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INFLUENCE OF SOME ORGANIC RESIDUES ON WHEAT AND MAIZE YIELD AND ERODED SOIL FERTILITY

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ABSTRACT – Investigations conducted during 2003-2009 at the Podu-Iloaiei Agricultural Research Station, Iaşi County, have studied the influence of different sewage sludge rates, crop residues and manure rates on yield quality and quantity and soil agrochemical characteristics. Trials were set up in a five year-crop rotation (soybean-wheat-maize-sunflower-wheat). Sewage sludge was applied every two years at rates of 20, 40 and 60 t/ha, with different mineral fertilizer rates, differentiated according to the growing plant. In wheat, we have used Gabriela Variety, and in maize, Oana Hybrid. The mean yield increases obtained during 2003-2009, by applying the rate of 60 t/ha sewage sludge, were of 1877 (93%) in winter wheat and of 2102 kg/ha (57%) in maize. After 7 years since the application of a rate of 60 t/ha sewage sludge, soil pH has increased 0.4 units, while phosphorus and potassium content from soil has increased by 39 and 115 mg/ kg soil, respectively. Sewage sludge from the Iaşi Water Treatment Station, which was applied every two years at rates of 40 and 60 t/ha, has determined the increase in the organic carbon content from soil by 3.4 g/kg (20.5%) and 4.7 g/kg (28.3%), respectively, compared to the unfertilized variant. Applying wheat and maize residues, at the rate of 6 t/ha DM, has determined the increase by 1.4-1.7 g/kg soil (8.2-9.9%) in the content of organic carbon from soil, compared to the mineral fertilization ($N_{80}P_{60}$), and by 1.9-2.2 g/kg (11.5-13.3%), compared to the unfertilized control.

Key words: sewage sludge, crop residue, organic carbon, heavy metals, wheat, maize

REZUMAT - Influenţa unor resturi organice asupra producţiei de grâu şi porumb şi a fertilităţii solurilor erodate. Cercetările efectuate în perioada 2003-2009 la Staţiunea de Cercetare – Dezvoltare

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Agricolă Podu-Iloaiei, jud. Iaşi, au urmărit influenţa diferitelor doze de nămoluri si resturi vegetale asupra cantităţii şi calităţii producţiei şi asupra însuşirilor agrochimice ale solului. Experienţele au fost organizate într-un asolament de 5 ani (soia-grâu-porumb-floarea-soarelui-grâu). Nămolurile s-au aplicat odată la 2 ani, în doze de 20, 40 şi 60 t/ha, împreună cu diferite doze de îngrăşăminte minerale, diferenţiate în funcţie de planta de cultură. La grâu, s-a folosit soiul Gabriela, iar la porumb, hibridul Oana. Sporurile medii de producţie obţinute în perioada 2003-2009, prin aplicarea dozei de 60 t/ha nămol fermentat au fost de 1877 (93%) la cultura grâului de toamnă şi de 2102 kg/ha (57%) la porumb. După 7 ani de la aplicarea dozei de 60 t/ha nămol fermentat, pH-ul solului a crescut cu 0.4 unităţi şi conţinutul de fosfor şi potasiu din sol a crescut, faţă de martorul netratat, cu 39 şi, respectiv, 115 mg/ kg sol. Nămolurile fermentate de la Staţia de epurare Iaşi, aplicate o dată la 2 ani, în doze de 40 si 60 t/ha, au determinat creşterea conţinutului de carbon organic din sol, în comparaţie cu varianta netratată, cu 3.4 (20.5%) şi, respectiv, 4.7 g/kg (28.3%). Aplicarea resturilor vegetale de grâu şi porumb, în doză de 6 t/ha s. u., a determinat creşterea conţinutului de carbon organic din sol cu 1.4-1.7 g/kg sol (8.2-9.9%), comparativ cu fertilizarea minerală ($N_{80}P_{60}$) şi cu 1.9-2.2 g/kg (11.5-13.3%), faţă de martorul nefertilizat.

Cuvinte cheie: nămoluri fermentate, resturi organice, carbon organic, metale grele, grâu, porumb

INTRODUCTION

Crop residues represent an economic source of carbon and nutrient supply of soil, protect soil against erosion and improve water holding capacity. The decay of crop residues is the result of complex microbial and chemical processes controlled by numerous factors.

The nitrogen lack from crop residues or soil is one of the main limitative factors of the decay process. Many studies in the last period have investigated the biochemical characteristics that determine crop residue decay. Investigations have shown that the main quality indicators of crop residues, on which depends carbon and nitrogen mineralization in soil, are the initial content of nitrogen from crop residues, lignin, polyphenols and concentration of soluble carbon (Constantinides and Fownes, 1994; Recous *et al.*, 1995; Martens *et al.*, 2005; Clay *et al.*, 2006; Kumar *et al.*, 2006; Luxhoi *et al.*, 2006; Mikha *et al.*, 2006).

Reicosky *et al.* (2002), Wilhelm (2004) and Johnson *et al.* (2006) estimated the quantity of biomass necessary to be incorporated in soil for maintaining the content of organic carbon. The lowest amounts of crop residues, necessary for maintaining the content of organic carbon from soil, determined by Johnson *et al.* (2006) in the case of moldboard plow tillage and chisel plow or no tillage are of 7.6 and 5.3 t/ha, respectively, in maize continuous cropping and of 12.5 and 7.9, respectively, in soybean-maize rotation (Johnson *et al.*, 2006). In western Minnesota, returning 8.25 Mg stover ha^{-1} yr^{-1} (for 29 years) did not prevent soil carbon loss with annual fall moldboard plowing and secondary spring tillage (Reicosky *et al.*, 2002).

Smith *et al.* (2001) revealed the options for each land management change of available organic materials, potential applications rates and SOC accumulation rates assumed to be applied to arable land for C mitigation purpose during the first Kyoto Commitment period (2008-2012) and the highest percentage area to which a management change is applicable during 2008-2012. Among these practices, manure application at rates of 5-20 t/ha contributes to the increase in SOC accumulation rate by 0.14 – 0.71%/year sewage sludge, at rates of 1 t/ha/year, by 0.49 %/year and cereal straw at rates of 2-10 t/ha/year (t ha^{-1} y^{-1}) determines the increase in SOC accumulation rate by 0.42- 1.31 % y^{-1}. Conservation works can be used during 2008-2012 on the arable lands of Europe, on maximum 7.3% of the area in the case of sewage sludge and 48.9% in cereal straw (Smith et al., 2001).

The studies carried out on the biochemical characteristics of 47 assortments of crop residues have shown that during residue decay in soil at 15^0C, after 168 days, the amounts of mineralized carbon varied between 330 and 670 g/kg per kg of applied carbon; only in crop residues with C/N <24 ratio, a surplus of mineral nitrogen was achieved in soil, compared to the unfertilized control, while in all the others, nitrogen immobilization was found, having values comprised between 1 and 33 g N per kg of applied C (Trinsoutrot *et al.*, 2000). The concentration of organic nitrogen from crop residues incorporated in soil has varied between 3 g/kg DM in rape, wheat and maize and 45 g/kg DM in alfalfa. The concentration of soluble polyphenols was of 1 g/kg DM in soybean stalks and 18 g/kg DM in rape. After 168 days since the incorporation of crop residues, the concentration of mineral nitrogen from soil had slightly negative values, compared to the untreated control, when the C/N ratio of crop residues was between 24 and 150 and positive values, when the C/N ratio had values between 10 and 24.

In rape residues, the concentration of soluble polyphenols has increased the process of nitrogen mineralization. The use of cover crops and crop residues within some cropping systems may represent good options for improving organic carbon content from soil. For each region with special temperature and humidity conditions, it is necessary to establish some cropping systems that result in reducing N_2O and CH_4 emissions. Carbon dioxide is absorbed from atmosphere by plants; some carbon is removed by plants through harvested production and some carbon returns through crop residues and forms the organic matter from soil. Soil microorganisms decompose crop residues and release CO_2 in the atmosphere.

GRACEnet Project (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network), developed by the Agricultural Research Service (ARS) of the U.S. Department of Agriculture investigates the identification of farming strategies that improve carbon storage in soil and reduce greenhouse gas emissions (Franzluebbers *et al.*, 2006).

In the regions from northern America, the application of manure has determined the increase in the content of organic carbon from soil by 0.15-0.72 Mg CO_2-C equivalents and the use of nitrogen fertilizers, by 0.09-0.18 Mg CO_2-C equivalents (Franzluebbers and Follett, 2005). In USA and Canada, agriculture releases only 7-8% of the percent of greenhouse gas emissions (USDA, 2004; Environment Canada, 2006). The crop residue decay results in the increase in the content of organic carbon from soil and is a means of soil C sequestration and optimizing the balance for more carbon in soil and less in the atmosphere.

Long-term trials from Bad Lanchsadt, Denmark have shown that in the 4 year-crop rotation - sugar beet (*Beta vulgaris* L.), spring barley (*Hordeum vulgare* L.), potato (*Solanum tuberosum* L.) and winter wheat (*Triticum aestivum* L.), the carbon content from soil after 18 years was of 1.48% in the unfertilized variant, 1.71% at the NPK fertilization (of which 82 kg N per ha every year), 2.26% in the case of applying 30 t/ha manure every two years and of 2.32 % at the NPK fertilization (of which 59 kg/ha N) +30 t/ha manure applied every two years (Berntsen et al., 2006).

The organic carbon from soil sequestered in the case of no tillage varies between 0.07 and 0.48 Mg CO_2-equivalent/ha/year in most of regions. Complex cropping systems determine the increase in organic carbon from soil (-0.12 to 0.29 Mg CO_2-C equivalent/ha/year), while the change of the category of field use from arable to grassland has a positive effect on the content of organic carbon from soil (–0.32 to –1.03 Mg CO_2-C equivalents ha^{-1} yr^{-1}) (the positive values represent gas emissions in the atmosphere and the negative values, C sequestration in soil) (Franzluebbers, 2005).

The decay rate and the release of nutrients from organic residues depend on the biochemical traits of crop residues. Crop residues having low values of the C/N and C/P ratio, with a balanced N/P ratio and low lignin content decay faster and release more phosphorus for plants. After 12 weeks, due to the decay of sunflower and wheat residues, the amounts of released mobile phosphorus were of 1502 (64.2%) and 740 (72.2%) mg P, respectively, per kg of applied crop residues (Jalali Mohsen and Ranjbar Faranak, 2009).

The application for 111 years of a rate of 21 kg/ha phosphorus as mineral fertilizer or a rate of 11 kg/ha phosphorus as manure, in maize-wheat-alfalfa rotation has determined the increase in the content of mobile phosphorus from soil to 44-45 mg/ kg soil (Negassa and Leinweber, 2009).

Organic acids that resulted during crop residue decay determine the increase in the content of mobile phosphorus from soil and improve plant phosphorus nutrition. Organic residues with high phosphorus content and low C:P ratio determine the increase in the content of mobile phosphorus from soil (Uygur and Karabatak, 2009).

MATERIALS AND METHODS

Investigations conducted during 2003-2009 at the Podu-Iloaiei Agricultural Research Station have studied the influence of different sewage sludge, crop residues 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). In wheat, we have used Gabriela Variety, and in maize, Oana Hybrid. Sewage sludge was applied at rates of 20, 40 and 60 t/ha, with different mineral fertilizer rates, differentiated according to the growing plant.

Investigations were carried out on a typical cambic Chernozem, which prevails in the Moldavian Plateau and have established the fertilizer rates ensuring efficient yield increases and increasing the content of organic carbon from soil. The soil on which experiments were set up has a loam-clayey texture (420 g clay, 315 g loam and 265 g sand), a neuter to weakly acid response and a mean nutrient supply. The soil on which physical and chemical analyses were carried out was sampled at the end of crop vegetation period.

The content of organic carbon was determined by the Walkley-Black method; to convert soil organic matter 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.

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 an average multiannual temperature of 9.6 ^{o}C and an average rainfall amount of 544 mm on 79 years, of which 161.2 mm, during September-December and 382.8 mm, during January-August. Average rainfall amounts, recorded during 2003-2009, from January to September, were lower with 44.1-174.7 mm in 3 years (2003, 2004 and 2007) and higher with 14.9-181.4 mm in the other 4 years, compared to the multiannual average on 79 years (425 mm) (*Table 1*).

The climatic conditions recorded during 2003-2009 resulted in a good uptake and use of mineral fertilizers and sewage sludge by the main crops.

The fermented sludge from the Iasi Municipal Treatment Station had a neutral reaction and an organic carbon content of 29-34% (*Figure 1*). The concentration of nitric nitrogen was low (0.16-0.42 ppm) and that of ammoniacal nitrogen between 24 and 830 ppm. The total macronutrient contents (N, P, K, Ca, Mg) from fermented sludge were 1.37% total N, 1.19% total P, 4.45% total K, the calcium content was higher (3.12%) and organic S and Mg had normal values comparable to those from untreated soils.

Due to its physical and chemical characteristics, the sewage sludge from the Iasi Water Treatment Station can be used in agriculture. The content of heavy metals from sewage sludge is found within the maximum allowable limits, established by regulations of Rule no. 86/278/EEC and Order no. 49 from 01/14/2004 (*Figure 2*).

Table 1 - Rainfall recorded at the Weather Station of Podu-Iloaiei, during 2003-2009

Years	I	II	III	IV	V	VI	VII	VIII	IX	Total
2003	35.3	21.6	22.3	21.1	10.0	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	461.0
2005	42.4	42.1	25.6	86.2	106.0	86.3	64.7	160.0	14.3	627.6
2006	29.3	7.8	97.3	98.0	57.0	93.7	163.0	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	80.0	56.5	37.5	5.0	44.0	139.0	122.0	12.0	25.0	521.0
Average	**40.9**	**27.4**	**36.7**	**54.5**	**44.4**	**62.8**	**114.6**	**78.3**	**45.6**	**505.1**
Average on 79 years	**27.6**	**23.9**	**24.5**	**41.8**	**53.1**	**77.5**	**73.1**	**61.4**	**42.1**	**425.0**
Difference	**13.3**	**3.5**	**12.2**	**12.7**	**-8.7**	**-14.7**	**41.5**	**16.9**	**3.5**	**80.1**

Figure 1 – Sewage sludge from Iasi Water Treatment Station

The mean yield increases obtained in the last 7 years in maize crop, by applying rates of 40 t/ha sewage sludge, were of 1534 kg/ha (42%), compared to the untreated control. The use of fermented sewage sludge on a maize crop, at a rate of 60 t/ha, resulted in a mean yield increase of 57% (2102 kg).

Mean yield increases obtained in the last 7 years in maize, for each tone of sewage sludge, calculated by the equation of multiple regressions, were of 30.6 kg/t (*Table 2*). The mean wheat yield increase after applying 40 t/ha sewage sludge was of 1877 kg/ha (93%), compared to the untreated control (*Table 3*).

Organo-mineral resources, such as sewage sludge, correctly applied, could be an acceptable substitute for expensive, commercially produced fertilizers and could contribute to the improvement of organic matter content in soil. For sloping lands degraded by erosion, sewage sludge with other organic resources may contribute to an improvement in soil characteristics. The application of rates of 60 t/ha raw sewage sludge has resulted in the accumulation of mobile phosphate in soil of 58 ppm, and the contents of organic carbon of 21.3 g/kg (*Table 4*).

The results showed that the application of 40 t/ha sewage sludge has increased the crop supply in mineral elements (especially N and P). It also ensured a mean annual supply of 24.8 t/ha organic matter, highly humificated, which explains the increase in soil carbon content (after 7 years), from 16.6 to 20.0 g/kg (*Table 4*).

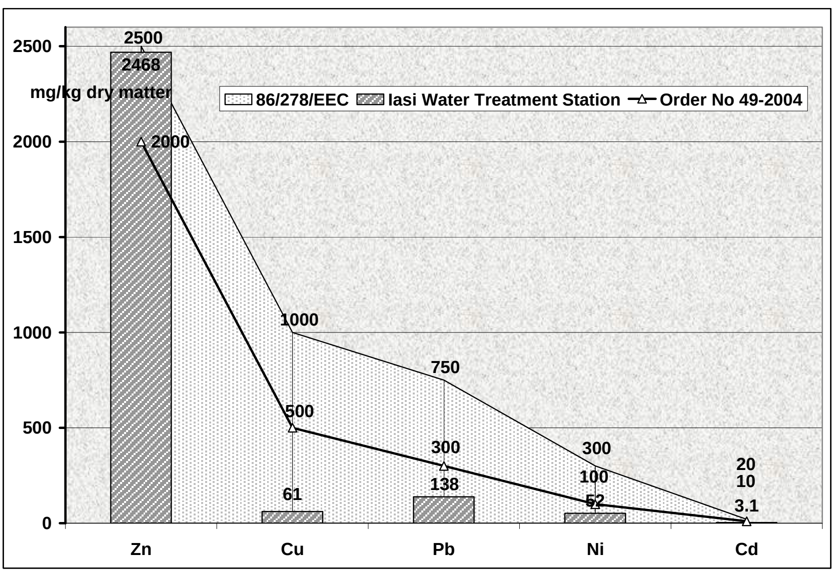

Figure 2 - Content of heavy metals (mg/kg dry matter) in sewage sludge from Iasi Water Treatment Station

Table 2 - Influence of sewage sludge and mineral element fertilization on maize yield (2003-2009)

Treatment	Years							Mean yield		Diff., kg/ha
	2003	2004	2005	2006	2007	2008	2009	kg/ha	%	
Unfertilized control	3564	4460	3213	3580	3342	3640	4038	3691	100	0
$N_{100}P_{80}$	4567	6790	5463	5864	4865	5740	6350	5663	153	1972
20 t/ha sewage sludge	3986	5040	3894	4620	4235	4620	5196	4513	122	822
20 t/ha sewage sludge+ $N_{100}P_{80}$	5960	7320	5507	6354	5689	6658	7189	6382	173	2691
40 t/ha sewage sludge	4537	5530	4767	5210	4862	5546	6120	5225	142	1534
40 t/ha sewage sludge+ $N_{100}P_{80}$	6277	7930	6100	6657	6124	6984	7562	6805	184	3114
60 t/ha sewage sludge	5436	6230	5387	5594	5349	5984	6573	5793	157	2102
60 t/ha sewage sludge+ $N_{100}P_{80}$	6845	8460	6403	6985	6486	7534	8124	7262	197	3571
LSD 5%	370	380	346	360	346	350	390			**363**
LSD 1%	480	476	458	457	452	460	490			**468**
LSD 0.1%	590	580	576	572	554	590	610			**582**
Yield (Y) = 3887.6 + 9.57 NP + 30.59 sewage sludge (t/ha), R^2=0.988, obs.=8										

Table 3 - Influence of sewage sludge and mineral element fertilization on wheat yield (2003-2009)

Treatment	Years							Mean yield		Diff., kg/ha
	2003	2004	2005	2006	2007	2008	2009	kg/ha	%	
Unfertilized control	1652	1980	2710	1824	1562	2345	2063	**2019**	100	
$N_{100}P_{80}$	3350	4158	4526	4660	3070	5063	4352	**4168**	206	2149
20 t/ha sewage sludge	2995	3425	3762	3658	2970	3864	3596	**3467**	172	1448
20 t/ha sewage sludge+ $N_{100}P_{80}$	3620	4352	4869	4386	3480	5122	4826	**4379**	217	2360
40 t/ha sewage sludge	3240	3786	4525	3930	3120	4537	4135	**3896**	193	1877
40 t/ha sewage sludge+ $N_{100}P_{80}$	3784	4632	5634	5120	3590	5324	5234	**4760**	236	2741
60 t/ha sewage sludge	3754	4326	4862	4539	3754	4986	4561	**4397**	218	2378
60 t/ha sewage sludge+ $N_{100}P_{80}$	3962	4826	5968	5548	4125	5624	5627	**5097**	252	3078
LSD 5%	290	305	350	320	260	310	306			**306**
LSD 1%	390	420	460	440	380	430	420			**420**
LSD 0.1%	452	520	585	580	450	570	526			**526**
Yield (Y) = 2639.93 + 6.424 NP (kg/ha) + 26.83 sewage sludge (t/ha), R^2=0.878, obs.=8										

Table 4 - Evolution of main agrochemical indices on the cambic Chernozem of Podu-Iloaiei, as influenced by different rates of sewage sludge, applied during 2003-2009

Treatment	pH (H_2O)	P-AL (ppm)	K-AL (ppm)	$N\text{-}NO_3$ (ppm)	Org. C, (g/kg)
Unfertilized control	6.6	19	219	3.6	16.6
$N_{100}P_{80}$	6.1	46	226	5.9	16.7
40 t/ha sewage sludge	6.8	48	289	6.2	20.0
40 t/ha sewage sludge+ $N_{100}P_{80}$	6.6	59	312	6.6	20.1
60 t/ha sewage sludge	7.0	58	334	6.9	21.3
60 t/ha sewage sludge+ $N_{100}P_{80}$	6.5	76	356	7.2	21.4
LSD 5%	0.21	4.2	14.2	0.09	0.11
LSD 1%	0.29	7.1	19.5	0.12	0.17
LSD 0.1%	0.36	9.2	24.1	0.17	0.21

Table 5 - Contents of heavy metals in maize and wheat grains fertilized with sewage sludge from the Iasi Water Treatment Station (mg/kg DM)

Element	Maize grain		Wheat grain		Maximum allowable concentrations, according to EC nr. 466/2001
	Untreated	30 t/ha sewage sludge dry matter	Untreated	30 t/ha sewage sludge dry matter	
Zn	1.89	2.16	11.9	13.6	-
Cu	0.16	0.23	0.12	0.42	-
Ni	-	0.03	-	-	-
Cd	-	-	-	-	0.1
Co	-	-	-	-	-
Pb	-	-	-	-	0.1
Fe	6.52	7.34	7.18	8.22	-
Mn	0.11	0.15	0.12	0.16	-
Cr, Pb, Cd and Hg were not found in plants and grains					

The heavy metal contents of the farm produces were within the normal limits for Cu and Ni, while Cr, Co, Cd, Pb and Hg were not present in plants and grains (or only as traces in a few plants) (*Table 5*). These results showed that sewage sludge, applied in maize crops did not affect the quality of yield. These results also showed that the only criterion limiting the rate of fermented sewage sludge at 10 t/ha dry matter was zinc content. These rates should be increased on soils, which are deficient in zinc. Zinc and copper content in the plants treated with high rates of sewage sludge were higher in maize cobs. This fact should be also taken into account when the rates of sewage sludge are established for this crop, especially on low pH soils.

The copper and zinc content from grains in wheat and maize crops, fertilized with 30 t/ha sewage sludge, was by two-four times higher, compared to the unfertilized control.

The positive effect of applying crop residues and sewage sludge, 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 (Antoniadis et al., 2007; Berntsen et al., 2006; Johnson et al., 2006). On slope lands, poor in humus and mineral elements, the use of crop residues has a special importance for improving soil fertility indicators. The long-term use of crop residues has determined a better soil conservation by increasing organic matter and mineral element stock from soil, resulting in a decrease with time in the necessary of nitrogen and phosphorus fertilizers for crops. 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.

On the eroded fields from the Moldavian Plateau, keeping the organic carbon content at over 19.1 g/kg was done by annual application of average mineral fertilizer rates ($N_{80}P_{60}$), together with 6 t/ha of wheat and maize residues, in annual legumes-wheat-maize rotation (*Table 6*).

Table 6 - Evolution of main agrochemical indices on the cambic Chernozem of Podu-Iloaiei, as influenced by different rates of cereal straw and legume stalks

Treatment	N total %	P-AL (mg/kg)	K-AL (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Org. C (g/kg)
N_0P_0	0.132	16	212	10	3.1	16.6
$N_{80}P_{60}$	0.154	52	186	13	3.8	17.1
60 t/ha manure	0.176	72	267	16	4.9	21.4
$N_{80}P_{60}$ + 60 t/ha manure	0.234	91	283	19	6.4	21.6
$N_{80}P_{60}$ + 6 t/ha hashed of wheat	0.163	65	245	15	4.2	19.1
$N_{80}P_{60}$+6 t/ha stalks of maize	0.158	61	238	14	3.9	18.8
$N_{80}P_{60}$+3 t/ha stalks of peas	0.175	58	219	16	4.5	18.5
$N_{80}P_{60}$+3 t/ha stalks of soybean	0.169	54	224	17	4.3	18.4
Mean	**0.170**	**59**	**234**	**15**	**4.4**	**18.9**
LSD 5%	0.03	5	14	0.48	0.06	0.09
LSD 1%	0.07	7	22	0.71	0.11	0.13
LSD 0.1%	0.09	10	33	1.08	0.17	0.19

On highly eroded fields, the carbon content was kept at values of 21.4-21.6 g/kg only by the annual application of a rate of 60 t/ha manure or $N_{80}P_{60}$+ 60 t/ha manure. Applying rates of $N_{80}P_{60}$+3 t/ha stalks of soybean has resulted in the accumulation of mobile phosphate stock in soil of 54 mg/kg and the potassium content (mobile forms from soil) was of 224 mg/kg. 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 compared to the processes of organic matter mineralization.

CONCLUSIONS

In the soils of the Moldavian Plateau, situated on slope fields, poor in organic matter and nutrients, the proper use of different organic resources may replace a part of the rich technological consumption and determines the improvement in the content of organic matter from soil.

Mean yield increases, obtained during 2003-2009, by applying the rate of 60 t/ha sewage sludge, were of 1877 (93%) in winter wheat and of 2102 kg/ha (57%) in maize.

After 7 years since the application of a rate of 60 t/ha sewage sludge, soil pH has increased 0.4 units, while phosphorus and potassium content from soil has increased by 39 and 115 mg/ kg soil, respectively.

Sewage sludge from the Iasi Water Treatment Station, which was applied every two years at rates of 40 and 60 t/ha, has determined the increase in the organic carbon content from soil by 3.4 g/kg (20.5%) and 4.7 g/kg (28.3%), respectively, compared to the unfertilized variant.

Applying wheat and maize residues, at a rate of 6 t/ha DM, has determined the increase by 1.4-1.7 g/kg soil (8.2-9.9%) in the content of organic carbon from soil, compared to mineral fertilization ($N_{80}P_{60}$) and by 1.9-2.2 g/kg (11.5-13.3%), compared to the unfertilized control.

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