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THE IMPACT OF THE CROPPING SYSTEMS ON YIELD, EROSION AND SOIL FERTILITY IN THE MOLDAVIAN PLAIN

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ABSTRACT - The influence of long-term fertilization on wheat and maize yield and soil fertility has investigated at the Agricultural Research and Development Station of Podu – Iloaiei, since 1967. These experiments were carried out on a 14 % slope field, with clayey loam texture (418 g clay, 324 g loam and 258 g sand), a neuter to weakly acid reaction and a mean nutrient supply. Within the experiment, the following rotation schemes have been followed: wheat and maize continuous cropping, two-year rotation (wheat-maize), three-year rotation (peas-wheat-maize) and four-year rotation + reserve field cultivated with legumes and perennial grasses (alfalfa + *Lolium* or Sainfoin + *Bromus*). The use of 3 and 4 year- rotations with annual and perennial meliorate plants has resulted in yield increases of 28.8 – 31.5 % (742 – 811 kg/ha) in wheat and 29.0-32.5% (1270-1420 kg/ha) in maize, as compared to continuous cropping. The investigations conducted on 16% slope fields, by means of erosion control plots, have shown that mean annual of soil losses by erosion were between 3.095 and 6.717 t/ha in row crops and between 0.548 and 1.779 t/ha in wheat and peas crops.

Key words: slope land, erosion, fertilizers, cropping system, organic carbon

REZUMAT – **Impactul sistemelor de cultură asupra producției, eroziunii și a fertilității solului în Câmpia Moldovei**. Influența fertilizării de lungă durată asupra producției de grâu și porumb si a fertilității solului au fost studiate la Stațiunea de Cercetare Dezvoltare Agricolă Podu – Iloaiei, din anul 1967. Aceste experiențe au fost amplasate pe un teren cu panta de 14%, cu o textură luto - argiloasă, o reacție neutră spre slab acidă și o aprovizionare medie în elemente nutritive. În cadrul experimentului, s-au studiat următoarele scheme de rotație a culturilor: monocultura de grâu şi porumb, rotația de 2 ani (grâu-porumb), rotația de 3 ani (mazăre – grâu – porumb) şi rotația de 4 ani, cu o solă săritoare, cultivată cu

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leguminoase şi graminee perene (lucernă + *Lolium* sau sparcetă + *Bromus*). Folosirea asolamentelor de 3 şi 4 ani cu plante amelioratoare anuale şi perene a determinat obținerea unor sporuri de producție, în comparație cu monocultura, de 28.8 – 31.5 % (742 – 811 kg/ha) la grâu si 29.0-32.5% (1270-1420 kg/ha) la porumb. Cercetările efectuate pe terenurile cu panta de 16%, cu ajutorul parcelelor pentru controlul eroziunii, arată ca pierderile medii anuale de sol prin eroziune au fost cuprinse între 3,096 si 6,717 t/ha la culturile prășitoare și intre 0,548 si 1,779 t/ha la culturile de grâu și mazăre.

Cuvinte cheie: teren în pantă, eroziune, fertilizare, sistem de cultură, carbon organic

INTRODUCTION

The objective of this paper is to present the results obtained in long-term experiments regarding the effect of organic and mineral fertilizers on main indices of soil fertility and yield of wheat and maize. In the last period, the goal of many studies carried out in different countries was to improve the technological elements concerning soil fertilization, tillage, and rotations with perennial grasses and legumes, which determine the increase in the content of organic carbon from soil and the diminution of soil erosion and the effect of greenhouse gases (Allmaras, 2006; Russell, 2006; Ailincăi *et al*, 2009; Lal, 2010). The innovative technology to meet the future demands must meet the restore degraded soils and ecosystems (Lal, 2010).

Many investigations conducted in different countries have shown that applying low rates of mineral fertilizers with nitrogen, phosphorus and potassium in wheat and maize continuous cropping and wheat-maize rotation has determined the diminution in the content of organic matter from soil (Allmaras, 2006; Russell, 2006; Nelson *et al*., 2008; Oprea *et al*., 2009). In clayey-loam Mollisol from Kanawha, the value of the organic carbon mass has increased from 33.3 to 37.3 g carbon kg/ soil, when using the rate of 270 kg/ha N against the unfertilized control, in maize-oats-alfalfa-alfalfa rotation (Russell, 2006**)**. Investigations conducted by Allmaras, 2006 on loam-sandy soils from Rosemount, Minnesota, have shown that applying rates of 200 kg nitrogen as ammonium sulfate [$(NH_4)_2$ SO_4]), contributed to the increase in the amount of organic residues from soil and determined the increase in the organic carbon content by 20% against the unfertilized control (Allmaras, 2006). On slope lands, of the Missouri Coteau region in south-central Saskatchewan, Canada mass of SOC was higher in the restored grassland catenae than in the cultivated equivalents. In the shoulder positions showed the greatest response in soil C sequestration to grass seed-down, with a 1.4–2.9 Mg ha/year SOC increase apparent over an approximately eight-year period (Nelson *et al.,* 2008).

At cambic chernozem from Fundulea, Călăraşi County, the results show an increase of the organic matter (Ct% and Nt%) in wheat monoculture, owing to vegetable remain, more abundant than in row crops (Oprea *et al*., 2009). On the clayey chernozem soil of Turda, during a 34 year experiment, in comparison with a content of 4.04% without fertilizers, chemical or organo-chemical fertilization improved the humus content with up to 0.32% (Ştefănescu, 2004).

MATERIALS AND METHODS

The research concerning the influence of fertilizers and crop rotation on wheat and maize yield and soil erosion was carried out within some stationary experiments conducted since 1967. The experiments were carried out on a cambic chernozem with a slope of 14 %, on a southern position.

The determination, in different crops, of water runoff, soil, humus and nutritive element losses by erosion was done by the help of plots for loss control, which are isolated from the rest of the area by metallic walls and have basins and devices for division; we took water and soil samples from plots for determining the partial turbidity and for chemical elements analyses.

The experiment was conducted according to the experimental scheme, to the method of blocks, on in uniform land, as concerns soil fertility, relief, predecessor plant and technology used. In wheat, we have used varieties Fundulea 4 (1995-2003) and Gabriela since 2004, and in maize, hybrids Podu - Iloaiei 110 (1995-2004) and Oana, since 2005.

After each cycle of crop rotation, physical, chemical and biological tests of soil samples were carried out in tested variants according to the well-known methods. The content of organic carbon was determined by the Walkley-Black method, to convert soil organic mater into soil organic carbon it was multiplied by 0.58. The content in mobile phosphorus from soil was determined by Egner-Riechm Domingo method, in solution of ammonium acetate-lactate (AL) and potassium was measured in the same extract of acetate-lactate (AL) at flame photometer.

RESULTS AND DISCUSSION

The climatic conditions in the Moldavian Plain were characterized by a multiannual mean temperature of 9.6°C and a mean rainfall amount, on 81 years, of 544 mm, of which 119.1 mm during October-December and 424.9 mm during January-September. In the last 15 years, the mean annual recorded quantity of rainfall was of 603.8 mm (100%), of which 374.4 (62%) mm determined water runoff and soil losses by erosion (*Table 1*).

The mean yield increases in wheat, during 1995-2009, were between 24.2 and 31.5 % (622 - 811 kg/ha), due to crop rotation and between 46.1 and 101.7 % (845 - 1866 kg/ha), due to applied fertilizer rates (*Table 2*).

Applying high fertilizer rates ($N_{160}P_{100}$) in wheat has determined, in the last 15 years, an average yield increase of 96.2 % (1765 kg/ha), while the use of low mineral fertilizer rates ($N_{80}P_{60}$), together with 30 t/ha of organic manure, resulted in getting an yield increase of 101.7% (1866 kg/ha).

Table 1 - Rainfall deviations during 1995-2009, compared to multiannual mean registered at the Weather Station of Podu - Iloaiei, Iași County (mm)

Years	I	II	III	IV	V	VI	VII	VIII	IX	Sum
1995	42.4	13	38.8	20.6	85.8	58	33	74.7	104	470.3
1996	32.1	35.7	34.8	49.8	24.2	81.6	69	66.1	208.2	601.5
1997	7.1	10.4	6.1	91.5	25.1	69.9	64.7	74.9	37.2	386.9
1998	29.4	6.8	38.7	55.7	61.7	92.9	102.8	33.4	60.6	482
1999	35.3	38.2	19.3	71.7	24.3	80	84.7	60.6	21.8	435.9
2000	24.3	27.4	26.7	62.8	10.6	43.3	77.5	39.5	136.9	449
2001	23	11.4	30.9	74.7	43.8	103.3	67.2	20.4	146.6	521.3
2002	6.9	6.6	56.6	18.9	29.4	57.4	120.2	107.6	38.3	441.9
2003	35.3	21.6	22.3	21.1	10	19.1	118.4	44.1	38.5	330.4
2004	67.9	31.3	18.5	16.8	19.8	20.7	125.3	99.1	61.6	461
2005	42.4	42.1	25.6	86.2	106	86.3	64.7	160	14.3	627.6
2006	29.3	7.8	97.3	98	57	93.7	163	121.5	18.9	686.5
2007	20.3	30.2	30.2	27.0	30.7	15.6	63.6	63.6	108.7	389.9
2008	10.9	2.6	25.2	127.3	43.2	65.2	145.1	48.0	52.0	519.5
2009	80	56.5	37.5	5	44	139	122	12	25	521
Mean	32.4	22.8	33.9	55.1	41.0	68.4	94.7	68.4	71.5	488.3
Mean for 81 years	27.6	23.9	24.5	41.8	53.1	77.5	73.0	61.4	42.1	489.5
Difference	-4.8	1.1	-9.4	-13.3	12.1	9.1	-21.7	-7.0	-29.4	1.2

Table 2 - Influence of long-term fertilization and crop rotation on wheat yield during 1995 - 2009

Treatment	Wcc*	WM	PWM	PWMSf+G	SWM+2G	Average	Differ.
N_0P_0	1419	1501	1994	2077	2180	1834	
$N_{80}P_{60}$	2156	2186	2911	3024	3121	2680	845^{xxx}
$N_{120}P_{80}$	2824	2876	3419	3658	3759	3307	1473^{xxx}
$N_{160}P_{100}$	3173	3291	3793	3887	3851	3599	1765^{xxx}
$N_{80}P_{60}$+ 30 t/ha manure	3315	3317	3882	3952	4032	3700	1866^{xxx}
Average	**2577**	**2634**	**3200**	**3320**	**3389**	**3024**	
Difference		57	622^{xxx}	742^{xxx}	811^{xxx}		

	Fertilizer	Crop rotation	Interaction	
LSD 5%	229	116	322	kg/ha
LSD 1%	333	156	443	kg/ha
LSD 0.1%	500	204	610	kg/ha

*Wcc=Wheat continuous cropping, WM=Wheat-maize rotation, PWM=Peas –wheat-maize rotation, PWMSf+G=Peas–wheat-maize–sunflower+reserve field, cultivated with legumes and perennial grasses, SWM+2 G=soybean-wheat-maize+two reserve field, cultivated with legumes and perennial grasses.

The highest yield increases the best from the economic point of view, obtained in wheat during 1995-2009, were of 1473 kg/ha (80.3%) at a rate of N_{120}+80 P_2O_5 and 1866 kg/ha (101.7 %) when N_{80}+60 P_2O_5 +30 t/ha manure was use. In wheat placed in four year rotation + two reserve field, cultivated with legumes and perennial grasses, after soybean, mean yield increases obtained for each kg of a. i. of applied fertilizer was between 6.4 and 6.7 kg grains.

The mean yield increases, obtained in maize during 1995-2009, were between 11 and 32 % (488 - 1420 kg/ha), due to crop rotation and between 41 and 97 % (1326 - 3154 kg/ha), due to applied fertilizer rates (*Table 3*). Placing maize crop in 3 and 4- year crop rotations with annual and perennial legumes has resulted in getting yield increases of 29 - 32 % (1270 - 1420 kg/ha), as compared to continuous cropping. On slope lands, the high mineral rate fertilization ($N_{160}P_{100}$) has determined, in the last 15 years, an average yield increase of 96.2 % (1765 kg/ha), in wheat and 93% (3025 kg/ha) in maize, as compared with the unfertilized control. In maize crop, the use of four year rotation + two reserve field, cultivated with legumes and perennial grasses resulted in getting mean yield increases obtained for each kg of a. i. of applied fertilizer was between 12.1 and 13.2 kg grains. The results obtained determined us to appreciate that on slope lands one may obtain yields similar to those obtained on plane lands, if technological processes and technical elements are correctly managed.

Table 3 - Influence of long-term fertilization and crop rotation on maize yield during 1995 - 2009

Treatment	Mcc	WM	PWM	PWMSf+G	SWM+2G	Average	Differ.
N_0P_0	2603	3014	3460	3556	3595	3246	
$N_{80}P_{60}$	3548	4076	4816	5094	5287	4571	1326^{xxx}
$N_{120}P_{80}$	4773	5319	5747	6006	6221	5613	2368^{xxx}
$N_{160}P_{100}$	5375	5881	6567	6704	6826	6271	3025^{xxx}
$N_{80}P_{60}$+ 30 t/ha manure	5515	5998	6619	6842	7023	6399	3154^{xxx}
Average	**4370**	**4858**	**5442**	**5640**	**5790**		
Difference		488	1072	1270	1420		

	Fertilizer	Crop rotation	Interaction	
LSD 5%	314	167	454	kg/ha
LSD 1%	457	223	625	kg/ha
LSD 0.1%	686	294	861	kg/ha

The results obtained demonstrated that on slope lands, the mineralization processes were stronger, in comparison with the humification ones, fact that required a more strict control of the soil supply with nutritive elements; they changed rapidly under the influence of soil erosion and technological processes. Soil organic carbon decomposition rates tend to increase with higher soil temperature and moisture levels (Bolinder, 2007).

In Cambic Chernozem, on the slope lands from the Moldavian Plain, a good supply in mobile phosphorus of field crops (36-44 mg/kg) was maintained in annual application of a rate of $N_{120}P_{80}$ and a very good supply (71-74) at the rate of $N_{80}P_{60}$+30 t/ha of manure, applied in crops from 3 or 4 -year crop rotations with perennial grasses and legumes (*Table 4*). The 41-year use of 3 and 4-year crop rotations, which included ameliorating plants of perennial grasses and legumes in the crop structure, has determined a good degree of the mobile phosphorus supply in soil (51-63 mg/kg) at the rate of $N_{120}P_{80}$. In comparison with 4-year crop rotations, with breeder plants (annual and perennial legumes and perennial grasses), in wheat-maize rotation the content in mobile phosphorus decreased from 57 to 46 P-AL, mg/kg. Annual application of rates of N_{80}+60 P_2O_5+ 30 t/ha manure in a three year rotation (soybean-wheat-maize) + two reserve fields with legumes and perennial grasses determined the accumulation of a reserve of organic carbon in soil of 19.5 g/kg (*Table 5*). The 41 year use of 4- year crop rotations, which included melioration plants, has determined the increase in organic carbon mass and mobile phosphorus from soil by 13.4% (2.3 C g/kg) and 39%, respectively (16 P-AL mg/kg), against maize continuous cropping (*Table 4,5*).

Table 4 - Influence of long-term fertilization and crop rotation on the content of mobile phosphorus from soil (P-AL, mg/kg)

Treatment	Mcc	WM	PWM	PWMSf+G	SWM+2G	Average	Differ.
N_0P_0	11	12	15	16	18	14	
$N_{120}P_{80}$	36	45	51	62	63	51	37^{xxx}
$N_{160}P_{100}$	49	58	64	69	71	62	48^{xxx}
$N_{80}P_{60}$+ 30 t/ha manure	66	69	71	74	77	71	57^{xxx}
Average	**41**	**46**	**50**	**55**	**57**		
Difference		5	9^{xx}	14^{xxx}	16^{xxx}		
	Fertilizer		Crop rotation		Interaction		
LSD 5%	3.3		5.1		8.		mg/kg
LSD 1%	4.5		7.4		11.6		mg/kg
LSD 0.1%	5.9		11.2		16.0		mg/kg

Table 5 - Influence of long-term fertilization and crop rotation on organic carbon from soil (C, g/kg)

Treatment	Mcc	WM	PWM	PWMSf+G	SWM+2G	Average	Differ.
N_0P_0	15.3	15.9	16.2	16.8	17.9	16.4	
$N_{120}P_{80}$	16.1	16.8	17.4	18.5	18.8	17.5	1.10^{xxx}
$N_{160}P_{100}$	17.6	18.3	18.5	19.4	19.7	18.7	2.28^{xxx}
$N_{80}P_{60}$+ 30 t/ha manure	19.6	19.9	20.3	21.2	21.6	20.5	4.10^{xxx}
Average	**17.2**	**17.7**	**18.1**	**19.0**	**19.5**	**18.3**	
Difference		0.53^{x}	0.90^{xxx}	1.78^{xxx}	2.30^{xxx}		

	Fertilizer	Crop rotation	Interaction	
LSD 5%	0.29	0.36	0.55	g/kg
LSD 1%	0.36	0.52	0.76	g/kg
LSD 0.1%	0.45	0.77	1.06	g/kg

The Soil Protection Framework Directive of EU includes the necessary legislative proposals, taken into account by all the Member States concerning the three main threats on the decline in organic matter, soil erosion and contamination and some additional aspects regarding compaction, diminution of biodiversity, floods and landslides. In the EU, more than 150 million hectares of soil are affected by erosion and 45% of the European soils have a low content of organic matter (Montanarella, 2008). The results obtained concerning erosion in the Coshocton USA, made according to measurements of Izaurralde (2007) carried out in the North Appalachian Experimental Watershed, showed that in the areas annual mean soil losses by erosion were of 1.18 t/ha (range, 0.35, wheat -7.36, maize). In Austria, during 1994-2007, the mean soil losses in three locations dropped from 6.1 to 1.8 t/ha, by using conservation tillage in cover crops, and until 1.0 t/ha/year with direct drilling. Nitrogen (9.2, 3.7, 2.5 kg/ha/year) and phosphorus (4.7, 1.3, 0.7 kg/ha/year) losses showed similar tendencies (Rosner *et al.*, 2008).

In the last 15 years, from the Moldavian Plain, the mean annual recorded quantity of rainfall was of 603.8 mm, of which 374.4 mm (62%) determined water runoff and soil losses by erosion. The results on runoff and soil loss by erosion in different crops, which were determined by the help of plots for runoff control have shown that, during 1995-2009, of the total of 603.8 mm rainfall, 374.4 mm caused runoff between 11.3 mm in perennial grasses on the second growing season and 34.5 mm in sunflower (*Table 6*). Annual soil losses by erosion registered at the same period were between 0.182 t/ha in perennial grasses on the second growing season and 6.717 t/ha in sunflower. In the last 15 years erosion was within the “allowable limits” of 3 t/ha/year in perennial grasses on the second growing season, wheat, pea and winter rape. Taking into account that the erosion process can not be avoided and that the tolerance level of soil annual losses is 3 t/ha, which correspond to the annual rate of soil renewal, soil annual mean losses by erosion, registered in the last 15 years in maize (6.392 t/ha) and sunflower (6.717 t/ha) can results in destruction of soil fertility. The research conducted until now has shown that erosion-affected soils had a lower profile depth, a rougher texture, a more alkaline reaction, and higher carbonate content and lower humus and mineral element content. Erosion affects soil fertility by removing together with eroded soil, significant organic matter and mineral element amounts which in maize and sunflower crops reach 13.7-14.2 kg/ha of nitrogen, 0.88-0.97 kg/ha of phosphorus and 1.5-2.4 kg/ha of potassium (*Table 7*).

Table 6 - Average annual water and soil runoff by erosion registered in different crops

Crop	Rainfall that caused runoff (mm)	Water Runoff (mm)	Runoff Coeff.	Average Turbidity (g/l)	Erosion (t/ha)
Pea	374.4	19.2	0.05	9.27	1.779
Wheat	337.2	13.1	0.04	4.18	0.548
Maize	374.4	32.7	0.09	19.55	6.392
Sunflower	374.4	34.5	0.09	19.47	6.717
Bean	374.4	28.4	0.08	13.72	3.897
Soybean	374.4	24.5	0.07	12.63	3.095
Rape	337.2	18.6	0.06	7.59	1.412
Ist year grasses	374.4	19.8	0.05	9.22	1.825
IInd year grasses	326.4	11.3	0.03	1.61	0.182
Field	374.4	49.6	0.13	28.50	14.138

Table 7 - Annual average losses of organic carbon and nutritive elements in different crops (kg/ha)

Crop	Nt at water runoff	Nt at eroded soil	Total N	P-AL	K-AL	Total NPK	Organic carbon
Pea	2.400	2.651	5.051	0.194	0.356	5.601	36
Wheat	1.729	0.800	2.529	0.061	0.137	2.727	11
Maize	4.611	9.077	13.688	0.876	1.540	16.104	131
Sunflower	4.589	9.605	14.194	0.967	2.378	17.539	137
Bean	3.749	5.690	9.439	0.429	0.779	10.647	80
Soybean	3.332	4.519	7.851	0.353	0.675	8.879	63
Rape	2.511	2.047	4.558	0.180	0.309	5.047	29
Ist year grasses	2.237	2.701	4.938	0.210	0.454	5.602	37
IInd year grasses	1.277	0.268	1.545	0.020	0.045	1.610	4
Field	4.424	20.217	24.641	1.626	3.393	29.660	289

Table 8 - Average annual water and soil runoff by erosion registered in different crops rotation

Crop rotation	Water Runoff (mm)	Erosion (t/ha)	Organic Carbon (kg/ha)	Row plants (%)
*Mcc	32.7	6.392	131	100
BWMSfW	24.4	3.620	74	60
WM	22.9	3.470	71	50
PWMSf+G	22.6	3.233	65	40
PWM	21.7	2.906	59	33
PWMSf+2G	21.1	2.816	56	33
BWM+ 2G	20.2	2.459	49	40
PWM +G	19.6	2.362	48	25
SWM+2G	19.4	2.299	46	40
PWM + 2G	18.4	2.035	40	20
RWM + 2G	18.2	1.962	39	20

*Mcc = Maize continuous cropping, BWSMW = Beans-wheat-maize sunflower-wheat rotation, WM = Wheat-maize rotation, PWM = Peas –wheat-maize, PWMSf+G = Peas–wheat-maize –sunflower + reserve field, cultivated with legumes and perennial grasses, BWM+ 2G = Beans-wheat-maize + 2 reserve field, SWM +2G = soybean- wheat-maize + two reserve field, RWM + 2G = winter rape-wheat-maize +two reserve field.

Table 9 - Annual average losses of nutritive elements in different crop rotations (kg/ha)

Crop rotation	Nt at water runoff	Nt at eroded soil	Total N	P-AL	K-AL	Total NPK
*Mcc	4.611	9.077	13.688	0.876	1.540	16.104
BWMSfW	3.281	5.194	8.475	0.479	0.854	9.808
WM	3.170	4.939	8.109	0.469	0.839	9.417
PWMSf+G	2.969	4.602	7.571	0.433	0.772	8.776
PWM	2.913	4.176	7.089	0.377	0.678	8.144
PWMSf+2G	2.727	3.981	6.708	0.372	0.668	7.748
BWM+ 2G	2.625	3.464	6.089	0.300	0.550	6.939
PWM +G	2.564	3.351	5.915	0.300	0.545	6.760
SWM+2G	2.541	3.230	5.771	0.285	0.529	6.585
PWM + 2G	2.355	2.856	5.211	0.253	0.465	5.929
RWM + 2G	2.377	2.735	5.112	0.246	0.278	5.636

*Mcc = Maize continuous cropping, BWSMW = Beans-wheat-maize sunflower-wheat rotation, WM = Wheat-maize rotation, PWM = Peas –wheat-maize, PWMSf+G = Peas–wheat-maize –sunflower + reserve field, cultivated with legumes and perennial grasses, BWM+ 2G = Beans-wheat-maize + 2 reserve field, SWM +2G = soybean- wheat-maize + two reserve field, RWM + 2G = winter rape-wheat-maize +two reserve field.

On eroded slope lands, in the Moldavian Plateau, applied growing systems must ensure the reduction in soil losses by erosion under the allowable limit of 3 t/ha/year and and allow getting efficient yields from the economic point of view. At three and four year rotations, which include good and very good cover plants for protecting soil against erosion, the amount of eroded soil lost by erosion were very close to the limit allowable for this area (*Table 8*). The results concerning water runoff and soil losses from crops, placed in different rotations, have shown that on 16% slope lands, the use of peas-wheat-maize rotation + two outside fields, cultivated with legumes and perennial grasses, resulted in soil losses, which diminished by 68 % (4.357 t/ha/year), as compared to maize continuous cropping.

From the results obtained, it was found out that the highest losses of nutritive elements were registered in maize continuous cropping and two year rotation (wheat-maize),13.7-8.1 kg/ha nitrogen, 0.9 - 0.5 kg/ha mobile phosphorus and 1.5 – 0.8 kg/ha mobile potassium, these amounts decreased very much at the same time with the increase in rotation structure of crops protecting soil against erosion, such as pea, wheat, alfalfa and perennial grasses (*Table 9*). During 1995-2009, the use of crop rotations with a percent until 20% of row plants (winter rape-wheat-maize) which also included outside fields cultivated with perennial grasses, has determined the diminution in soil and mineral element losses by 43.5% (1.508 t/ha) and, respectively, 40.1% (3.781 kg/ha), as compared to two-year crop rotation (wheat-maize).

CONCLUSIONS

The 41-year use of the rotation peas – wheat – maize – sunflower + reserve field, cultivated with perennial grasses and legumes, determined a high yield increase, as compared with continuous cropping, of 24% (811 kg/ha) in wheat and 24.5% (1420 kg/ha) in maize.

On slope lands, the mean rate mineral fertilization ($N_{80}P_{60}$), together with 30 t/ha manure, has determined the yield increase of 102% (1866 kg/ha) in wheat and 97% (3153 kg/ha) in maize, as compared with the unfertilized control.

The investigations conducted on 16% slope fields, by means of erosion control plots, have shown that mean annual of soil losses by erosion were between 3.095 and 6.717 t/ha in row crops and between 0.548 and 1.779 t/ha in wheat and peas crops.

The mean annual losses of nitrogen, phosphorus and potassium, once with runoff water and eroded soil, during 1995-2009, on 16% slope fields were of 16.1 kg/ha in maize continuous cropping, 9.4 kg/ha in wheat-maize rotation and 5.6 kg/ha in crop rotation winter rape-wheat-maize + two reserve fields cultivated with perennial grasses and legumes.

The crop structure, which determined, during 1995-2009, the diminution in mean soil losses by erosion until 2.035 t/ha/year included 20 % straw cereals, 20% annual legumes, 20% row crops and 40 % perennial grasses and legumes.

The 42-year use of 4- year crop rotations + reserve field, cultivated with perennial grasses and legumes, has determined the increase in the mass of total carbon from soil by 13.4% (2.2 C g/kg), in comparison with maize continuous cropping.

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