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Influence of winter cover crops and different spring crops on soil structure indicators on Chernozem

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Abstract

The intensive form of agricultural production often leads to disruption of physical, chemical and biological properties of the soil. Therefore, in recent years there has been an increasing focus on research and finding ways to preserve the soil with management practices that support soil conservation. The research was conducted on the experimental field of the Institute for Field and Vegetable Crops Novi Sad on Rimski Šančevi. The experiment was set up as a randomized block design. The winter cover crops consisted of the combined intercrops: Triticale (×T*riticosecale* Wittm. ex A. Camus) and winter pea (*Pisum sativum* ssp. *arvense* L.) (T+P), solo winter fodder pea crop (*Pisum sativum* ssp. *arvense* L.) (P) and a control without winter cover crops (sole or mixtures)(Ø). The experiment with winter cover crops was divided into two blocks. In the first block, the winter cover crops were chopped and plowed, while treatments in the second block were mowed using a rotary mower and the fodder was removed for feeding ruminants. After ploughing and preparing the soil for sowing, sowing of spring crops (soybean, maize and sudan grass) was carried out on all varieties in the subsequent sowing period. This research aims to determine the influence of different types of winter cover crops and spring crops from subsequent sowing period on the physical properties of Chernozem with a special emphasis on soil structure. It was determined that values of MWD on the treatments where the mixture of cover crops (T+P plowed) ranged from 1.11 mm to 1.39 mm, which indicated a better aggregates stability compared to the control treatments where no cover crops were sown. Due to variable root morphology and water requirements, which may alter soil structure, it is required to pay more attention to the adaptation of management strategies through the use of cover crops as well as the selection of their mixes.

Keywords: cover crop, soil structure, soybean, maize, Sudan grass

Introduction

The intensive form of agricultural production often leads to disruption of physical, chemical and biological properties of the soil (Vojnov et al., 2019). In recent decades, the soil has been exposed to intense anthropogenic influence (Vojnov et al., 2020a). Modern understandings of the role of soil in sustainable agriculture start with harmonizing production with natural fertility and soil quality (Ćirić et al., 2014). Progressive soil degradation is not only the threat to the world's food supply, but it is also influencing global climate change (Steiner, 1996). According to Pagliai (2004), soil degradation processes present an immediate threat to both biomass and grain yields, as well as a long-term hazard to future crop yields. The Environmental Protection Agency (EPA) estimates that about 85% of the recorded erosion consequences in the Vojvodina province originate from wind erosion. In response to the more obvious soil degradation and loss of its fertility, the Food and Agriculture Organization (FAO) in 2015 declared soil a non-renewable resource indicating that it represents a priceless natural asset (Vojnov et al., 2019).

Soil structure is one of the most important physical soil properties and it is considered a key process of agro-ecosystem sustainability (Bronick and Lal 2005; Sarker et. al 2018; Shaheb et al. 2021). Achieving high and stable yields of cultivated plants strongly depends on soil structure. Soil with a good structure retains more accessible water for plants, reduces water losses and provides greater resistance to the formation of crusts (Belić et al., 2014b). In the Vojvodina province, Republic of Serbia the Chernozem soil type commonly has a good structure because of crumbly structural aggregates, but this can be changed due to inadequate soil management. Ćupina et al. (2011) point out that due to the reduced livestock production, and thus the lack of manure in the Republic of Serbia, it is necessary to make changes in agricultural production to preserve the fertility and quality of the soil. Many authors consider that the conventional method of soil tillage with the use of heavy machinery damages the soil structure, which worsened when working in wet soil with high soil pressure (Botta et al., 2010; Shaheb et al. 2021). Therefore, it is necessary to determine the new way of preserving soil physical properties in the modern agricultural practices. Also, the coverage of the soil during the winter period in Vojvodina which represent flat area, generally, is of great importance to mitigate the negative impact of wind erosion.

Due to reduced livestock, it is considered that cover crops can be an effective solution in reducing the lack of manure (Vojnov et al., 2020a, Vojnov et al., 2022). Cover crops in such a way can play a significant role in terms of preserving soil quality. Cover crops represent one crop, or a mixture of crops grown between two main crops (Ćupina et al. 2004, Vojnov et al. 2020). The use of cover crop mixtures can be an effective strategy for winter use cover crops because cereals and annual legumes complement each other very well (Ćupina et al., 2017). These characteristics have numerous annual fodder plants from the Fabaceae, Brassicaceae and Poaceae families thus they are used as cover crops (Ćupina et al., 2017; Vojnov et al., 2019; Vojnov et al., 2020b). Cover crop residues affect soil structure by reducing evapotranspiration i.e. plant stress during the dry period (Ćupina et al. 2007). Cover crops are also useful in preventing damage caused by erosion (Van Pelt and Zobeck, 2004; Blanco-Canqui et al., 2015). By establishing cover crops, the soil is protected because the plants used for this purpose bind soil particles with their root system, and their above-ground biomass prevents particles from being carried away from the soil surface (Ugrenović and Filipović 2017). Cover crops, like any other plant, can change soil physical and structural features, either directly through the creation of pores and aggregates by roots or indirectly through the input and decomposition of shoot and root residues (Kaspar and Singer 2011). Fast-growing crops with their above-ground biomass protect the soil from the negative impact of summer showers when large raindrops can form a crust when hitting the soil (Ćupina et al. 2007). Organic matter in the soil stabilizes the structural aggregates, makes the soil easier to cultivate, increases aeration, water and buffer capacity (Carter and Stewart, 1996). This research aims to determine the influence of different types of winter cover crops and spring crops from subsequent sowing period on the physical properties of Chernozem with a special emphasis on soil structure.

Materials and Methods

The research was conducted on the experimental field of the Institute for Field and Vegetable Crops Novi Sad, an Institute of national importance for the Republic of Serbia, on Rimski Šančevi (45°20' N, 19°51' E, 86 m). The experiment was set up on Chernozem soil type, subtype of Chernozem formed on loess and loess-like sediments, carbonate soil variety and moderately deep soil form. The experiment was set up as a randomized block design. The winter intercropping trial consisted of a joint crop of winter fodder pea (*Pisum sativum* ssp. *arvense* L.) and triticale (× *Triticosecale* Wittm. ex A. Camus) (T+P), a pure winter fodder pea crop (P) and a control without winter cover crops (sole or mixtures) (Ø). In the last decade of 2020 ploughing of cover crops and the control plot was performed. Ploughing of cover crops (sole or mixtures) utilized as sideration was done with a plow at a depth of 27 cm. At the beginning of June, maize, soybean and sudan grass were sown. Nitrogen fertilization was carried out with 50 kg N ha^{-1}. The experiment with winter cover crops was divided into two blocks. In the first block, the winter cover crops were chopped and plowed, while treatments in the second block were mowed using a rotary mower and the fodder was removed for feeding ruminants. Plowing of forage in the form of sideration (green manure) and seedbed preparation was carried out the day after mechanical termination.

Two plant species of winter cover crop were used in the experiment: triticale (×

Triticosecale Wittm. ex A. Camus - *NS Odisej*) (T) and winter fodder pea (*Pisum sativum* ssp. *arvense* L. - *NS Kosmaj*) (P) and 3 plant species in the subsequent sowing period: soybean (Glycine max - *NS Fortuna*), maize (Zea mays - *NS4051*), sudan grass (Sorghum Sudanese - *NS Sava*). Winter cover crop sowing was done in October at the optimal sowing period. Winter fodder pea was sown at an inter-row spacing of 30 cm and 2 cm deep, and in the first block of the plot, triticale was cross-sown with an Amazon grain seeder at an inter-row spacing of 12.5 cm. When combining T and P, the ratio of the seeds was 30:70, so that there would be no competitive effect of triticale over winter peas. During of flowering of peas and triticale, they were mowed and plowed.

After ploughingand preparing the soil for sowing, sowing of spring crops (soybean, maize and sudan grass) was carried out on all varieties in the subsequent sowing period. The sowing of the crops in the subsequent sowing period was carried out a few days apart after ploughing and soil preparation. Maize was sown in 4 rows with a distance of 75 x 23 cm, a depth of 5 cm, soybean in 6 rows with a distance of 50 x 3 cm, a depth of 4 cm, and sudan grass in 8 rows with an inter-row distance of 37.5 cm at a depth of 2 cm. During the growing season, two inter-row cultivations were applied for soybeans and maize, as well as hoeing. The soil was sampled in autumn before the harvest of crops from the subsequent sowing period.

Soil texture

In the Laboratory for Soil, Fertilizer and Plant Material Testing at the Department of Pedology and Soil Water Regime at the Faculty of Agriculture in Novi Sad, the soil texture was determined. Fractions of fine soil are determined by a combined method based on the different falling speed of particles in the liquid, which can be calculated by the Stockes’ formula:

$$v = \frac{gr^2(\rho z - \rho v)}{\eta} \tag{1}$$

v - velocity of particle sedimentation (cm s^{-1})
r - particle radius (cm)
ρz - specific mass of soil particles (dispersed phase) ~2.65 g cm^{-3}
ρv - density of water (dispersed medium). At 20°C it is ~1 g cm^{-3}, and it changes with the addition of a peptizer.

η – water viscosity at 20°C is 0.01 paise. It changes rapidly under the influence of temperature changes.

To achieve peptization of mechanical elements, the soil samples were treated with sodium pyrophosphate.

Structural aggregates distribution - dry sieving

According to Savinov (1936), the dry sieving method is carried out as follows: 500 g of air-dry soil sample is sieved through a series of sieves with square holes of diameter 10, 5, 3, 2, 1, 0.5 and 0.25 mm, to obtain eight aggregate classes (>10, 10-5, 5-3, 3-2, 2-1, 1-0.5, 0.5-0.25 and <0.25 mm). Each class was then measured. The duration of sieving each sample is 1 minute.

The coefficient of structure (Ks) is used to assess the soil structure, which represents the ratio of the % of mesoaggregates (0.25-10 mm) and the sum of megaaggregates and microaggregates (>10 + <0.25 mm) (Gajić, 2006).

$$Ks = C / B \tag{2}$$

Where, C = mass of aggregate class from 0.25 mm to 10 mm; B = aggregate class mass >10 mm and <0.25 mm

According to this coefficient, soils with Ks above 1.5 have a good structure, those with values of 1.5-0.67 have satisfactory structure, and if Ks is lower than 0.67, the soil has an unsatisfactory structure (Veršinin 1958, cited by Belić et al., 2014).

Structural aggregates stability analysis - wet sieving

The wet sieving procedure is a method used to determine the aggregate stability. Weigh 100 g of air-dry soil and wet it on a sieve of 2000 µm, by immersing it in deionized water for 2 minutes. The 8000-2000 µm fraction was obtained by moving the sieve through the water for 2 minutes in a 3 cm up-and-down movement with 30 repetitions. The remaining aggregates on the sieve are transferred to an aluminum vessel with a stream of water. Aggregates that remained (<2000 µm) in the second vessel, which passed through the sieve, are transferred to the next sieve with a smaller diameter. The sieving is repeated with vertical movements (20 repetitions) for a sieve with a diameter of 250 µm and 10 repetitions for a sieve with a diameter of 53 µm. The rest represents the fourth - the smallest fraction. The resulting stable aggregates are dried in oven, and their mass is determined (Elliott 1986). With this procedure, four fractions of structural aggregates were separated (Ćirić 2014): large macroaggregates >2000 µm, small macroaggregates 2000-250 µm, microaggregates 250-53 µm, Silt and clay fraction <53 µm.

When determining the stability of structural aggregates, the following parameters were used: average weight diameter of particles MWD (mean weight diameter) and percentage of water-stable aggregates (% WSA) (Hillel 2004).

$$MWD = \sum_{i=1}^{n} \bar{x}iwi \qquad (3)$$

Where, x̄i – average diameter of each soil fraction; wi – proportional share in the total mass of the sample of each of the soil fractions

Percentage of water-stable aggregates (%WSA):

$$\text{WSA (\% of soil >250 µm)} = \frac{WSA-S}{(Wag\ x\ k)-S}\ X\ 100 \qquad (4)$$

Where, WSA – mass of water-resistant soil aggregates after drying in a dryer; Wag – total mass of soil samples (100 g); S – mass of coarse sand fractions (g); K – correction factor (total mass of all fractions after drying/mass of air-dry soil)

Results and Discussion

Soil Texture

The soil textural class was determined based on Serbian soil classification system (Belić et al., 2014b). All studied soils at 0-20 cm and 20-40 cm depths, is classified as loamy clay, which corresponds to the studied locality and soil type - Chernozem. From an agronomic point of view, the most favorable ratio of sand-silt-clay fractions is 35-40% – 35-40% – 20-30% (Ćirić, 2014).

Soil structure - dry sieving

Based on size, aggregates are divided into: megaaggregates (>10 mm), macroaggregates (10-0.25 mm) and microaggregates (<0.25 mm). In agricultural production, aggregates with a diameter of 0.25-10 mm are the most favorable for soil structure (Belić et al. 2014).

The results of dry sieving show that the soil samples grown on soybeans (Table 1), maize (Table 2) and sudan grass (Table 3) have the highest percentage of aggregates sizes >10 mm and 10-5 mm, and the lowest percentage of aggregates size < 0.25 mm. According to the data in Tables (1,2 and 3), mega-aggregates had the largest share individually (average values: soybean 38.8%, sudan grass 32.0% and maize 25.7%), and macroaggregates (10-5 mm) in total. In soybean crops, the highest percentage of megaaggregates was obtained when ploughing pea (P plowed 58.2%), in maize crops in the control variant without cover crops (Ø 40.6%), and in sudan grass when ploughing a mixture of triticale and pea (T+P plowed 39.2%). Macroaggregates are the most abundant in the size 10-5 mm in the control variant without cover crops in soybeans (Ø 27.7%), in maize when ploughing a mixture of cover crops (T+P plowed 26.7%), and in sudan grass when mowing pea (P mowed 30.2%). In terms of microaggregates (<0.25 mm), they were most represented in the maize crop when pea was plowed (P plowed 2.6%), and the least in the sudan grass crop when using a mixture of cover crops and ploughing or mowing them (T+P plowed, T+P mowed 1.1%).

Table 1. Percentage of structural aggregates and coefficient of structure in soybean crops

Crop type	Cover crop with their way of use	Aggregate content in %								
		Aggregate size class (mm)								
		>10	10-5	5-3	3-2	2-1	1-0.5	0.5-0.25	<0.25	Ks
Soybean	T+P plowed	38.8	24.0	12.4	7.4	9.2	4.9	2.0	1.3	8.2
	T+P mowed	25.4	23.3	17.0	10.2	13.8	6.5	2.2	1.5	10.6
	P plowed	58.2	20.4	6.3	3.6	4.9	3.1	1.5	1.4	7.6
	P mowed	32.1	25.6	13.4	7.9	10.4	6.1	2.7	1.9	11.5
	Ø	41.7	27.7	11.0	5.6	7.0	3.6	1.7	1.6	9.6
	x̄	38.8	24.0	12.4	7.4	9.2	4.9	2.0	1.3	9.3

Used symbols: T+P - triticale+pea, P - pea, Ø - control, x̄ - arithmetic mean, Ks - structural coefficient

Table 2. Percentage of structural aggregates and coefficient of structure in maize crops

Crop type	Cover crop with their way of use	Aggregate content in %								
		Aggregate size class (mm)								
		>10	10-5	5-3	3-2	2-1	1-0.5	0.5-0.25	<0.25	Ks
Maize	T+P plowed	18.4	26.7	18.0	11.0	14.8	7.5	2.5	1.2	10.1
	T+P mowed	28.5	25.1	14.7	9.5	11.2	6.2	2.8	2.0	12.3
	P plowed	22.1	20.2	13.5	9.3	16.5	11.2	4.6	2.6	16.2
	P mowed	18.9	19.1	15.5	11.1	18.3	11.3	4.1	1.7	12.7
	Ø	40.6	22.7	11.0	6.5	9.4	5.7	2.5	1.6	9.5
	x̄	25.7	22.8	14.5	9.5	14.1	8.4	3.3	1.8	11.8

Used symbols: T+P - triticale+pea, P - pea, Ø - control, x̄ - arithmetic mean, Ks - structural coefficient

Table 3. Percentage of structural aggregates and coefficient of structure in crops of sudan grass

Crop type	Cover crop with their way of use	Aggregate content in %								
		Aggregate size class (mm)								
		>10	10-5	5-3	3-2	2-1	1-0.5	0.5-0.25	<0.25	Ks
Sudan grass	T+P plowed	39.2	26.3	12.6	6.6	8.4	4.1	1.6	1.1	7.2
	T+P mowed	35.5	28.1	13.9	7.7	8.4	3.7	1.4	1.1	7.2
	P plowed	30.9	28.6	13.3	8.0	10.4	5.3	2.1	1.5	9.6
	P mowed	29.3	30.2	14.0	7.7	10.0	5.1	2.1	1.6	10.5
	Ø	25.2	23.7	14.9	9.5	13.5	7.7	3.5	2.0	13.1
	x̄	32.0	27.4	13.7	7.9	10.1	5.2	2.1	1.5	9.5

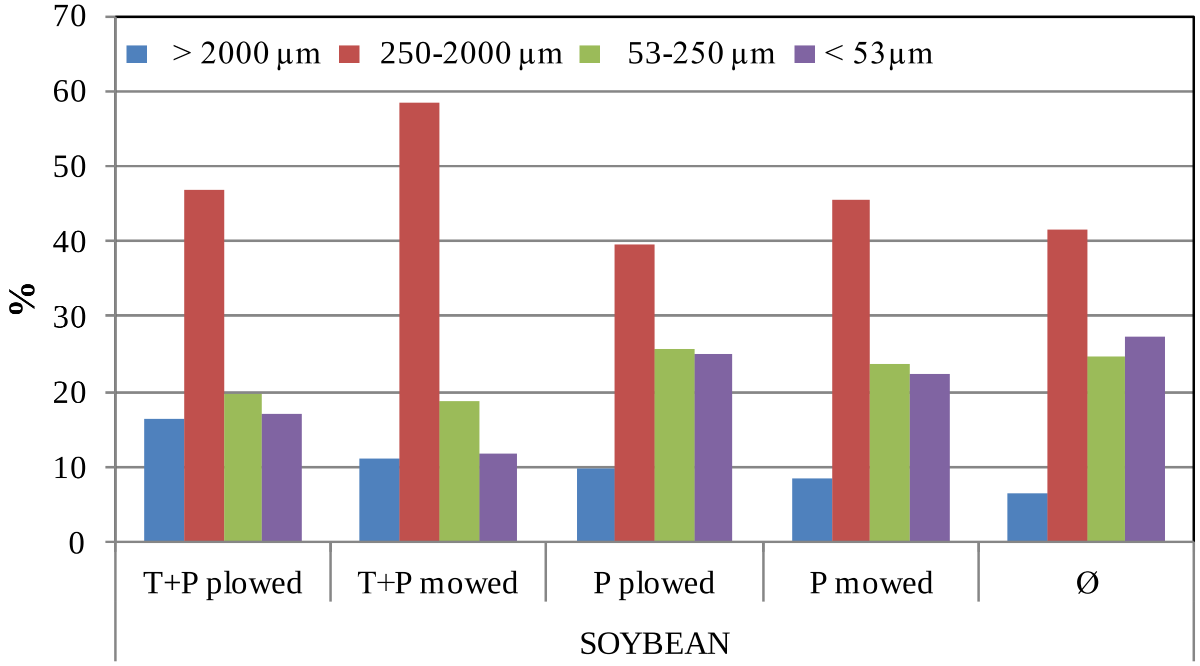
Used symbols: T+P - triticale+pea, P - pea, Ø - control, x̄ - arithmetic mean, Ks - structural coefficient

Regarding the coefficient of structure (Ks), according to Veršinin (1958), soil whose structural coefficient is greater than 1.5 is considered to have a good structure. According to the data from the preceding tables, it can be seen that Ks, in all cultivated crops and when applying all cover crop treatments, is greater than 1.5, which classifies the soil as having a good structure. The highest value of this coefficient was observed in maize when peas were plowed (P plowed 16.2), and the lowest in Sudan grass crops where a mixture of cover crops was used and ploughing or mowing was applied (T+P plowed, T+P mowed, Ks = 7.2). In the Sudan grass crop in the control treatment (Ø - 13.1) where no cover crops were used, a high value of this coefficient is observed due to the different tillage and soil management practices for this crop and the different types of root system compared to soybeans and maize. By comparing all the obtained values, it was noted that the highest Ks of the soil was after harvesting maize compared to soybean and Sudan grass.

During their research, in Ćirić et al. (2012) concluded that Ks is significantly correlated with the content of organic matter (OM) in the soil. The importance of OM in soil is attributed to its acting as a cementing agent and protecting the structure from degradation. Ploughing intercropping allows a greater amount of fresh organic matter in the soil and prevents nitrogen loss from the soil (Couëdel et al., 2018, Qin et al., 2013).

Soil structure - wet sieving

Soil aggregate stability strongly depends upon colloid content and cement materials (sesquioxides, polyuronides, polysaccharides, clay minerals, Ca-humates, and humic substances) and soil management/tillage practices. According to the division of aggregates obtained after wet sieving according to Ćirić (2014), the results showed that in soybean crops, the least aggregates were obtained in the fraction >2000 µm - large macroaggregates, and the most in the fraction 2000-250 µm - fine macroaggregates (Graph 1). In terms of microaggregates (250-53 µm) and silt and clay (<53 µm) in the same crop, the highest abundance is observed in the control variant where cover crops were not applied, and the lowest when mowing a mixture of triticale and pea (T+P mowed).

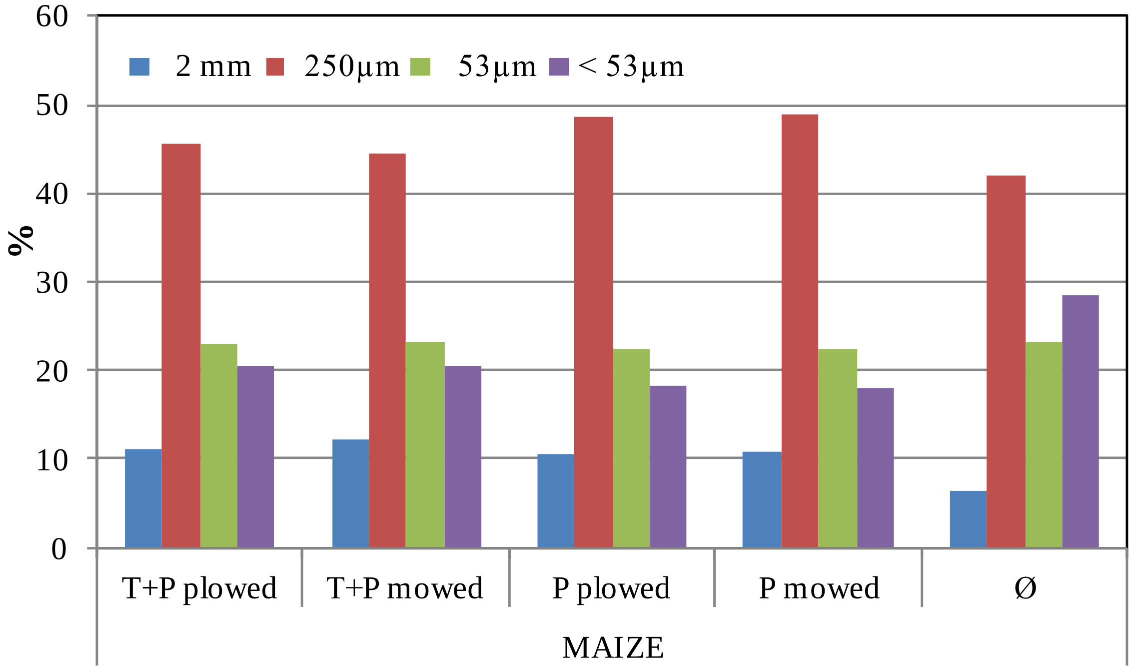


Graph 1. Content of structural aggregates in soybean crops

T+P p- Triticale+Pea (plowed); T+P m- Titicale+Pea (mowed); P – pea (plowed); P – pea (mowed); Ø - control

In the case of maize (Graph 2), the least aggregates were also obtained in the >2000 µm fraction - large macroaggregates, and the most in the 2000-250 µm fraction - small macroaggregates (highest abundance when ploughing pea (P plowed) or mowing peas (P mowed)). In terms of microaggregates, approximately equal values were obtained for all treatments.

The soil under the Sudan grass crop (Graph 3) is characterized by the highest prevalence of small macroaggregates during intercrop ploughing (T+P plowed, P plowed). There are also the least large macroaggregates as in the previous crops (especially in the control variant). Microaggregates are the most common on the treatments on which mixtures of cover crops (T+P) are mowed.

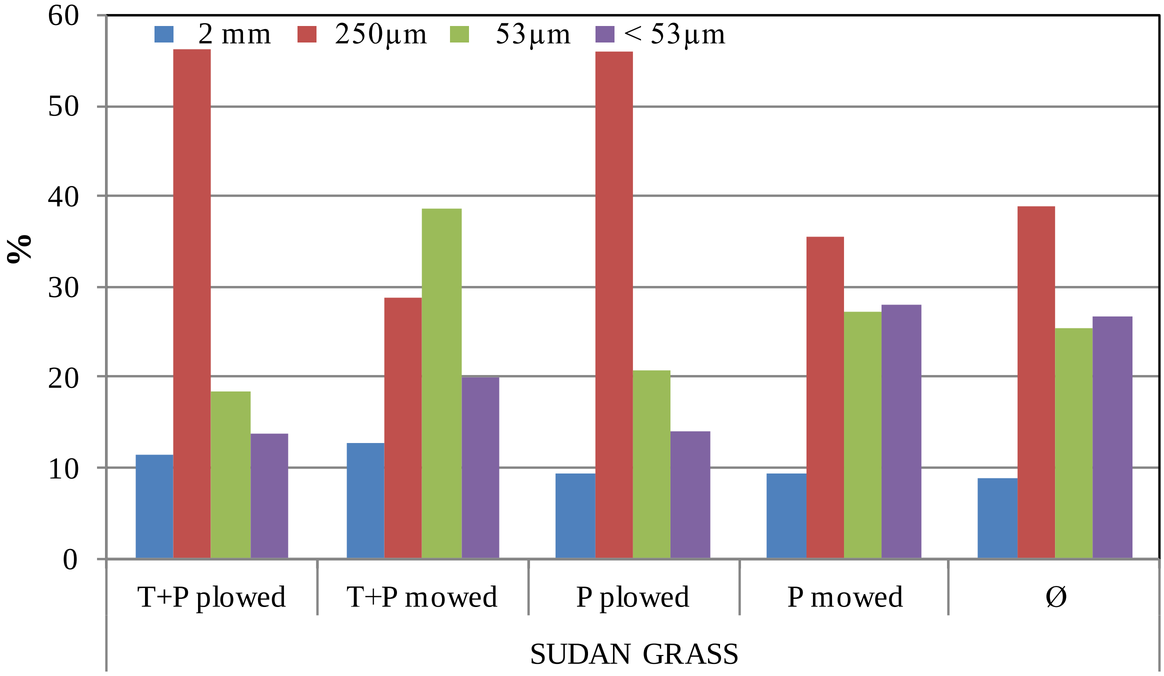


Graph 2. Content of structural aggregates in maize crops

T+P p- Triticale+Pea (plowed); T+P m- Titicale+Pea (mowed); P – pea (plowed); P – pea (mowed); Ø - control

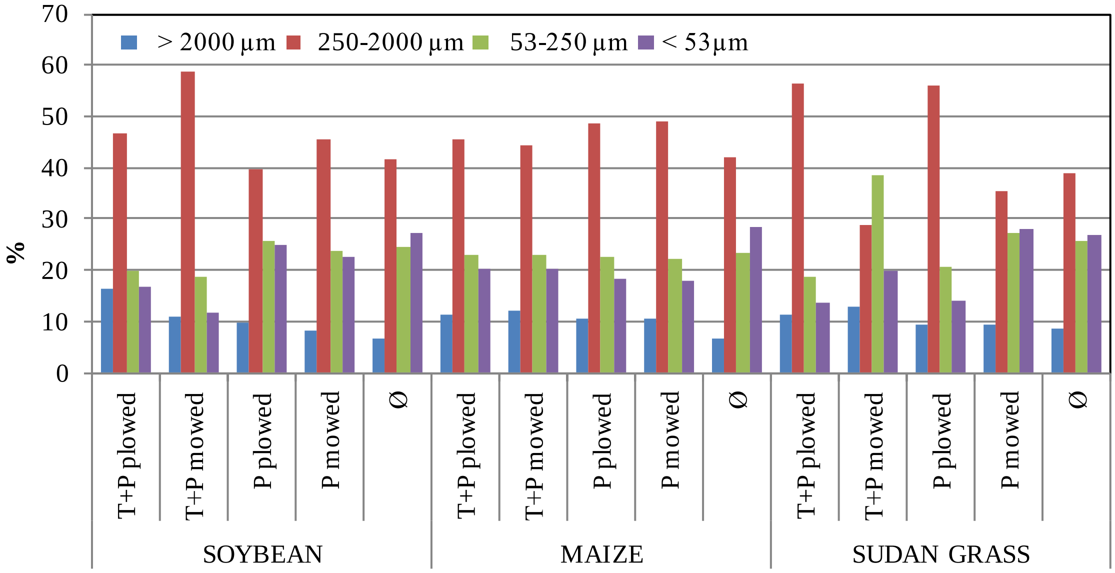
The soil under the Sudan grass crop (Graph 3) is characterized by the highest prevalence of small macroaggregates during intercrop ploughing (T+P plowed, P plowed). There are also the least large macroaggregates as in the previous crops (especially in the control variant). Microaggregates are the most common on the treatments on which mixtures of cover crops (T+P) are mowed.

To compare the previously obtained results of soybean, maize and Sudan grass crops and the use of different varieties of cover crops, Graph 4 shows the differences in the content of soil aggregates.



Graph 3. The content of structural aggregates in Sudanese grass crops

T+P p- Triticale+Pea (plowed); T+P m- Titicale+Pea (mowed); P – pea (plowed); P – pea (mowed); Ø - control



Graph 4. The content of structural aggregates of soybean, maize and Sudan grass in the 0-30 cm layer

T+P p- Triticale+Pea (plowed); T+P m- Titicale+Pea (mowed); P – pea (plowed); P – pea (mowed); Ø - control

The proportion of macroaggregates larger than 2000 µm was the lowest in all treatments. On the soil structure of the arable layer, the treatments T+P affected the highest percentage representation of macroaggregates larger than 2000 µm. The lowest macroaggregate content was recorded in the control varieties. Small macroaggregates (250-2000 µm) in all varieties made up the largest share concerning aggregates of other dimensions, while microaggregates (53-250 µm) were the most covered by the control variant in maize crops. Even though the assessment of the soil structure cannot be made only by considering the ratio of individual fractions of aggregates, the fact is that the largest proportion of aggregates dimensions of 0.25-7 mm provides the most favorable water-air soil properties (Belić et al., 2014).

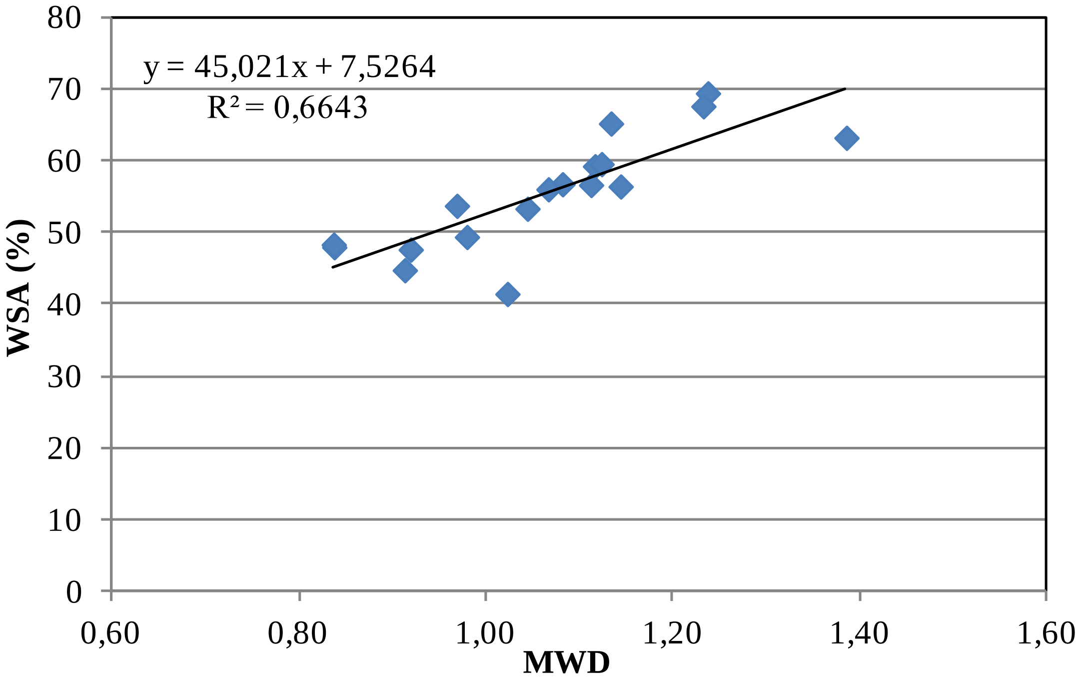
Table 4. Indicators of soil structure - MWD and WSA

Crop	Indicators of soil structure	Cover crops and their utilization				
		T+P plowed	T+P mowed	P plowed	P mowed	Ø
Soybean	MWD (mm)	1.39	1.24	0.98	0.97	0.84
	WSA (%)	63.3	69.51	49.45	53.8	48.02
Maize	MWD (mm)	1.11	1.14	1.12	1.12	0.84
	WSA (%)	56.71	56.5	59.33	59.63	48.38
Sudan grass	MWD (mm)	1.23	1.02	1.13	0.91	0.92
	WSA (%)	67.7	41.49	65.29	44.81	47.69

Used symbols: T+P - triticale+pea, P - pea, Ø - control, MWD - average diameter of structural aggregates, WSA (%) - percentage of waterproof aggregates

When comparing different types of cover crops, way of utilizing cover crops and types of crops grown in the subsequent sowing period, it is observed that the average diameter of the structural aggregates - MWD (Table 4) ranges between the minimum value of 0.84 mm, which shows that the given aggregates are class 2 - unstable (at control varieties - Ø soybean and maize, where cover crops were not used) and the highest value of 1.39 mm, which shows that the aggregates belong to class 4 - stable (for soybean crops - T+P plowed). Higher values of this parameter were observed when using a mixture of cover crops and their ploughing than when mowing and ploughing pea as an intercrop, and the lowest values of 0.84-0.92 mm were obtained in the control varieties (class 3 - medium stable) because no cover crops were used. Le Bissonnais (1996) states that MWD values from 0.8-1.3 mm make medium unstable soil characterized by medium appearance of soil crust, however, in our research on treatments T+G, where cover crops plowed, the values ranged from 1.11 to 1.39 mm, indicating a significantly better stability of structural aggregates compared to control treatments without cover crops.

Soil structure is usually expressed as the degree of overall stability of aggregates during gasification in water. According to Ćirić et al. (2012), MWD was related to the clay and silt content of the soil. When determining the percentage of water resistance of aggregates - WSA (%) (Table 4), the lowest results were also obtained in control varieties without cover crops (47.69% - Ø Sudan grass), and the highest value was determined in soybean crops when mowing a mixture of triticale and pea (T+P mowed - 69.51%). When comparing the methods of using cover crops, it is concluded that in soybean crops, the most water-resistant aggregates are found when using a mixture of cover crops and their mowing (T+P mowed 69.51%), in maize crops when ploughing or mowing pea (P plowed - 59 .33% and P mowed - 59.63%), and in the case of Sudanese grass crops when ploughing a mixture of cover crops (T+P plowed - 67.7%). In short-term research Castiglioni and Behrends Kraemer (2019) also found higher MWD values in soils on which cover crops were previously grown. Hermawan and Bomke (1997) point out that cover crops grown have a better effect on the soil structure after the spring tillage compared to land without cover crops. By looking at the average values of WSA % in our research, according to Kačinski (Shein et al., 2001), the examined soil is characterized by good (40-60%) to excellent stability (60-75%), especially on with T+P treatments after soybean cultivation. The lowest WSA % values were recorded at control plots without intercrops. The obtained results agree with other studies (Liu et al., 2005; Hoorman et al., 2009) where on the control treatments without cover crops values of WSA % were lower. Graph 5 shows the relationship between MWD - average diameter of structural aggregates and WSA (%) - percentage of water-stable aggregates. As the diameter of aggregates increases, their ability to resist gasification in water likewise increases. Šeremešić et al. (2012) state that the unfavorable structure of the arable layer also occurs as a result of tillage at unfavorable soil moisture, so monitoring the soil moisture and choosing a favorable moment of tillage is an important practice in quality plant production. The obtained results show that soil structure is a very complex parameter for the interpretation of which it is necessary to use different indicators to better understand its role.



Graph 5. Correlation of MWD and WSA

Conclusion

In the research it was determined that values of MWD on the treatments where the mixture of cover crops (T+P plowed) ranged from 1.11 mm to 1.39 mm, which indicated a better aggregates stability compared to the control treatments where no cover crops were sown. The lowest percentage of water- resistant aggregates - WSA (%) was observed on the control treatment (without cover crops). Based on the values of the coefficient of structure - Ks (7.2-16.2), it was determined that the analyzed soil after growing cover crops had a favorable structure. Therefore, it is necessary to pay more attention to the adaptation of management practices through the use of cover crops, as well as the selection of their mixtures due to different root morphology and the water requirements, which could affect the soil structure.

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Uticaj ozimih međuuseva i različitih jarih useva na strukturu zemljišta tipa černozem

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Izvod

Intenzivna poljoprivredna proizvodnja često dovodi do narušavanja fizičkih, hemijskih i bioloških svojstava zemljišta. Zbog toga je poslednjih godina sve veći fokus na istraživanju i pronalaženju načina za očuvanje zemljišta u savremenoj poljoprivrednoj praksi. Istraživanje je sprovedeno na oglednom polju Instituta za ratarstvo i povrtarstvo Novi Sad na Rimskim Šančevima. Ogled je postavljen kao randomizovani blok dizajn. Ogled sa ozimim međuusevima sastojao se iz združenog useva: tritikala (×*Triticosecale* Vittm. ek A. Camus) i ozimog graška (*Pisum sativum* ssp. Arvense L.) (T+P), čistog međuuseva – ozimi stočni grašak (*Pisum sativum* ssp. arvense L.) (P) i kontrole bez ozimih međuuseva (Ø). Ogled sa ozimim međuusevima bio je podeljen u dva bloka. U prvom bloku ozimi međuusevi su izmalčirani i zaorani, dok su tretmani u drugom bloku pokošeni rotacionom kosilicom i odneti sa parcele u vidu krme. Nakon oranja i pripreme zemljišta za setvu, izvršena je setva jarih useva (soja, kukuruz i sudanska trava) u naknadnom roku setve. Ovo istraživanje imalo je za cilj da utvrdi uticaj različitih vrsta ozimih i jarih useva iz naknadnog roka setve na fizička svojstva černozema sa posebnim akcentom na strukturu zemljišta. Analizom vrednosti MWD na varijantama sa zaoranim ozimim međuusevom tritikalea i graška kretale su se od 1,11 mm do 1,39 mm i imale su znatno bolju stabilnost strukturnih agregata u odnosu na kontrolne varijante bez međuuseva. S toga je potrebno više pažnje posvetiti prilagođavanju načina gazdovanja kroz upotrebu međuuseva, kao i izboru načina združivanja zbog različite morfologije korena gajenih biljaka i njihovog zahteva za vodom, što može uticati na strukturu zemljišta.

Ključne reči: međuusevi, struktura, černozem, kukuruz, soja, sudanska trava

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