

EFFECT OF USING A COMPLEX OF AGRO-TECHNICAL PRACTICES ON PLANOSOLS

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Abstract: The problem of updating agricultural technology, particularly in the field of agriculture, is important for agriculture. Alternative technology solutions that meet the performance criteria are a prerequisite for successful economic activity.

The aim of the study is to determine the effect of the application of an agro-technical complex of events, which successfully supports the soil fertility of the Planosols and the sustainable level of productivity of the field crops.

In the field experiment in the station for irrigation agricultural Pazardzhik Valley, in three-polar crop rotation maize-barley-rape are studied three factors - soil tillage system, mineral fertilization and ways of managing plant residues.

The study found that the moisture content of the soil was mainly influenced by the type of treatment applied (loosening as a main plow and plowing as a pre-sowing) and the use of plant residues. The over compaction found in the beginning of the experiment in the 25-40 cm layer is partly overcome by performing a deep rupture to the depth of 35 cm. Despite the short period of the study, there was a certain decrease in the content of digestible potassium forms. The results show the activation of the microbiological activity after planting of the plant residues - an increase of the amount of the cellulose microorganisms and of the ammonifiable bacteria, the most noticeable in the high fertilization rate and the intensive treatments. The main part in the formation of crop rotation productivity is mineral fertilization. The impact of the tillage system is more marked in the first year of maize and especially during the third year of rape. Lack of fertilization influences yields significantly in rapeseed compared to maize and barley.

KEY WORDS: AGRICULTURAL PRACTICES, SOIL TILLAGE, FERTILIZATION, PLANT RESIDUES, PRODUCTIVITY

INTRODUCTION

The problem of updating agricultural technology in agriculture, grain-production in particular, is important for production. Alternative technology solutions that meet the performance criteria are a prerequisite for successful business activity. In order to achieve sustainable agriculture, it is necessary to make periodic changes in the technologies for growing individual crops and adding additional calories of energy in the form of fertilization, plant protection, watering and growing in environmentally disadvantaged areas (Arvidsson et al., 2003; Stoynev, 2004; Basitov, 2008). Agro-technical solutions also play a vital role as a major part of production technology. For a major agro-technical practice to be carried out, a number of requirements have to be met and the most accurate solution to be taken (Mitova et al 1999, Terra et al 2006, Karlen et al., 2013)

The rationalization of agro-technical practices allows the reproductive potential of crops to be more fully used at a good level of soil fertility (Dimitrov and Mitova, 1998, Nikolova et al., 2001, Zarkov and Koteva 2005, Terra et al., 2006; Toncheva et al., 2015).

The aim of the study is to determine the effect of the application of an agro-technical complex of practices, which

Scheme 1. Systems for soil cultivation in crop rotation

Crop	Option O ₁	Option O ₂
Maize for grain	tillage 25-30cm	disc harrow 10-12 cm tillage 25-30cm
Barley (winter)	tillage 15-18 cm	disc harrow 10-12 cm
Oilseed rape	disc harrow 10-12 cm loosening 35-40cm	tillage 20-25cm

Scheme 2. Fertilization variants

Crop	Fertilization variants		
	T ₀	T ₁	T ₂
Maize	no fertilization (фон P ₇)	N ₂₀ P ₁₅ K ₀ Superphosphate, ammonium nitrate	N ₂₅ P ₂₀ K ₀ Ammophos, Ca- ammonium nitrate
Barley	no fertilization	N ₆ P ₈ K ₀ Superphosphate, ammonium nitrate	N ₈ P ₁₀ K ₀ Ammophos, Ca- ammonium nitrate
Rape	no fertilization	N ₁₅ P ₁₂ K ₆ potassium sulfate Superphosphate, ammonium nitrate	N ₂₀ P ₁₅ K ₆ Eurobio NPK fertilizer, Ca- ammonium nitrate

The following indicators have been monitored: productivity - main and additional crop production and total crop rotation productivity calculated in kg/da;

successfully to supports the soil fertility of the planosols and the sustainable level of productivity of the field crops.

MATERIAL AND METHODS

In a field experiment conducted in the Experimental Station on Irrigated Agriculture, Pazardzhik in three-field crop rotation system maize-barley-rape in the conditions of irrigated agriculture, three factors were studied - soil treatment system (scheme 1), mineral fertilization norms (scheme 2) and plant residues management methods - by introducing the plant residues into the soil with the treatment (option O₁) and by removing them, by baling or chopping, and extracting them outside the test area (option O₂).

According to the requirements of the crops and the agro-ecological conditions, differentiated processing systems are used with variants of basic, pre-sowing and inter-row machining solutions. In the experiment, three levels of fertilization - zero and two fertilization norms with nitrogen and phosphorous fertilizer, potassium fertilization was carried out for the third crop in the crop rotation - oilseed rape.

water-physical: moisture content by weight% and density in g/cm³ - by Kaczynski's weight method, every 10 cm in depth up to 60 cm depth with 100 cm³ volume rings; hardness - with a weight-down

hardness meter with a cone angle of 30°, every 5 cm to a depth of 40 cm; general porosity of the soil - by ratio of bulk and relative mass of the soil;

agrochemical - mobile forms: nitrogen - by the method of Bremner and Keeney; phosphorus - by the method of P. Ivanov; potassium by the method of P. Ivanov; soil solution reaction (pH) - potentiometrically in water and potassium chloride; carbonates - using the Scheibler method, organic matter content in the soil - by Tyurin;

microbiological indicators: main groups of soil micro-organisms - ammonifying bacteria, actinomycetes, mineral nitrogen digesting bacteria, microscopic fungi, cellulose digesting microorganisms. The samples are taken from the surface layer of the soil (0-30 cm) near the roots of the plants; total biological activity (soil respiration) - determined by the method of Alef and Nannipieri.

The amount of plant residues is determined from 0.5m² area in three replicates; layer distribution of residues - by wet soil sieving of ¼ m².

The sum of the rainfall during the growing season of the crops is for maize 2014 (IV-IX) - 569,3 mm, for winter barley 2014/2015 (X-VI) - 627,7 mm and for oilseed rape 2015 / 2016 (IX-VI) -447.3 mm.

RESULTS AND DISCUSSION

The tested agrotechnical factors influence the condition of the soil parameters and the productive potential of the cultivated crops.

Effect on soil's physical characteristics: After maize sowing, a consistent differentiation of water content in the soil was established. In the surface layer, as a result of moisture evaporation, the content is 75-87% of Saturation, in the layer 20-30 cm is about 90% and in the deeper layers within the boundaries of Saturation. Substantial differences due to soil treatment have not been established. Only one irrigation with a rate of 80 m³/da was made to maintain a presumptive humidity of 75% of Saturation.

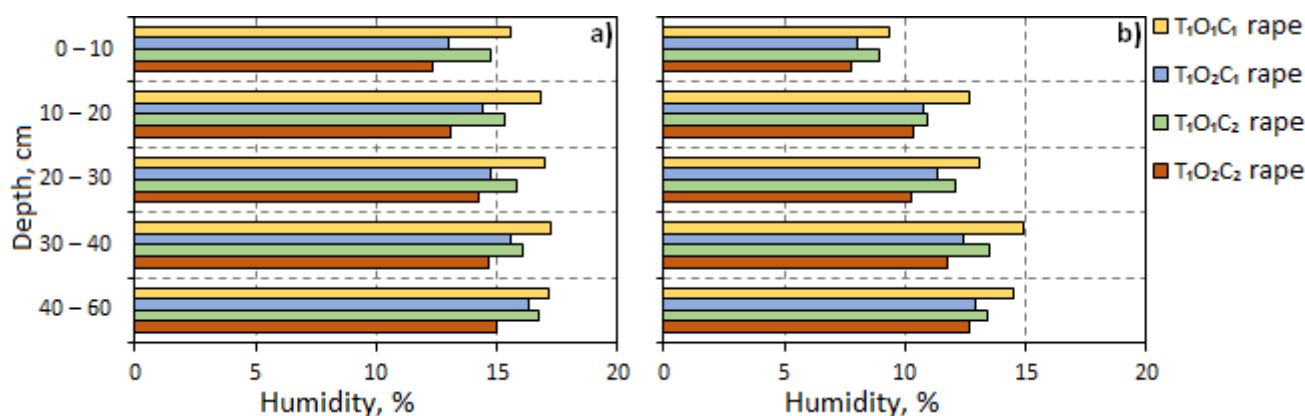


Fig. 1. Content of soil moisture in weight% 2015/2016 – rape [a] germination, b) before harvesting]

When inspecting the barley until the wax ripeness phase begins, the moisture content of the test area decreases with the measured values from 11.22% to 16.06%. There is a tendency of higher moisture content in the soil of the lots with tillage of the vegetation residues - the value differences are from 1.10% to 2.03%.

The moisture content of the Planosols in the autumn after rape sowing is from 12.36 to 17.23% (Fig. 1,a). A watering with a 20 m³/da rate was made to accelerate germination. The measured soil moisture values in the pre-harvest test were from 9.35% to 14.87% (Fig. 1,b). The humidity in the 0-40 cm layer for the loosening area is higher than the plowing trough - from 1.3% in the surface layer to 2.47% in the 30-40 cm layer due to different

evaporation rates and the retention of moisture to the depth of loosening.

In the first year, the high moisture content has an impact on soil density. In the wax ripeness phase, when the humidity is about 80% of the Saturation, an increase in the values of this parameter in the 0-20 cm layer was recorded, the differences with post- germination readings being in the range 0.08-0.13 g/cm³. Although less expressed, there is an increase in volume density for the layer 30-40 cm. Prior to harvesting of the barley, the bulk density was high for the entire studied layer 0-40 cm, which ranged from 1.63 g/cm³ to 1.76 g/cm³. In order to overcome this overflow of the layer for option O1, rupture is included up to a depth of 40 cm.

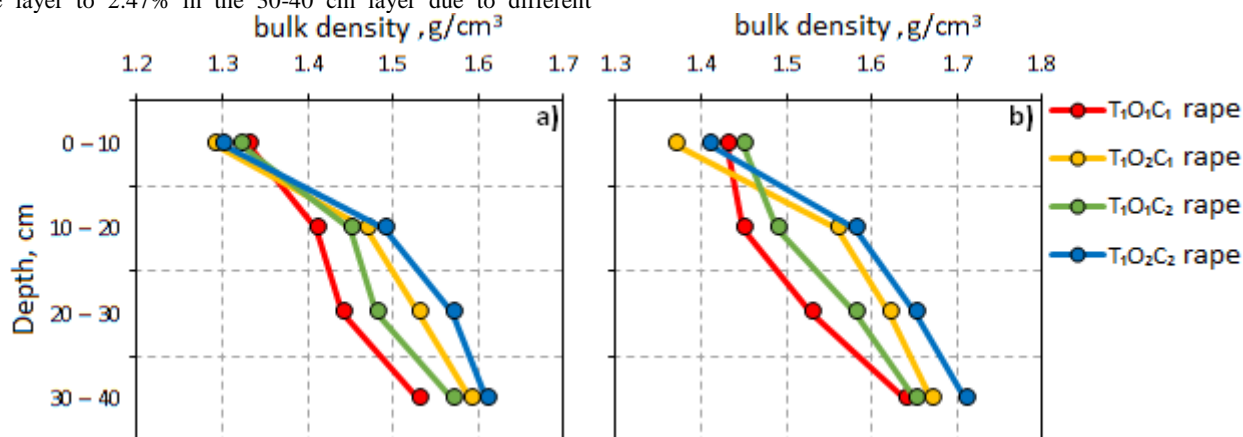


Fig. 2. Soil bulk density g/cm³ 2015/2016 z. – rape [a] germination, b) before harvesting].

In the third year in the rape rosette stage it was found that after loosening to a depth of 35 cm the soil bulk density in the layer 10-20 cm was lower with 0.06-0.07 g/cm³ of the lots with the

residue and 0.05-0.09 g/cm³ in the removal variants compared to the plowing at 20-25 cm (Figure 2, a). Prior to harvesting rape, the bulk density was high for the entire studied layer 0-40 cm (Figure 2, b).

Combining the effect of loosening with the use of plant residues from previous crops helps to lower the parameter values compared to those with plowing 0.08-0.11 g/cm³ for the 10-20 cm layer and 0.07-0.09 g/cm³ for the 20-30 cm layer, respectively for variants O₁ and O₂.

Taking into account the soil hardness, similar trends have been established with those of the bulk density. In the third year of rape growing, it was found that, after loosening, the values for this parameter were about 20 kg/cm² lower in the 20-30 cm layer compared to the tillage lots. Until the harvesting of the crop, the values increase significantly after the drought.

Effect on agrochemical characteristics of the soil: From the analysis of the taken field baseline samples, the content of digestible nitrogen in the soil layer of 0-30 cm was good and at a depth of 30-60 cm from satisfactory to good. A comparative uniformity of content from individual sampling was established. The content of mobile forms of phosphorus marks the same trend. From the agrochemical analysis it was found that potassium had a satisfactory quantity and no fertilization with this macroelement was planned.

After the completion of the vegetation of the first crop of crop rotation - grain maize, it was found that, despite high nitrogen fertilization rates and pre-existing soil reserves, the ammonia and nitrate nitrogen content was lowered. It can be assumed that a part of the nitrogen labile compounds are washed in depth of the soil profile as a result of the abundant supply of rainwater. From a

content of 13.0-21.9 mg/100g of soil in the plow horizon, phosphorus decreases to 7.8-13.7 mg/100g of soil. With smaller differences, the content of digested potassium is also decreased. After barley vegetation, it is found that there is a satisfactory supply of digestible nitrogen. There is no reduction in nitrogen as a result of the denitrification activity of the micro-organisms. The content of digestible forms of phosphorus in the high fertilizer variants T₁ is higher with 1.2-1.7 mg/100g of soil compared to variants T₂. The potassium content decreases in all tested variants.

In the third year, from the samples taken at the end of rapeseed's vegetation, the highest content of digestible nitrogen is in the variant with zero fertilization and use of the plant residues from the previous crops (T₀O) - 22.8 mg/kg, probably due to fewer harvested plants and lower yields. In the variants with plowing of plant residues the level of digestible phosphates increases - from 11.4 mg/100g after plowing to 16.1 mg/100g soil after loosening to 35 cm (Table 1). There is a tendency of decrease of phosphorus in the under layer in variants without plant residues (O₂).

Potassium decreases in the variants with removal of the plant mass - by 2.5; 4.6 and 5.6 mg/100 g of soil according to the fertilization options. This fact confirms the positive role of plant mass usage for improving the soil diversity diet - Planosols. The reaction of the soil solution is slightly acidic, and in the variants using the physiologically neutral and alkaline mineral fertilizers T₂ there is a slight tendency to raise the pH.

Table 1. Agrochemical characteristics of Planosols in rape growing in 2016.

Variant	Depth of the layer in cm	pH		Σ N-NH ₄ +NO ₃ mg/kg	P ₂ O ₅ mg/100gr	K ₂ O mg/100gr	Humus %
		H ₂ O	KCl				
T ₀ O ₁ C ₁	0-30	6,1	5,4	22,8	10,1	22,0	1,99
T ₀ O ₁ C ₁	30-60	6,3	5,6	17,3	3,2	16,7	1,08
T ₁ O ₁ C ₁	0-30	6,2	5,3	18,1	11,2	25,5	1,88
T ₁ O ₁ C ₁	30-60	6,3	5,4	11,5	8,0	14,8	1,56
T ₂ O ₁ C ₁	0-30	6,4	5,6	20,2	16,1	26,5	1,80
T ₂ O ₁ C ₁	30-60	6,5	5,7	13,2	12,0	13,9	1,43
T ₀ O ₂ C ₂	0-30	6,1	5,3	20,7	10,1	19,5	1,77
T ₀ O ₂ C ₂	30-60	6,2	5,4	16,7	8,6	12,3	1,78
T ₁ O ₂ C ₂	0-30	6,1	5,2	21,3	11,0	21,9	1,97
T ₁ O ₂ C ₂	30-60	6,1	5,3	14,8	8,7	17,2	1,54
T ₂ O ₂ C ₂	0-30	6,3	5,4	22,4	11,4	20,9	1,72
T ₂ O ₂ C ₂	30-60	6,2	5,4	18,4	8,6	11,3	1,43

Effect on microbiological activity in the soil: In the Planosols, the highest amount of ammonifying bacteria was recorded in both treatments at the fertilization rate T₂. In the jointing phase of the barley growth, an increase in the amount of cellulose-producing microorganisms was detected in all variants when plowing plant residues.

Table 2. Number of main groups of microorganisms in rapeseed rhizosphere at harvesting – 2016

Variant	Ammonifying bacteria	Actinomycetes	Mineral nitrogen digesting bacteria	Microscopic fungi	Cellulose decomposing microorganisms
T ₀ O ₁ S ₂	7.47 d	1.4 c	3.87 c	6.4 d	9.73 c
T ₁ O ₁ S ₂	12.53 bc	3.67 b	9.07 b	7.47 cd	16.0 b
T ₂ O ₁ S ₂	10.2 cd	0.53 c	5.33 c	25.07 a	9.93 c
T ₀ O ₁ S ₁	11.2 cd	3.0 b	8.27 b	9.4 c	9.2 c
T ₁ O ₁ S ₁	15.33 b	1.47 c	5.13 c	7.0 d	14.93 b
T ₂ O ₁ S ₁	52.67 a	10.07 a	15.27 a	22.67 b	96.4 a

During the third year when in the deposition area was introduced plant mass from 669.4 to 1004.8 g/m² and good conditions were created for activating the activity of microorganisms in the soil. In the rosette formation stage in the rape rhizosphere an increase in the amount of cellulose microorganisms was registered in all variants with plowing of plant residues - higher in those with mineral fertilization.

In the ripe phase, the amount of ammonifiers is increased in all variants when plowing plant residues and the most noticeable at the higher fertilization rate (Table 2). Cellulose decomposing microorganisms increase at both fertilizer levels - more significant in higher T₂. A general tendency for the experiment is the increase of the microbiological activity in the lots of the area with the plowing of the residues from the previous crops.

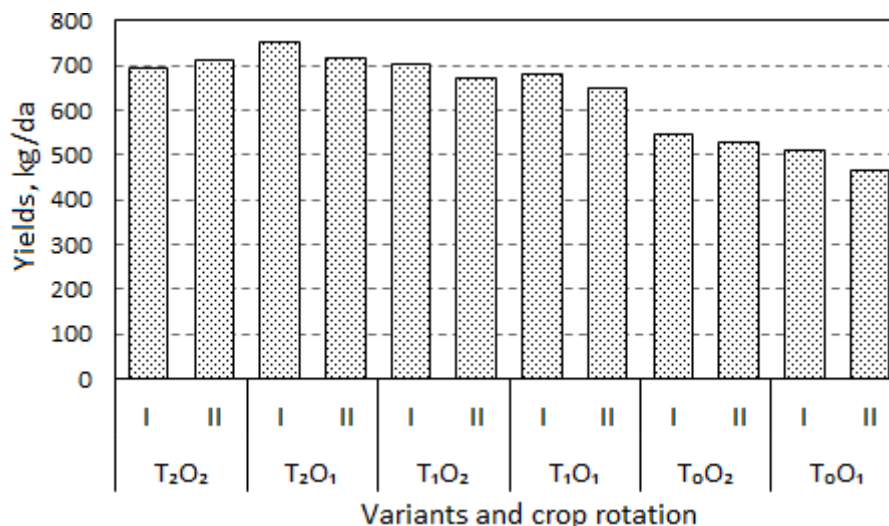


Fig. 3. Yields grain maize kg/da experiment at Experimental Station on Irrigated Agriculture, Pazardzhik

Effect on crop productivity: For the conditions of the studied area, yields are influenced by agro-technical factors.

In the first year of cultivation - grain maize, relatively high yields were obtained, with a yield of 694 to 751 kg / da (Figure

3) being obtained for the highest T₂ fertilization rate. The higher norm logically leads to an increase in yield, with differences between the fertilizer lots T₂ and T₁ from 37.8 kg/da to 71.1 kg/da.

Table 3. Dispersion analysis of maize yield 2014.

Source of variation	Sum of the squares	Sum of the squares %	Degrees of freedom	Average quadratic deviation	F-test	Level of significance
Fertilizing (F)	39801,812	80,363	2	19900,906	51,919	,000***
Processing (O)	2610,031	5,270	1	2610,031	6,809	,023 *
F*O	2516,271	5,080	2	1258,136	3,282	,073 -
Error	4599,722	9,287	12	383,310		
Total sum	49527,836		17			

Statistical data processing indicates that fertilization has the most significant impact on yields. Soil treatment has a negligible effect on yields. The impact of the interaction between the agrotechnical factors tested is also very low.

Table 4. Dispersion analysis of barley yield 2015.

Source of variation	Sum of the squares	Sum of the squares %	Degrees of freedom	Average quadratic deviation	F-test	Level of significance
Fertilizing (F)	34101.080	75,888	2	17050.540	79.505	0.000 ***
Processing (O)	2500.000	5,563	1	2500.000	11.657	0.002 **
F*O	1901.042	4,231	2	950.521	4.432	0.021 *
Error	6433.738	14,318	30	214.458		
Total sum	44935.860		35			

In the second year the increase of the yield is mainly due to the fertilization carried out. For barley, at three fertilization levels and two soil treatment systems, the dispersion analysis of the data shows that on the yields a significant effect on have both fertilization (probability of error $p < 0.1\%$) and soil treatment (at $p < 0.2\%$). The mutual influence of the two studied factors is also statistically proven (at $p < 5\%$).

For the rapeseed also the greatest impact on agro-technical factors has the fertilization. The highest yields are

fertilization variant T₂ - in option O₁ after loosening 260 kg/da, and in option O₂ 212,2 kg/da (Fig. 4). Compared to the non-fertilizing variants, the increase in the yield is 60.2% and 55% respectively for options O₁ and O₂. The application of loosening as the main treatment increases the yields compared to the plowing - 41.1 and 19.6 kg/da for the T₂ and T₁ fertilizer lots, and with 15.8 and 16.8 kg/da respectively for the residue removal area. With zero fertilization the differences are negligible.

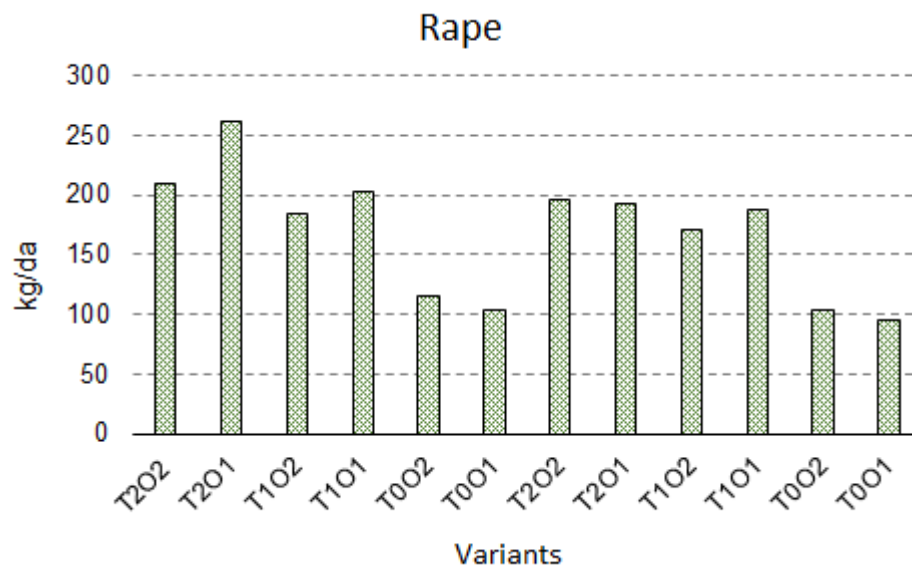


Fig.4. Rape yield kg/da, Experimental Station on Irrigated Agriculture, Pazardzhik 2016.

From the dispersion analysis, it can be seen that for rape, statistically fertilization has the highest impact on yields ($p < 0.1\%$). There are statistically proven differences between the average yields obtained from the different fertilization variants, as the fertilization

rate increases as well as the yields (Table 5). Soil treatment has less impact on the yield value ($p < 1\%$), but as has been shown in other studies, it supports the effective impact of other agro-technical factors.

Table 5. Dispersion analysis of rape yield – 2016.

Source of variation	Sum of the squares	Sum of the squares %	Degrees of freedom	Average quadratic deviation	F-test	Level of significance
Fertilizing (F)	78261.744	85,408	2	39130.872	112.565	0.000 ***
Processing (O)	995.403	1,086	1	995.403	9.863	0.002 **
F*O	1946.832	2,125	2	973.416	4.300	0.027 *
Error	10428.838	11,38175,	30	347.628		
Total sum	91632.816		35			

Rape seed yield is also influenced by the use of plant mass. In variants O₁ (with the plowing of the available plant mass) and O₂ (with removal from the experimental area) differences in yields were obtained - with loosening and high fertilization rate of 48.8 kg, and after plowing with 23.4 kg, at the lower fertilizer rate of 16.4 kg and 13.5 kg respectively, and the smallest differences were recorded in the non-fertilizing variants - 8.5 kg and 11.0 kg, respectively.

CONCLUSIONS

Effective growth of crop yields of three-field crop rotation system maize-barley-rape is ensured by applying a treatment system including more intensive treatments, optimal fertilization, and plowing residual plant mass in the soil. The most significant is the impact of applied mineral fertilization with nitrogen and phosphorus. Lack of fertilization influences yields more significantly in rapeseed compared to maize and barley. The soil treatment system also has an impact on the level of yields obtained, better evidenced when growing oilseed rape.

The moisture content of the soil is mainly influenced by the type of treatment applied (loosening as a base and plowing as a pre-sowing) and by the use of plant residues. The excessive compaction found in the beginning of the experiment in the 25-40 cm layer is partly overcome by performing a deep loosening to the depth of 35 cm.

In spite of the short period of the study, there was a certain decrease in the content of digestible potassium forms and a slight increase in soil pH.

The results show the activation of the microbiological activity after plowing of the plant residues - an increase of the amount of the cellulose decomposing microorganisms and of the

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