations was to assess the long-term impact of reduced intensity tillage systems, straw and green manure combinations on soil physical properties, on soil penetration resistance, shear strength and soil aggregate stability.

A short crop rotation was introduced: winter wheat, spring barley, spring oilseed rape. The results were obtained in 2017–2018. The treatments were arranged using a split-plot design. In a two-factor field experiment, the straw was removed from one part of the experimental field, and the entire straw yield was chopped and spread at harvest in the other part of the field (Factor A). There were three different tillage systems as a subplot (conventional deep ploughing, cover cropping with following shallow termination, and no-tillage) (Factor B). There were four replications. The total size of each plot was 102 (6 × 17) m^2 and net size was 30.0 (2.0 × 15) m^2. The soil samples have been analyzed in the Agro biological laboratory of Vytautas Magnus University Agriculture Academy.

Long-term application of reduced tillage results in a significant increase in soil penetration and soil shear resistance. The lesser the tillage depth, the higher the soil penetration and soil shear resistance. The effect of plant residue spreading is lower. Long-term tillage of different intensities and plant residue spreading as well as catch crop cultivation for green manure did not have significant effect on soil structure. Meanwhile, soil structural stability was highly dependent on soil tillage. Incorporation of green manure of white mustard into the soil by a rotovator before sowing increased it by up to 2.0 times and direct drilling by up to 1.9 times, compared with deep ploughing. In the upper 0–10 and 10–25 cm layers, reduced tillage and no-tillage had a positive effect on soil aggregate stability.

Keywords: Tillage intensity, catch crop, soil physical properties.

Effect of exogenous organic matter application on soil spectral properties

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Aim of the study: Soil organic matter (SOM) is an important factor in soil quality assessment. SOM content and composition can be analyzed by non-destructive spectroscopic methods. Therefore, the purpose of the research was to analyze the impact of exogenous organic matter (on the example of biochar) on the spectral properties of soils related to the presence of natural carbon stocks.

Materials and methods: Four soils (S1-S4) selected for the experiment were collected from the surface layer (0–30 cm) of agricultural lands with different SOC content (S1: 14.6 $g \cdot kg^{-1}$, S2: 10.0 $g \cdot kg^{-1}$, S3:11.2 $g \cdot kg^{-1}$, S4: 8.5 $g \cdot kg^{-1}$). The experiment was conducted in two trials: soil amended by biochar (trial I: S1-S4) and soils without biochar (trial II: S1B-S4B). The soils were air-dried, passed through a 2-mm mesh sieve, and 50 g portions were transferred into plastic containers. The biochar was added as a dry and crushed (ϕ <300 µm) state at doses of 5% m/m. The soil-biochar mixtures were shaken on a rotary shaker for 24 h. The experiment was carried out in laboratory over 9 months in darkness, constant air and water conditions (humidity: 60% full water holding capacity at temperature: 20±1°C).

After the end of the experiment soil samples were scanned in the 350–2500 nm spectral range using a VIS-NIR spectroradiometer PSR-3500® (Spectral Evolution Inc., Lawrence, MA, USA) according to the method described by Ukalska-Jaruga et al. (2019). The spectroradiometer was calibrated using a 99% white NIST reference panel (5x5 cm). Four replicate scans were taken for each soil sample and each replicate was the average of 30 scans. Raw spectra were transformed with moving average for smoothing (noise reduction) using Unscrambler X$^{@}$ version 10.3 (Camo As, Olslon Norway).

Results and discussion. The impact of biochar application to soils was clearly demonstrated by the differences in VIS-NIR spectroscopic characterization (Fig. 1). The soil samples without biochar treatment had reflectance spectra typical of the upper layer of mineral soils (Debaene et al. 2017). Usually, a higher SOC content means a lower reflectance, but this is not the case here. This is probably due to differences in soil texture having a significant impact on spectra. The small peak observed in natural soils at 390 nm can be attributed to labile SOC structures such as humic substances. The two peaks at 1400 and 1900 nm are related to water (O-H bonds). The 2200 nm peak is also related to water (hygroscopic) and clay minerals. The highest reflectance is obtained at 2130 nm and is related to N-H and C=O combination region bands, originating from labile SOC. The peaks at around 2300 nm are due to methyl groups derived from aromatic stable SOC structures.

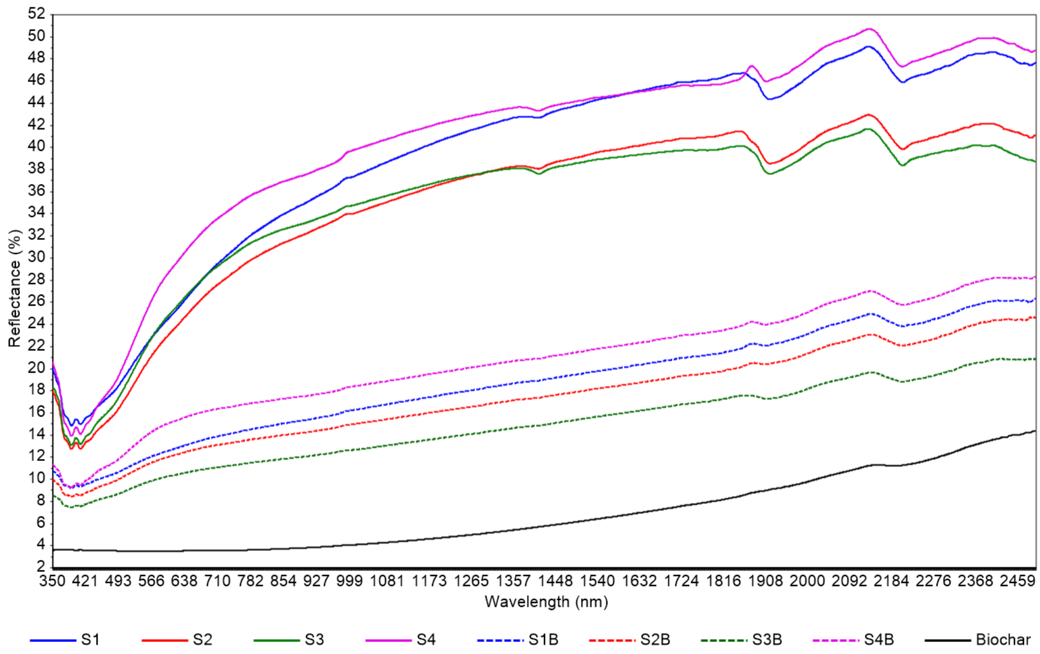

Figure 1. Spectra in VIS-NIR range of soils treated and untreated with biochar

The obtained results indicated that the natural samples were characterized by spectral properties typical for Polish agricultural soil (results not published) and may constitute a broader reference to other soils from temperate climatic conditions.

Soil S4 without biochar application, presented the highest reflectance in the predominant range of the spectrum, followed by soil S3 that presented lower reflectance (before 1600 nm), and sample S2 that showed the lowest reflectance (before 1300 nm). After the addition of 5% biochar, there was a significant decrease of the soil reflectance of about 50%, but the reflectance increased proportionally between soils as follows: S3B < S2B < S1B < S4B. In the soil samples with the biochar treatment, the typical spectral features are less evident (e.g. the 1400 nm peak from water is almost invisible) and the disparity between samples was also less clear. The VIS-NIR region between 700–1800 nm becomes featureless. The use of 5% biochar is sufficient to remove the effect of texture on the spectra by intensifying the influence of the carbon fraction and its individual components.

Conclusions: The addition of biochar to the soils, significantly affected their spectroscopic properties related to SOC component. Moreover, spectroscopic properties indicate molecular diversity within soil components responsible for the processes of humification and mineralization of organic matter.

References

1. Ukalska-Jaruga A., Debaene G., Smreczak B. 2020. Dissipation and sorption processes of polycyclic aromatic hydrocarbons (PAHs) to organic matter in soils amended by exogenous rich-carbon material. *J Soil Sediment*, DOI: 10.1007/s11368-019-02455-8.
2. Debaene G., Bartmiński P., Niedźwiecki J., Miturski T. 2017. Visible and near-infrared spectroscopy as a tool for soil classification and soil profile description. *Pol J Soil Sci* 50:1–10.

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Keywords: soil, exogenous organic matter, spectral properties.

Siltation of drainage systems in different textured soils of Lithuania

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Although in Lithuania there are probably no two soils that are identical in all respects, however it is quite obvious that the prevailing moisture regime in Lithuanian soils is semi hydromorphic (Lithuanian National Atlas, 2014). Thus, temporarily excessive moisture is the main reason for creating the favourable conditions for the formation of gleyic soils. In addition, the heavy textured soils (originate from loamy and clayey sediments) predominate in Lithuania, which is also a favourable factor for the occurrence of more or less soil waterlogging (Soils of Lithuania, 2000). Soils are mostly waterlogged in the case of hydromorphic (i.e., permanently excessive) and fluvial (i.e., flood water) irrigation, which is characteristic of (respectively) peat and alluvial soils.

Field surveys (expeditions) were conducted (2019-2021) to determine siltation of drainage systems in different textured soils of Lithuania. Having excavated drainage trenches, soil profiles were described and soil samples from each genetic soil horizon and silted drain pipes of different diameter were collected (Figure 1). The assessment of particle size distribution of soil samples against standard pipette method was performed at the Agrochemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry.

Figure 1. The excavated drainage trench and soil profiles

(research object near Rietavas in the western Lithuania, 2020, photo by R. Vaisvalavičius)

Among the tested soils, the highest degree of the siltation in drainage pipes was observed in medium-textured soils (sandy loams, loams), where the degree of siltation was up to 80–100% (Figure 2). While in the heavy-textured soils the degree of siltation was only up to 30%.

Figure 2. Silted drain pipes of different diameters

(research object near Rietavas in the western Lithuania, 2020, photo by R. Vaisvalavičius)

Our investigations verified that the particle size distribution in the deposited (silted) drain pipes is very similar to that in the soil layers covering it (Table 1), which shows that the causes of drainage siltation are mostly related to the laying quality of the pipeline itself and soil compaction due to the use of heavy machinery for agricultural work, especially in early spring or late autumn, when these negative effects are greatest.

Table 1. Particle size distribution in soil profile and drain pipes *(research object near Rietavas)*

Soil sampling site	*Soil horizon and / or sampling depth, cm*	*Soil texture classes*		
		sand 2–0,063 mm	*silt 0,063–0,002 mm*	*clay <0,002 mm*
Soil profile	Ap 0–25	75.9	16.3	7.8
Soil profile	Bg 25–45	76.7	17.3	6.0
Soil profile	Bkg 45–53	57.9	33.3	8.8
Soil profile	Bkr 53–60	26.2	62.2	11.6
Soil profile	Ckr 60–120	83.4	12.6	4.0
Drain pipe 20 cm diameter (upper layer of sediments)	120	51.9	37.3	10.8
Drain pipe 20 cm diameter (middle layer of sediments)	120	88.1	8.6	3.3
Drain pipe 20 cm diameter (lower layer of sediments)	120	85.6	10.7	3.7
Drain pipe 7,5 cm diameter	120	60,7	30,7	8,6

References

1. Lithuanian National Atlas. Volume I. (2014). Vilnius: National Land Service under the Ministry of Agriculture of the Republic of Lithuania, Vilnius University, 142 p.
2. Soils of Lithuania. (2001). Monograph. Vilnius, Lietuvos mokslas. Book 32, 1244 p. (In Lithuanian, Summary – in English).

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Keywords: drainage systems, siltation, soil texture.

Soil compaction impact on soil quality parameters

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Soil compaction becoming a worldwide problem because of intensive cropping, increased use of heavy machinery, short crop rotations and inappropriate soil management practices. It is an important parameter, which can alter soil water and air circulation and subsequently the plant growth and vitality (Keller et. al, 2019, Schjønning et. al, 2016). The objective of this study is to evaluate an impacts of soil compaction on soil carbon stocks, greenhouse gas emissions, water balance, crop growth and yield in a climate change context.

Two ongoing field experiments are initiated at the Lithuanian Research Centre for Agriculture and Forestry in spring of 2022 in soils differing in genesis on two geographical sites. One of them was established at the Institute of Agriculture, on an *Endocalcari-Epihypogleyic Cambisol (55°24'38.4"N 23°51'00.1"E)* and the other field experiment was set up at Vėžaičiai Branch on an *Bathygleyic Dystric Glossic Retisol (55°43'26.1"N 21°30'15.8"E).*

Field experiments includes two treatments (C – headland (compacted area), N – normal field area (non-compacted)) in five replications. Soil penetration resistance and moisture content were measured before the start of the experiments (Fig. 1). Soil samples were collected also for the other key soil parameters, such us soil texture, bulk density, water retention, nutrient content including pH and organic carbon. Effect of soil compaction on key soil functions and crop productivity will be determined by measuring above and below-ground biomass as well as crop yield, C-inputs and stock, change of CO_2 and N_2O emissions, other assessments.

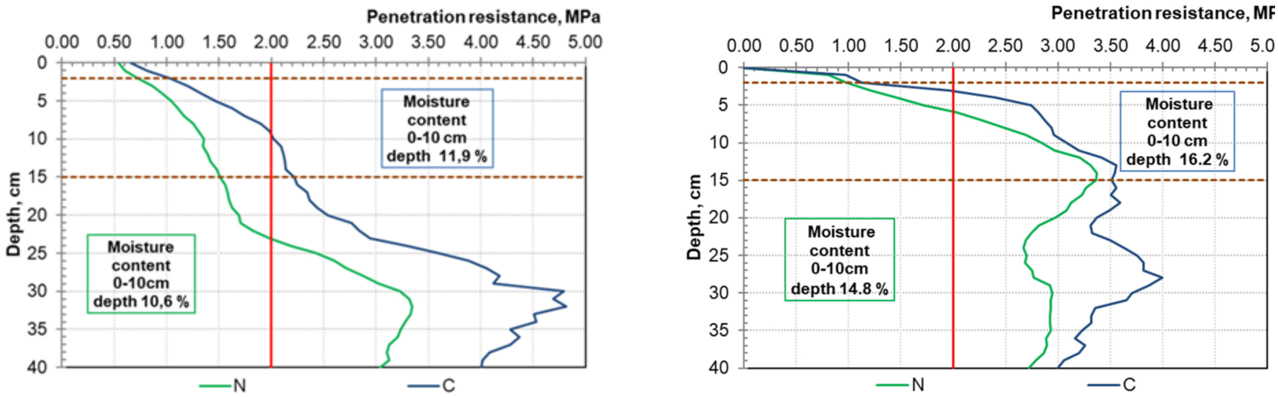

Figure 1. Soil compaction effect on soil penetration resistance and moisture content in *Cambisol* and *Retisol*

Penetration resistance (PR) in plant root zone (2–15 cm depth) is very important, because it can weaken root systems. In a *Cambisol,* PR in normal area for root zone was optimal and ranged from 0.72 up to 1.50 MPa, when in headland at 10 cm depth it exceeded critical PR of 2 MPa, limiting root growth (Fig. 1). In a *Retisol* PR for the root zone was quite high in both treatments, but in headland it already exceeded 2 MPa at 4 cm depth, when in normal field it was obtained slightly deeper.

Acknowledgement. This work was supported by the European Union ‘s Horizon 2020 research and innovation program via the SoilCompaC project “Mapping and alleviating soil compaction in a climate change context “(Grant agreement No 862695).

References

1. Keller, T., Sandin, M., Colombi, T., Horn, R. & Or, D. (2019). Historical increase in agricultural machinery weights enhanced soil stress levels and adversely affected soil functioning. *Soil & Tillage Research*, 194, 104293.
2. Schjønning P., Lamandé M., Munkholm L. J., Lyngvig H. S., Nielsen J. Aa. (2016). Soil precompression stress, penetration resistance and crop yields in relation to differently-trafficked, temperate-region sandy loam soils. *Soil & Tillage Research* 163, 298–308.

Keywords: soil bulk density, penetration resistance, headlands.

INDEX OF AUTHORS

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