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INFLUENCE OF DIFFERENT ORGANIC RESOURCES ON CROP YIELD AND SOIL FERTILITY IN THE MOLDAVIAN PLATEAU

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ABSTRACT *- Investigations conducted during 2003-2007 at the Podu-Iloaiei Agricultural Research Station have studied the influence of different sewage sludge, manure and crop residues on yield quality and quantity and soil agrochemical characteristics. Experiments were set up in a five year-crop rotation (soybean-wheat-maize-sunflower-wheat). Sewage sludge was applied annually at rates of 20, 40 and 60 t/ha, together with mineral fertilizer, differentiated according to the growing plant. The Cambic Chernozem used for experiments had a clayey-loam texture (415 g clay, 305 g loam and 280 g sand), a weakly acid reaction and a mean supply with mobile phosphorus and a very good one with mobile potassium. Applying rates of 24.6 t/ha DM sewage sludge resulted in the accumulation of mobile phosphate stock in soil of 49 ppm and the microelements content (mobile forms from soil) was of 12.4 ppm at Cu, 0.47 ppm at B, 142 ppm at Zn and 382 ppm at manganese. The combined use of mean rates of mineral fertilizers ($N_{70}P_{70}$), together with 40 t/ha manure or 6 t/ha crop residues from wheat and maize crops, has resulted in improving soil physical and chemical characteristics and getting yield increases in wheat of 2313-2214 kg/ha (136-130 %), on weakly eroded lands, and 2074-2001 kg/ha (178-172 %) on highly eroded lands, compared to the unfertilized control. Both on weakly and highly eroded lands, the mineral fertilization with lower rates than $N_{140}P_{100}$ kg/ha has determined the decrease in humus content from soil until 2.49- 3.05 %. On highly eroded lands, the humus content was kept at values of 3.42-3.49% only by the annual application of the rate of 60 t/ha manure or $N_{70}P_{70}$+ 60 t/ha manure.*

Key words: fertilization, sewage sludge, manure, straw, wheat, soil fertility, soil erosion

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REZUMAT - Influența diferitelor resurse organice asupra producției şi a fertilității solului din Podişul Moldovei. *Cercetările efectuate în perioada 2003-2007, la Stațiunea de Cercetări Agricole Podu-Iloaiei, au studiat influența diferitelor doze de nămol orăşănesc, resturi vegetale şi gunoi, asupra calității şi cantității producției şi a caracteristicilor agrochimice ale solului. Experiențele au fost realizate intr-o rotație de cinci ani (soia-grâu-porumb-floarea-soarelui-grâu). Namolurile orasenesti au fost aplicate în doze de 20, 40 şi 60 t/ha, împreună cu îngrăşăminte minerale, în funcție de planta cultivată. Cernoziomul cambic folosit pentru experiențe are o textură luto-argiloasă (415 g argilă, 305 g lut şi 280 g nisip), o reacție slab acidă , un nivel mediu de aprovizionare cu fosfor mobil şi unul foarte bun cu potasiu mobil. Aplicarea unor doze de 24.6 t/ha SU nămol orăşănesc a dus la acumularea unei rezerve de fosfați mobili în sol de 49 ppm, iar conținutul de microelemente (forme mobile în sol) a fost de 12.4 ppm Cu, 0.47 ppm B, 142 ppm Zn şi 382 ppm mangan. Folosirea combinată a dozelor medii de îngrăşăminte minerale ($N_{70}P_{70}$), împreună cu 40 t/ha gunoi de grajd sau 6 t/ha resturi vegetale, provenite de la culturile de grâu şi porumb, a îmbunătățit caracteristicile fizice şi chimice ale solului şi a dus la creşteri de producție la grâu de 2313-2214 kg/ha (136-130 %), pe solul slab erodat, şi de 2074-2001 kg/ha (178-172 %) pe solurile puternic erodate, în comparație cu varianta martor nefertilizată. Atât pe solurile slab erodate, cât şi pe cele puternic erodate, fertilizarea minerală cu doze mai mici de $N_{140}P_{100}$ kg/ha a determinat scăderea conținutului de humus din sol până la 2.49- 3.05 %. Pe solurile puternic erodate, conținutul de humus s-a menținut la valori de 3.42-3.49%, doar în cazul aplicării anuale a unei doze de 60 t/ha gunoi de grajd sau $N_{70}P_{70}$+ 60 t/ha gunoi de grajd.*

Cuvinte cheie: fertilizare, nămol orăşănesc, gunoi de grajd, paie, grâu, fertilitatea solului, eroziunea solului

INTRODUCTION

In all the countries, the quality of environment factors was affected by economic activities, climatic changes and pollution (Russell, 2006; Sgouras, 2007). The North Eastern region of Romania has 15.45% (2,131,421 ha) of the farming area of the country (14,836,585 ha) and has large areas with soils affected by erosion (over 56%), acidification, compaction, slides, and other forms of degradation (Project of Regional Development for North-East 2007-2013).

All the countries are concerned by finding other nutrient sources, using legumes, manure, straw and composted sewage sludge. Other nutrient sources supplement only a small part of the necessary of nutrients available for the world food demand. This will increase with 1%/year or with 6.3 billion nowadays to 8.3 billion in 2030 and 10 billion in 2070 (Fresco, 2003).

The sewage sludge, rich in organic matter and mineral elements for plants, can be a substitute for the fertilization but also a source of heavy metals pollution for soil, when high rates are applied or when it is used for many years on the same field. The use of sewage sludge in agriculture is one of the most important alternatives (Singh et al., 2008), but the new technologies allow the transformation and the recycling of sewage sludge into a solid fuel (Peregrina et al, 2008). Applying sewage sludge determines the modification of soil physical, chemical and biological characteristics and getting higher yields, as compared to the unfertilized control (Singh et al., 2008). Potato and maize crops, cultivated on sandy-loam fields in New Scotland and Canada, and treated with different rates of municipal solid waste compost, had a lower N content in tissues, as compared to the mineral fertilization with NPK and NPK+solid waste compost. On two years of experiments, the P mean content from tissues has varied between 1.92 and 3.17 g kg^{-1} in potato and between 2.32 and 3.46 g kg^{-1}. In addition, the NPK fertilization, together with solid waste compost, has determined the diminution by 30% in phosphorus absorbed from soil (Mkhabela et al., 2005). The sewage sludge application on acid soils from Larissa, Greece has resulted in increasing pH and the content of organic matter, nitrogen and phosphorus from soil (Tsadilas et al., 2005). The investigations conducted for six years on the effect of municipal solid waste composts and N mineral fertilization on physical and chemical characteristics, enzyme activities and on the composition and activity of soil microorganisms showed that the composts have been used to maintain the long-term productivity of agroecosystems and to protect the soil environment from overcropping (Crecchio et al., 2004). Applying rates of 12 and 24 t ha^{-1} sewage sludge for two years, on fields cultivated in the rotation sugar beet-wheat has determined the increase in the content of organic carbon from 13.3 to 15.0 g kg^{-1} soil and total N from 1.55 to 1.65 g kg^{-1} soil. On soils treated with composted sewage sludge, significant increases in dehydrogenase (9.6%), β-glucosidase (13.5%), urease (15.4%), nitrate reductase (21.4%) and phosphatase (9.7%) activities were found. The increase in the rate of sewage sludge from 12 to 24 t ha^{-1} has determined the diminution in protease activity from 3.6 to 2.8 U g^{-1} soil (Crecchio et al., 2004). The soils contaminated with Cd, Zn, Pb, Ni and Cu may be recovered by immobilizing the heavy metals with different matters (lime) or by metal extraction in different plants.

Metal sorption depends on the nature of organic and inorganic soil constituents, as well as soil pH (Antoniadis et al., 2007). Applying for two years a rate of 16 t ha composted sewage sludge on three types of soils (neutral loam, alkaline sandy soil and acidic sandy soil) has determined significant increases in total soil Cu concentrations (Sebastiao et al., 2000). On clayey Luvisol from Dottikon and Rafz in Switzerland, the application for over 20 years of sewage sludge has resulted in Cd, Zn, Pb, Ni and Cu contamination, and on Cambisol from Girnico, only in Zn and Cd. The application of gravel sludge containing 42% clay mineral, 31% $CaCO_3$, 18% quartz, 7% plagioclase, 2% dolomite and 2% organic matter, has diminished by 4% Zn, Cu and Cd concentrations from soil. In Dottikon and Rafz $NaNO_3$-extractable Zn concentrations were of 0.69-8.04 mg Zn kg^{-1} and 2.10 to 3.99 mg kg^{-1} dry soil prior to the gravel sludge application and after the application of gravel sludge 0.2 and 0.5 mg kg dry soil (Krebs, 1999). In maize, potato and clover crops, treated with composted sewage sludge, the Cu content has increased, but, in most of cases, metal concentrations remained below toxic levels (Hargreaves, 2008).

MATERIALS AND METHODS

Investigations conducted during 2003-2007 at the Podu-Iloaiei Agricultural Research Station have studied the influence of different sewage sludge and manure rates on yield quality and quantity and soil agrochemical characteristics. Experiments were set up in a five year-crop rotation (soybean-wheat-maize-sunflower-wheat). Sewage sludge was applied annually at rates of 20, 40 and 60 t/ha, with different mineral fertilizer rates, differentiated according to the growing plant. The Cambic Chernozem used for experiments has a clayey-loam texture (415 g clay, 305 g loam and 280 g sand), a weakly acid reaction and a mean supply with mobile phosphorus and a very good one with mobile potassium.

The soil on which physical and chemical analyses were done, was sampled at the end of plant growing period. Soil response was determined in water suspension by potentiometrical means with glass electrode. The content of organic carbon was determined by the Walkley-Black method and the content of mobile phosphorus from soil was determined by the 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. Determinations of cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc in extracts of soil- were measured by flame and electro-thermal atomic absorption spectrometric method, with the International Standard ISO 11047:1998. ANOVA was used to compare treatment effects.

RESULTS AND DISCUSSION

The climatic conditions in the Moldavian Plain were characterized by a mean multiannual temperature of 9.6 ^{o}C and a mean rainfall amount, on 80 years, of 542 mm, of which 161.2 mm, during September-December, and 380.8 mm, during January-August. The climatic conditions registered during 2003-2007 have resulted in a good capitalization of mineral fertilizers, manure and sewage sludge in main crops.

The analyses of sewage sludge from Iasi water treatment station were applied in crops on Chernozem of Podu-Iloaiei. They have shown that in 2005, only at zinc, it exceeded the limit established by EU regulations and Romanian laws (by Order no. 49 from 01.14.2004) (*Table 1*). Sewage sludge from the Iasi Treatment Station, by its physical and chemical characteristics, can be used in agriculture. The content of heavy metals from sewage sludge is within maximum allowable limits, established by regulations of Rule no. 86/278/EEC and Order no. 49 from 01/14/2004, under conditions of sewage sludge application on certain soils (*Table 2*). Small increases of total soil Zn concentrations were observed, where solid waste compost was applied at a rate of 15 Mg ha^{-1} to an alkaline sandy soil, but no increases were found when the compost was applied to an acidic sandy soil or a neutral sandy loam (Sebastiao et al., 2000).

Table 1- Content of heavy metals at sewage sludge from the Iasi station, used for the experiments (mg/kg DM)

Year	Zn	Cu	Fe	Mn	Pb	Ni	Cr	Co	Cd	Hg
2004	2475	42.9	20668	315	187	38	87	37	3.6	2.02
2005	3260	63.9	21629	323	174	57	86	35	3.5	1.91
2006	2461	61.3	24558	325	164	64	74	33	3.3	1.82
2007	2284	68.0	26608	355	148	81	66	29	3.1	1.87
2007	2224	76.0	31567	385	123	36	56	11	1.3	1.75
Mean	**2541**	**62**	**25006**	**341**	**159**	**55**	**74**	**29**	**3.0**	**1.87**
LSD 5%	189	4.6	670	15.5	9.6	8.4	5.2	3.4	0.17	0.13
LSD 1%	275	6.7	975	22.6	14.0	12.2	7.5	4.9	0.25	0.19
LSD 0.1%	413	10.0	1463	33.9	21.0	18.3	11.2	7.5	0.37	0.29

Table 2 - Maximum allowable concentrations for farming sewage sludge, according to Directive 86/278/EEC (further amended by Council Regulation 1882/2003/EC) and Order no. 49 (mg/kg DM)

Heavy metals	Heavy metals content from Iasi water treatment station (mg/kg DM)	Directive 86/278/EEC, Council Regulation 1882/2003/EC) (mg/kg DM)	Maximum allowable concentrations for farming sewage sludge, according to Order no. 49 (mg/kg DM)
Zn	2541	2500-4000	2000
Cu	62	1000-1750	500
Fe	25006	-	-
Mn	341	-	-
Pb	159	750-1200	300
Ni	55	300-400	100
Cr	74	-	500
Co	29	-	50
Cd	3.0	20 – 40	10
Hg	1.87	16 – 25	

The results obtained have shown that by applying a rate of 30 t/ha raw sewage sludge (18.51 t/ha), the maximum allowable limits were not exceeded. By applying a rate of 60 t/ha raw sewage sludge (37.0 t/ha DM), the limits established by Norm 86/278/EEC and Order no. 49 from 01.14.2004 were exceeded only at zinc (*Table 3*).

The mean yield increases obtained in the last 5 years in maize crop, by applying rates of 40 t/ha sewage sludge, were of 2110 kg/ha (58%), compared to the untreated control. Mean yield increase obtained in the last 5 years in maize, for each tone of sewage sludge, calculated by the equation of multiple regressions, was of 30.5 kg/t (*Table 4*).

Table 3 - Content of heavy metals from soil (mg/kg DM) at different rates of chemical fertilizers and sewage sludge applied on the cambic chernozem at the Podu-Iloaiei Agricultural Research Station

Heavy metals from soil (0-20 cm)	Rates applied					LSD 5; 1; 0.1% mg/kg
	N_0P_0	$N_{100}P_{80}$	40 t/ha sewage sludge	$N_{100}P_{80}$ +40 t/ha sewage sludge	60 t/ha sewage sludge	
Zn	123	118	168	203	438	4.0;5.9;8.8
Cu	7.5	8.2	12.06	10.6	13.9	1.2;1.7;2.5
Fe	17928	18336	18736	18354	20580	599;871;1307
Mn	295	329	387	392	412	13;19;28
Pb	43	45	59	54	68	5;8;11
Ni	32.4	34.2	42.3	38.2	48.5	2.1;3.0;4.5
Cr	29.3	31.4	47.2	48.6	49.6	0.8;1.2;1.8
Co	21.6	24.1	25.9	24.3	28.1	1.8;2.6;3.8
Cd	1.03	1.05	1.15	1.07	1.17	0.05;0.08;0.12

Table 4 - Influence of sewage sludge and mineral elements fertilization on maize yield in Oana hybrid

Treatment	Mean yield		Difference, kg/ha	Signif
	kg/ha	%		
Unfertilized control	3620	100		
$N_{100}P_{80}$	6080	168	2460	xxx
20 t/ha sewage sludge	4720	130	1100	xxx
20 t/ha sewage sludge+ $N_{100}P_{80}$	6580	182	2960	xxx
40 t/ha sewage sludge	5730	158	2110	xxx
40 t/ha sewage sludge+ $N_{100}P_{80}$	6980	193	3360	xxx
60 t/ha sewage sludge	6140	170	2520	xxx
60 t/ha sewage sludge+ $N_{100}P_{80}$	7160	198	3540	xxx
Yield (Y) = 4136 + 9.15NP + 30.5 sewage sludge (t/ha), R^2=0.923, obs=8				
LSD 5%= 256 kg/ha, LSD 1%= 355 kg/ha, DL 0.1% = 493 kg/ha				

On weakly eroded lands, the mean wheat yields obtained during 1998-2007, were comprised between 1697 kg/ha (100 %) at the unfertilized control and 4894 kg/ha (188 %) at rates of 70 kg N + 70 kg P_2O_5 + 60 t/ha manure (Table 5). Under these conditions, by applying rates of 100 kg N + 100 kg P_2O_5 or 140 kg N +100 kg P_2O_5/ha, the mean yield increases obtained were of 2381 and, respectively, 2826 kg/ha.

On highly eroded soil, the mean wheat yields obtained during 1998-2007, in wheat crop, placed in peas-wheat-maize rotation, were of 1163 kg/ha, under unfertilized, and of 3665 kg/ha at high mineral fertilizer rates ($N_{140}P_{100}$). In wheat, the application of mean rates of mineral fertilizers with 60 t/ha manure has resulted in getting yield increases of 183 % (2131 kg/ha), compared to the unfertilized variant. In wheat placed on weakly eroded lands, the mean yield increases obtained for each kg of a. i. of applied fertilizers varied, according to fertilizers rates applied, between 9.15 and 11.8 kg grains ($N_{40}P_{40}$-$N_{140}P_{100}$). On highly eroded lands, the mean wheat yields obtained under unfertilized were of 1163 kg/ha, the mean yield increases obtained by applying 40 or 60 t/ha manure, being of 41.3-35.5 kg grains per ton of manure applied. By applying mineral fertilizers ($N_{40}P_{40}$-$N_{140}P_{100}$), mean yield increases of 8.1- 10.4 kg grains/kg a. i. of applied fertilizer were obtained. Very close yield results were also obtained by applying, for 42 years, rates of 70 kg N + 70 kg P_2O_5/ha +3 t/ha stalks of peas or soybean, variants at which the yield increases obtained varied, according to soil erosion, between 2313 and 2214 kg/ha (136-130 %) on weakly eroded lands, and between 2074 and 2001 kg/ha (178-172 %) on highly eroded lands (*Table 5*).

Table 5 - Influence of mineral and organic fertilizers on wheat yields, in weakly and highly eroded lands, (Fundulea-4 varieties)

Fertilizer rate	Weakly eroded soil		Highly eroded soil	
	Wheat yields, kg/ha	Differ. kg/ha	Wheat yields, kg/ha	Differ. kg/ha
N_0P_0	1697	0	1163	0
$N_{70}P_{70}$	3192	1495	2478	1315
$N_{100}P_{100}$	4078	2381	3248	2085
$N_{140}P_{100}$	4523	2826	3665	2502
$N_{70}P_{70}K_{70}$	3384	1687	2710	1547
$N_{100}P_{100}K_{100}$	4398	2701	3570	2407
$N_{140}P_{140}K_{140}$	4797	3100	3923	2760
20 t/ha manure	2761	1064	2165	1002
40 t/ha manure	3445	1748	2813	1650
60 t/ha manure	4018	2321	3294	2131
$N_{70}P_{70}$+20 t/ha manure	4102	2405	3304	2141
$N_{70}P_{70}$+40 t/ha manure	4619	2922	3669	2506
$N_{70}P_{70}$+60 t/ha manure	4894	3197	4011	2848
$N_{70}P_{70}$+6 t/ha hashed straw	3770	2073	3041	1878
$N_{70}P_{70}$+6 t/ha stalks of maize	3578	1881	2929	1766
$N_{70}P_{70}$+3 t/ha stalks of pea	4010	2313	3237	2074
$N_{70}P_{70}$+3 t/ha stalks of soybean	3911	2214	3164	2001
Mean	**3632**		**2916**	
LSD 5%		340		310
LSD 1%		450		430
LSD 0.1%		580		570

The analysis of results obtained has shown that the erosion process, by decreasing soil fertility, has determined the differentiation of mean wheat yields, according to slope and erosion, from 3632 (100%) to 2916 kg/ha (80.3%). The mean annual yield losses, registered in wheat in the last 10 years, caused by erosion, were of 716 kg/ha (19.7%). The positive effect of applying crop residues, together with moderate nitrogen rates, on crop yield and soil physical, chemical and biological characteristics was found in many regions with different climatic conditions and soils (Clapp et al., 2000; Nelson, 2004; Campbell, 2005; Liu, 2006; Russell, 2006). The investigations conducted by Campbell (2005) on low slope fields, in the semi-arid zone from Saskatchewan, Canada, on a Chernozem with a pH of 6.5 and a mean texture, have shown that, during 36 years, wheat straws have supplied wheat crop with 37 kg nitrogen/ha.

Many research works have shown that the additional N application was necessary, when crop residues remained in soil, for avoiding the immobilization of N from soil and increasing the carbon content from soil (Clapp et al., 2000; Wilhelm et al., 2004). Other studies have shown that determining the rates of crop residues, which had to be applied in order to improve soil characteristics and diminish erosion, must consider the climatic conditions, soil type and cultural practices (Linden, 2000; Wilson et al. 2004; Yadav, 2008).

The investigations conducted in the trials from the University of Padua (Veneto Region, NE Italy), set up in 1962 on loam sandy soils (sand 47%, silt 38%, clay 15%), showed that in wheat-maize rotation, the phosphorus content from soil, after 40 years of experiencing, was between 18.2 and 21.8 mg kg^{-1}, when they applied rates of 70, 70, 90 kg ha^{-1} of N, P_2O_5, K_2O and 140, 140, 180 kg ha^{-1} of N, P_2O_5, K_2O. Under the same fertilization conditions, the phosphorus content from soil had values between 23.2 and 23.8 mg kg^{-1} in 6 year-rotation (maize–sugar beet–maize–wheat–alfalfa–alfalfa) and between 20.2 and 25.3 mg kg^{-1} in 4 year-rotation (sugar beet - soybean - wheat – maize) (Morari et al., 2008).

Applying for 40 years rates of 140, 140 and 180 kg ha^{-1} of N, P_2O_5, K_2O has increased from 50.0 to 64.5 the content of mobile potassium from soil, compared to the untreated variant, and has made a balance (average yearly gross balance of P and K) (gross balances were calculated considering the elements applied with fertilizations and removed in crop biomass ($\sum$inputs − $\sum$removals), from -30 to 79 kg ha^{-1} (Morari et al., 2008).

On 16% slope fields from the Moldavian Plateau, the erosion process has resulted in decreasing the content of humus and nutrients from soil and the mean wheat yield by 19.7% (716 kg/ha), in 10 years. Both on weakly and highly eroded fields, the mineral fertilization with lower rates than $N_{140}P_{100}$ kg/ha has resulted in diminishing the humus content from soil until 2.49- 3.05 % (*Table 6*). On weakly eroded fields, keeping the humus content at over 3.2% was done by annual application of average mineral fertilizer rates ($N_{70}P_{70}$), together with 6 t/ha of wheat and maize residues, in annual legumes-wheat-maize rotation. On highly eroded fields, the humus content was kept at values of 3.42-3.49% only by the annual application of a rate of 60 t/ha manure or $N_{70}P_{70}$+ 60 t/ha manure. The annual application for 40 years, of 6 t/ha crop residues, together with 70 kg/ha nitrogen and 70 kg/ha P_2O_5, has kept the humus content from soil at values of 3.14-3.28% on weakly eroded fields and of 3.08-3.12% on highly eroded fields.

Applying organic fertilizers and introducing crop rotations with perennial grasses and legumes are the main opportunities for maintaining a humus positive balance, the humification processes being prevalent towards the processes of organic matter mineralization. The humus amount, which results from the biodegradation of organic resources, depends on their content in nitrogen organic compounds, the way of application and soil-climatic conditions. The humification content, expressed by the ratio between the amount of formed humus and the amount dry organic matter applied in soil, is influenced by many factors, of which nature of organic resources, moisture content from soil, physical, chemical and biological soil characteristics are the most important ones (Lixandru, 2006).

Table 6 - Effect of soil erosion and fertilization system on the humus and mineral element content in 16% slope fields from the Moldavian Plateau

Fertilizer rate	Weakly eroded lands				Highly eroded lands			
	pH (H_2O)	Humus (%)	P-AL (ppm)	K-AL (ppm)	pH (H_2O)	Humus (%)	P-AL (ppm)	K-AL (ppm)
N_0P_0	7.2	2.86	18	206	7.1	2.46	9	189
$N_{70}P_{70}$	6.8	2.91	52	189	6.7	2.49	42	162
$N_{100}P_{80}$	6.3	3.05	87	186	6.1	2.66	61	154
$N_{140}P_{100}$	5.8	3.12	89	174	5.6	2.84	59	151
60 t/ha manure	7.3	3.72	79	287	7.1	3.42	62	254
$N_{70}P_{70}$ + 60 t/ha manure	7.1	3.79	94	314	6.9	3.49	79	286
$N_{70}P_{70}$ + 6 t/ha hashed of wheat	6.9	3.28	62	238	6.7	3.12	58	206
$N_{70}P_{70}$+6 t/ha stalks of maize	6.5	3.22	59	246	6.4	3.09	49	187
$N_{70}P_{70}$+3 t/ha stalks of peas	6.8	3.18	48	235	6.7	3.10	52	185
$N_{70}P_{70}$+3 t/ha stalks of soybean	6.8	3.14	49	232	6.7	3.08	49	179
Mean	**6.8**	**3.23**	**64**	**231**	**6.6**	**2.98**	**52**	**195**
LSD 5%	0.25	0.11	4.97	18.08	0.27	0.16	4.52	15.82
LSD 1%	0.36	0.16	7.15	26.00	0.39	0.23	6.50	22.75
LSD 0.1%	0.53	0.24	10.52	38.24	0.57	0.33	9.56	33.46

On 10% slope fields, erosion caused the diminution in the content of organic carbon, which was between 1.94 kg C m^2 in non-eroded lands to 1.76 kg C m^2 in eroded lands and of 0.86 kg C m^2 on highly eroded soils. On over 18% slope fields, the content of organic carbon was between 1.00 kg C m^2 in non-eroded lands and 0.70 kg C m^2 in eroded soils and of 0.50 kg C m^2 on highly eroded fields (Yadav and Malanson, 2008).

On weakly eroded Cambic Chernozem from the Moldavian Plateau, a good supply with mobile phosphorus in wheat and maize crops (37-72 mg/kg) was done in case of the annual application of a rate of $N_{100}P_{80}$, while a very good supply (69-78) was achieved at the rate of $N_{70}P_{70}$+60 t/ha manure. On highly eroded fields, a very good supply with mobile phosphorus and potassium was done by applying manure at the amount of 60 t/ha or at the rate of $N_{70}P_{70}$ + 60 t/ha manure.

CONCLUSIONS

In soils from the Moldavian Plateau, most of them situated on slope fields, poor in organic matter and nutrients, the proper use of different organic resources may replace a part of rich technological consumption (mineral nutrients), determines the improvement in the content of organic matter from soil and ensures better conditions for the capitalization of nitrogen fertilizers.

Utilization of sewage sludge in agriculture has a major interest, due to nitrogen and phosphorus and microelements supply (Zn, Cu). For slope lands degraded by erosion, sewage sludge with other organic resources can contribute to the improvement in soil characteristics.

Applying rates of 24.6 t/ha DM sewage sludge has resulted in the accumulation of mobile phosphate stock in soil of 49 ppm and the microelement content (mobile forms from soil) was of 12.4 ppm at Cu, 0.47 ppm at B, 142 ppm at Zn and 382 ppm at manganese.

The combined use of mean rates of mineral fertilizers ($N_{70}P_{70}$), together with 40 t/ha manure or 6 t/ha crop residues from wheat and maize crops, has resulted in improving soil physical and chemical characteristics and getting yield increases in wheat of 2313-2214 kg/ha (136-130 %), on weakly eroded lands, and 2074-2001 kg/ha (178-172%) on highly eroded lands, compared to the unfertilized control.

Both on weakly and highly eroded lands, the mineral fertilization with lower rates than $N_{140}P_{100}$ kg/ha has determined the decrease of humus content from soil until 2.49- 3.05 %. On highly eroded lands, the humus content was kept at values of 3.42-3.49% only by the annual application of the rate of 60 t/ha manure or $N_{70}P_{70}$+ 60 t/ha manure.

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