Cercetări Agronomice în Moldova
Vol. XLII , No. 2 (138) / 2009

INVESTIGATIONS ON THE INFLUENCE OF LONG-TERM FERTILIZATION ON WHEAT AND SUNFLOWER YIELD AND SOIL FERTILITY IN THE MOLDAVIAN PLAIN

Despina AILINCĂI[1], C. AILINCĂI[2*], Maria ZBANȚ[1], Ad. MERCUŞ[1], Adriana BALAN

[1]Agricultural Research and Development Station, Podu-Iloaiei, Iaşi County
[2]University of Agricultural Sciences and Veterinary Medicine, Iaşi

Received November 10, 2008

ABSTRACT - The investigations conducted in stationary experiments, at the Podu-Iloaiei Agricultural Research Station, which were set up in 1967, under non-irrigated, have followed the influence of mineral fertilization on wheat and sunflower yield and on the evolution of soil physical, chemical and biological characteristics. In bean-wheat-sunflower-wheat-maize crop rotation, applying mineral fertilizers during 2005-2008 has resulted in getting mean yield increases, which varied, according to rates, between 41 and 94% (767-178 kg/ha) in sunflower ($N_{40}P_{40}$-$N_{120}P_{80}$) and between 89 and 146% (1658-2718 kg/ha) in wheat ($N_{80}P_{80}$-$N_{160}P_{80}$). The mean yield increases, obtained for each kg of a.i. of applied fertilizer, were comprised between 8.4 and 8.9 kg in sunflower ($N_{80}P_{80}$-$N_{120}P_{80}$) and between 11.3 and 16.2 kg in wheat ($N_{60}P_{40}$-$N_{160}P_{80}$). On the Cambic Chernozem from the Moldavian Plain, a good supply in mobile phosphorus in bean-wheat-sunflower-wheat-maize crop rotation (47 mg/kg) was done at the annual application of a rate of $N_{80}P_{40}$, while a very good supply (93 mg/kg) was achieved at the rate of $N_{160}P_{100}$. After 41 years of experiences, in bean-wheat-sunflower-wheat-maize crop rotation, the content of organic carbon from soil has decreased by 22.5% (4.5 g/kg soil) at the unfertilized control, by 17.0% (3.4 g/kg soil) at the rate of $N_{80}P_{80}$ and by 13.5% (2.7 g/kg soil) at the rate of $N_{120}P_{80}$. After 41 years of experiences, in bean-wheat-sunflower-wheat-maize crop rotation, with high fertilizer rates ($N_{160}P_{80}$), the content of organic carbon from soil had close values to the initial ones, with a slight diminution of approximate 0.31 g / kg soil/ year.

Key words: fertilization, nitrogen, phosphorus, organic matter, sunflower, wheat, soil fertility

REZUMAT – Cercetări privind influența fertilizării pe termen lung asupra producției de grâu şi floarea-soarelui şi a fertilității solului în Câmpia Moldovei. Cercetările efectuate în experimente staționare la Stațiunea de Cercetare-Dezvoltare Agricolă Podu-Iloaiei, jud. Iaşi,

* E-mail: ailincai@uaiasi.ro

înfiinţate în 1967, în condiţii de neirigare, au urmărit influenţa fertilizării cu ingrăşăminte minerale asupra producţiei de grâu şi floarea-soarelui şi a evoluţiei caracteristicilor fizice, chimice şi biologice ale solului. În rotaţia fasole-grâu-floarea-soarelui-grâu-porumb, aplicarea de îngrăşăminte minerale, în perioada 2005-2008, a determinat obţinerea unor sporuri medii de producţie, care au variat, în funcţie de doză, între 41 şi 94% (767-178 kg/ha) la floarea-soarelui ($N_{40}P_{40}$-$N_{120}P_{80}$) şi între 89 şi 146% (1658-2718 kg/ha) la grâu ($N_{80}P_{80}$-$N_{160}P_{80}$). Sporurile medii de producţie, obţinute la fiecare kg s.a. de îngrăşământ aplicat, au fost cuprinse între 8.4 şi 8.9 kg la floarea-soarelui ($N_{80}P_{80}$-$N_{120}P_{80}$) şi între 11.3 şi 16.2 kg la grâu ($N_{60}P_{40}$-$N_{160}P_{80}$). Pe solul cernoziom cambic din Câmpia Moldovei, s-a obţinut o bună aprovizionare cu fosfor mobil în rotaţia fasole-grâu-floarea-soarelui-grâu-porumb (47 mg/kg), prin aplicarea anuală a dozei $N_{80}P_{40}$ şi o foarte bună aprovizionare (93 mg/kg), prin aplicarea unei doze de $N_{160}P_{100}$. În rotaţia fasole-grâu-floarea-soarelui-grâu-porumb, conţinutul de carbon organic din sol a scăzut, după 41 de ani de experimentare, cu 22.5% (4.5 g/kg sol) la martorul nefertilizat, cu 17.0% (3.4 g/kg sol) la doza de $N_{80}P_{80}$ şi cu 13.5% (2.7 g/kg sol) la doza de $N_{120}P_{80}$. În cazul fertilizării culturilor, în rotaţia fasole-grâu-floarea-soarelui-grâu-porumb, cu doze mari de îngrăşăminte ($N_{160}P_{80}$), conţinutul de carbon organic din sol, după 41 de ani de experimentare, s-a menţinut la valori apropiate de cele iniţiale, cu o uşoară tendinţă de scădere cu aproximativ 0.31 g / kg sol/ an.

Cuvinte cheie: fertilizare, azot, fosfor, substanţă organică, floarea-soarelui, grâu, fertilitatea solului

INTRODUCTION

The experiments conducted at the Research Agricultural Station of Podu-Iloaiei, during 1967-2008, had in view the establishment of technical elements for setting up soil protection rotations, thus contributing to the improvement of soil chemical, physical and biological characteristics.

The studies carried out on soil quality from Romania have shown that of 10 million ha arable field, only 3.7 million ha (37%) met the necessary conditions for a sustainable agriculture. The rest is affected by acidification (1.6 million ha), compaction (3.0 million ha), humus deficit and low nutrient supply (4.05 million ha). The North-Eastern region of Romania represents 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). The results of the investigations conducted under various soils and climatic conditions showed that the long-term practicing of wheat-maize crop rotation has determined high nutrient consumption from soil, while soil physical-chemical and biological characteristics worsened; therefore, improving measures are required (Poulton, 1996; Hera and Borlan, 1980; Mihăilă, 1996; Ailincăi, 2007, Jităreanu, 2007).

The database importance of the experimental fields is widely known, having a duration of over 165 years and is functional even today

(Rothamsted, 1843, England, Gottingen, 1873, Halle, 1878, Germany, Askov, 1894, Denmark, Morrow Plots in Illinois, 1876, USA, etc), where the technological effects on environment, production quantity and quality, evolution of physical, chemical and biological soil condition are well controlled. The investigations conducted in long-term experiments at Rothamsted have shown that only at high fertilizer rates (>$N_{192}P_{35}K_{90}Mg_{35}$) a significant increase was found in the mass of total organic carbon and stable carbon from soil (Blair et al., 2006). The diminution in the mass of organic carbon from soil, when lower rates than 180 kg N/ha were applied, was also noticed in long-term experiments carried out on sandy loam Mollisols from Nashua and on clayey-loam Mollisols from Kanawha at North of Iowa, USA (Russell, 2006).

The studies carried out in the province of Teramo (Abruzzo Region), where soil erosion is the main cause of the diminution in the content of organic matter from soil show that almost 87% of the total area has a low content in organic matter, comprised between 1.00 and 2.19%. A percent of 6.4% of the area has a very low content and 6.5% of the area has a mean content (Marchetti, 2008).

The increase in mineral fertilizer rates might be an opportunity for yield optimization, but because of high nitrate–N leaching loss and N_2O emissions, fertilizers should be incorporated into soil and applied as nitrification inhibitors, for diminishing their impact on environment. The application of organic fertilizers and the use of crop rotations with melioration plants for soil fertility is the best management practice (BMP) system.

The long-term trials were set up on Fluvi-Calcaric Cambisol with sandy loam texture from the University of Padua (Veneto Region, NE Italy), which, at the beginning of experiences (1962) had a content of organic carbon of 1.2% and a C/N ratio of 12. Applying for 40 years 140, 140, and 180 kg ha^{-1} $year^{-1}$ of N, P_2O_5 and K_2O did not determine the increase in the content of organic carbon from soil, compared to unfertilized control, both in 4-year crop rotation (sugar beet–maize–wheat–maize) and in 6-year crop rotation (sugar beet–maize–wheat–alfalfa) (Lugato et al., 2007). On Fluvi-Calcaric Cambisol with sandy loam texture, after 40 years use of 6-year crop rotation with melioration plants (sugar beet–maize–wheat–alfalfa), the content of organic carbon at depths of 0-20 cm had mean values on three fertilization levels higher with 33-283 g C m^{-2}, compared to 4-year crop rotation (sugar beet–maize–wheat–maize) (Lugato et al., 2007). On the fields from the Czech University of Agriculture in Prague, applying rates of 120 kg/ha nitrogen in wheat-maize crop rotation has determined the decrease in the content of organic carbon, compared to unfertilized control, from 26.7 to 25.2 mg/kg, when ammonium sulphate was applied, and the increase

until 33.3 mg/kg, when the same quantity of nitrogen was assured by applying a rate of 40 t/ha manure (Balík et al., 2003). The diminution in the content of organic carbon from soil until 11.3 g C kg^{-1}, at depth of 0-5 cm and until 2.3 g C kg^{-1}, at depth of 30-55 cm, was also found in loam clayey soils from Texas, USA, in wheat continuous cropping and soybean-wheat and sorghum-soybean-wheat rotations, where low fertilizer rates were applied, respectively, 90 kg N ha^{-1} in sorghum, 68 kg N ha^{-1} in wheat and 15 kg P ha^{-1} in soybean (Wright et al., 2007).

As a result of the implementation of the EU Nitrate Directive (91/976/EC), which aims to prevent and reduce nitrate water pollution from agricultural sources, Palumbo found that in two agricultural areas from Southern Italy (Campamarino and Venafro), with an area of 45 km^2, the NO_3^- concentration had lower values than 36 mg/l on 59% from East and NE Venafro and higher values than 100 mg/l in the central area. The determinations carried out on sandy irrigated fields from the Jyndevad Research Station, Denmark (Orthic Haplohumod with 4.7% clay, 4.4% silt, 90% sand and 1.3% C), by means of porous ceramic suction cups installed at 1 m depth, have shown that in spring barley, the annual quantity of leached $N\text{-}NO_3$ was of approximate 100 kg ha^{-1}, while in clover and ryegrass crops, these losses diminished by 40-80% (Askegaard, 2008). In clover and ryegrass crops, the NO_3-N concentrations diminished from 13–16 to 5–8 mg L^{-1}, compared to spring barley. At rates of 120 kg/ha nitrogen, applied in wheat-maize crop rotation in the fields of the Czech University of Agriculture in Prague, the nitrate ($N\text{-}NO_3$) amount, intercepted by lysimeters during 1st October 1992–17th October 1994, has increased, compared to unfertilized control (1 kg/ha), until 8.6 kg/ha, when this nitrogen amount was applied as ammonium sulphate, until 6.2 kg/ha, when the same nitrogen amount was supplied by the application of liquid manure + 5 t/ha wheat straw and 6.4 kg/ha at the rate of 40 t/ha manure. On clayey-sandy soils from Iowa, the maize fertilization for 20 years with 120 kg N ha^{-1} has resulted in getting a mean yield of 10,500 kg dry matter ha^{-1},under conditions of mean annual exportation from soil of 140 kg N ha^{-1} $year^{-1}$ and of the diminution in the content of organic carbon from soil by 86 kg C ha−1 $year^{-1}$ and mean annual leaching of 47 kg N ha^{-1} $year^{-1}$ (Farahbakhshazad et al., 2008).

MATERIALS AND METHODS

The results shown in this scientific paper are obtained in long-term fertilization experiments, placed on cambic chernozem of Podu-Iloaiei, under unirrigated, with clayey loam texture, weakly acid reaction and mean supply with mineral elements. Experiments were conducted in randomized blocks with split plots in six replicates. They followed the influence of long-term application of different fertilizer rates on wheat crop grown after bean and sunflower, in 5-year crop rotation (bean-wheat-maize-

sunflower-wheat). After each rotation cycle, we carried out analyses of soil physical, chemical and biological characteristics according to the well – known methods. Soil on which the physical and chemical analyses were done was sampled at the end of plant growing period. Chemical analyses on soil and plant samples were carried out according to the methods established by the Research Institute of Bucureşti, which are practiced in all the laboratories of agrochemistry from Romania. 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 (Nelson and Sommers, 1982). ANOVA was used to compare the treatment effects. In wheat, we have used the Gabriela Variety and in sunflower, the Performer Hybrid.

RESULTS AND DISCUSSION

The climatic conditions of the Moldavian Plain are characterized by a mean multiannual temperature of 9.6 ^{0}C and mean rainfall amounts, on 80 years, of 517 mm. During 2005 – 2008, the climatic conditions were favourable to plant growing and development in 3 years in wheat and 2 years in sunflower.

Under these conditions, the mean sunflower yields obtained during 2005-2008, in 5-year crop rotation, were comprised between 1893 kg/ha (100%) at the unfertilized control and 3678 kg/ha (194%) at a rate of 120 kg N + 80 kg P_2O_5 /ha (*Table 1*). The application of higher than 40 kg/ha potassium rates did not result in obtaining significant yield increases and the yield increases obtained by increasing phosphorus rates from 80 to 120 kg/ha in this period were not statistically ensured.

The unilateral fertilization of sunflower crop grown after wheat crop, only with potassium rates, resulted in limitation of yield increases of 150,365 kg/ha. The mean yield increases obtained in sunflower for each kg of applied nitrogen, phosphorus and potassium, calculated with regression equation, were of 9.68, 6.58 and 2.87 kg.

In wheat crop grown in 5- year crop rotation after sunflower, the mean obtained yields, during 2005-2008, were comprised between 1861 kg/ha (100%) at the unfertilized control and 4461 kg/ha (239%) at rates of 140 kg N +80 kg P_2O_5 (*Table 2*). The application of higher nitrogen rates than 140 kg/ha did not result in obtaining significant yield increases and yield increases obtained by increasing phosphorus rates from 40 to 80 kg/ha, in this period, were not statistically ensured.

In wheat crop grown in 5-year rotation after sunflower, the mean yield increases obtained for each kg of a. i. of applied fertilizer were between 13.8 and 11.3 kg grains ($N_{80}P_{40}$ – $N_{160}P_{80}$).

The mean yield increases obtained during 2005-2008 in wheat crop grown in 5-year crop rotation after bean, by the application of mineral fertilizers, were comprised between 70 and 121 % (1620-2813 kg/ha), according to applied rates ($N_{60}P_{40}$- $N_{140}P_{80}$) (*Table 3*). In wheat crop grown in 5-year crop rotation

after bean, the mean yield increases obtained for each kg a. i. of applied fertilizer were between 16. 2 and 12.8 kg grains ($N_{60}P_{40} – N_{140}P_{80}$).

The mean yield increases, calculated by means of action coefficients for nitrogen, phosphorus and potassium in the regression equation, in wheat crop grown after bean (5247 kg/ha), compared to wheat crop grown after sunflower (4461 kg/ha), at the rate of $N_{140}P_{80}$, were of 785 kg/ha (17.6%).

The field experiments with fertilizers have the great advantage that they allow the study of the production potential and agrochemical indices in all the factors that condition crop yield formation and soil fertility. Establishing fertilizer rates, under conditions of present costs, required the determination of agrochemical indices and the analysis of nutrient balance in the system soil- plant - air and establishing the necessary of nutrients with which one must interfere at a certain level of supply on consumption requirements of different crops and crop levels.

Table 1- Mean yields obtained in sunflower crop grown in 5-year rotation during 2005 – 2008

Fertilizer rate, kg/ha a.i.			Years				Mean		Diff. kg/ha
Nitrogen	P_2O_5	K_2O	2005	2006	2007	2008	Kg/ha	%	
0	0	0	2150	1520	1590	2310	**1893**	100	0
0	0	40	2380	1680	1680	2430	**2043**	108	150
0	0	80	2560	1710	1720	2590	**2145**	113	252
0	0	120	2610	1890	1790	2740	**2258**	119	365
40	40	0	3150	2230	1980	3280	**2660**	141	767
40	40	40	3410	2450	2150	3510	**2880**	152	987
40	40	80	3520	2560	2270	3620	**2993**	158	1100
40	40	120	3650	2690	2350	3760	**3113**	164	1220
80	80	0	3860	2780	2460	3850	**3238**	171	1345
80	80	40	3970	2810	2540	3970	**3323**	176	1430
80	80	80	4090	2930	2630	4130	**3445**	182	1552
80	80	120	4180	3020	2690	4260	**3538**	187	1645
120	80	0	4310	3190	2860	4350	**3678**	194	1785
120	80	40	4520	3280	2940	4480	**3805**	201	1912
120	80	80	4570	3390	3060	4560	**3895**	206	2002
120	80	120	4620	3450	3140	4590	**3950**	209	2057
Mean			**3597**	**2599**	**2366**	**3652**	**3053**		
LSD 5%			260	230	200	270	240		
LSD 1%			330	300	282	340	313		
LSD 0,1%			400	360	383	410	388		
Y = 1971.07+9.682N+6.583P+2.873K, R^2=0.986									

Table 2 - Mean yields obtained in wheat crop grown in 5-year rotation, after sunflower, during 2005 - 2008

Fertilizer rate, kg/ha a.i.			Years				Mean		Diff.
Nitrogen	P_2O_5	K_2O	2005	2006	2007	2008	Kg/ha	%	kg/ha
0	0	0	1520	1530	1215	3180	**1861**	100	0
0	0	40	1650	1700	1244	3420	**2004**	108	143
0	0	80	1760	1740	1325	3490	**2079**	112	218
0	0	120	1890	1780	1406	3560	**2159**	116	298
80	40	0	3842	3810	1843	4580	**3519**	189	1658
80	40	40	3982	3900	2067	4730	**3670**	197	1809
80	40	80	4120	3960	2204	4850	**3784**	203	1923
80	40	120	4350	4030	2303	4930	**3903**	210	2042
120	80	0	4576	4357	2653	5162	**4187**	225	2326
120	80	40	4615	4458	2874	5346	**4323**	232	2462
120	80	80	4689	4586	2916	5524	**4429**	238	2568
120	80	120	4975	4685	2987	5672	**4580**	246	2719
160	80	0	5160	4750	2735	5670	**4579**	246	2718
160	80	40	5420	4790	2892	5970	**4768**	256	2907
160	80	80	5590	4930	3028	6060	**4902**	263	3041
160	80	120	5730	5020	3159	6270	**5045**	271	3184
Mean			**3992**	**3752**	**2303**	**4901**	**3737**		
LSD 5%			220	230	171	260	220		
LSD 1%			290	306	236	374	302		
LSD 0,1%			360	400	323	520	401		
Y = 1934.425+13.547N+7.878P+3.157K, R^2=0.987									

The research concerning the influence of crop rotation and fertilizers on soil chemical characteristics pointed out the significant changes after 41 years of testing, the obtained data giving special information for following the survey of nutrients and diagnosing the evolution tendencies of soil fertility. The analyses concerning the evolution of soil response under the influence of crop rotation and fertilizers pointed out that pH lowest values were recorded in wheat-maize rotation and in case of a long-term use of rates of $N_{160}P_{80}$. After 41 year application of rates of 160 kg/ha nitrogen, as ammonium azotize, we determined the pH decrease from 7.1 to 5.3 (*Figure 1*).

The annual application of rates of 80 kg/ha P_2O_5 has determined the accumulation of a reserve of mobile phosphates in soil, comprised, according to applied nitrogen, between 74 and 79 ppm. The mobile phosphorus content of soil, after 41 years of testing, was maintained at a good supply level, when the applied rates were of at least $N_{120}P_{80}$ (*Figure 2*).

Table 3 - Mean yields obtained in wheat crop grown in 5-year rotation, after bean, during 2005 - 2008

Fertilizer rate, kg/ha a.i.			Years				Mean		Diff.
Nitrogen	P_2O_5	K_2O	2005	2006	2007	2008	Kg/ha	%	kg/ha
0	0	0	2070	2370	1207	3620	**2317**	100	0
0	0	40	2190	2625	1297	3940	**2513**	108	196
0	0	80	2310	2701	1389	4020	**2605**	112	288
0	0	120	2560	2761	1441	4060	**2706**	117	389
60	40	0	4390	4226	2022	5110	**3937**	170	1620
60	40	40	4560	4541	2228	5320	**4162**	180	1845
60	40	80	4680	4581	2382	5430	**4268**	184	1951
60	40	120	4910	4652	2549	5520	**4408**	190	2091
100	80	0	5388	4675	2630	5876	**4642**	200	2325
100	80	40	5400	4872	2678	5978	**4732**	204	2415
100	80	80	5482	4965	2786	6185	**4855**	210	2538
100	80	120	5732	5234	2986	6324	**5069**	219	2752
140	80	0	5690	5415	3207	6210	**5130**	221	2813
140	80	40	6030	5479	3382	6520	**5353**	231	3036
140	80	80	6240	5689	3449	6610	**5497**	237	3180
140	80	120	6410	5708	3476	6780	**5593**	241	3276
Mean			**4628**	**4406**	**2444**	**5469**	**4237**		
LSD 5%			240	250	187	280	239		
LSD 1%			310	320	252	390	318		
LSD 0.1%			380	410	333	530	413		
Y = 2456.097+14.219N+9.997P+3.572K, R^2=0.978									

The carbon organic content from soil, in 5-year crop rotation, under unfertilized, was of 15.5 g/kg and was kept at values close to the initial ones, in the balanced fertilization with high rates of phosphorus and nitrogen (160 kg N + 80 kg P_2O_5/ha) (Figure 3). During the long-term fertilization of sunflower, wheat and maize crops with high rates of mineral fertilizers ($N_{140}P_{100}$), the total content of carbon has increased by 23.2% (4.1 g organic C/kg soil), compared to the unfertilized control.

In bean-wheat-sunflower-maize crop rotation, the mineral fertilization with 120 kg/ha nitrogen +80 kg/ha P_2O_5 has determined, after 41 years of testing, the diminution in the content of organic carbon from soil by 2.7 g/kg (13.5%). The content of organic carbon from soil, in 5-year crop rotation, has diminished by approximate 2.2 g/kg/year in unfertilized control, by 1.3 g/kg/year at the rate of $N_{80}P_{80}$ and by 0.97 g/kg/year at the rate of $N_{120}P_{80}$.

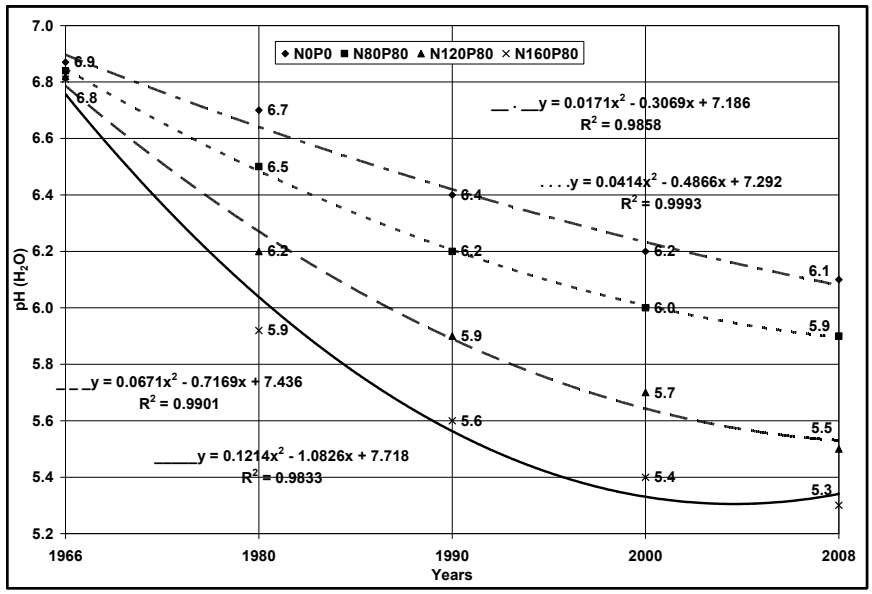

Fig. 1 - Change of soil reaction, in 5-year crop rotation, at different fertilizer rates, after 41 years of experiments

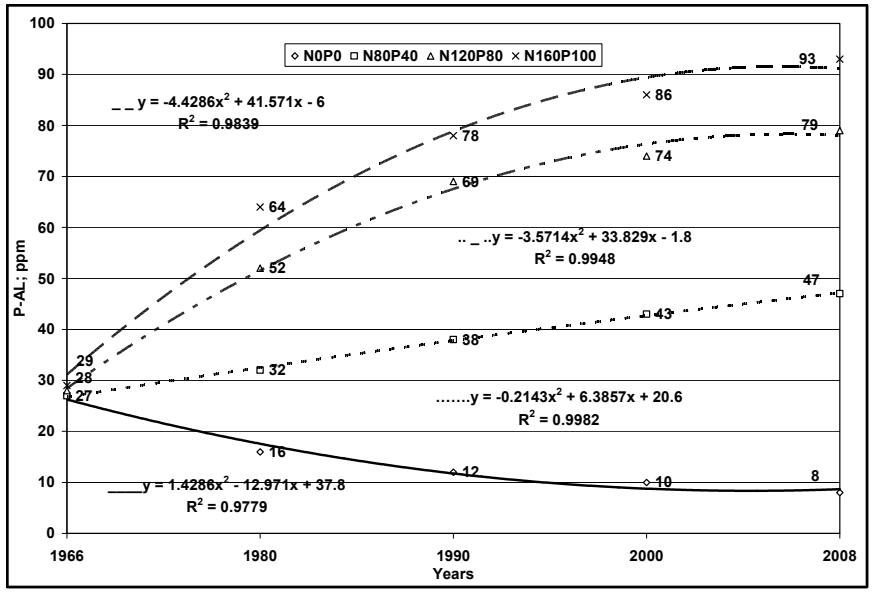

Fig. 2 - Change of mobile phosphate content (P-AL) from soil, as influenced by different fertilizer rates, after 41 years of experiments

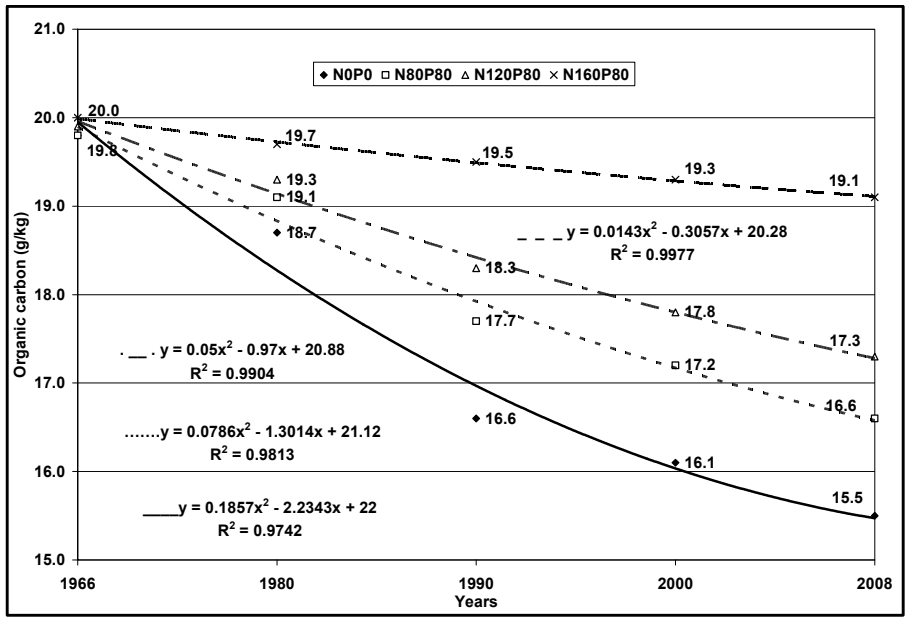

Figure 3 - Influence of long-term fertilization on total organic carbon from soil (C, g/kg)

CONCLUSIONS

In bean-wheat-sunflower-wheat-maize rotation, applying mineral fertilizers during 2005-2008 has resulted in getting mean yield increases, which varied according to rates, between 41 and 94% (767-178 kg/ha) in sunflower ($N_{40}P_{40}$-$N_{120}P_{80}$) and between 89 and 146% (1658-2718 kg/ha) in wheat ($N_{80}P_{80}$-$N_{160}P_{80}$).

The mean yield increases, obtained for each kg of a.i. of applied fertilizer, were comprised between 8.4 and 8.9 kg in sunflower ($N_{80}P_{80}$-$N_{120}P_{80}$) and between 11.3 and 16.2 kg in wheat ($N_{60}P_{40}$-$N_{160}P_{80}$).

On Cambic Chernozem of the Moldavian Plain, a good supply with mobile phosphorus in bean-wheat-sunflower-wheat-maize rotation (47 mg/kg) was done at the annual application of a rate of $N_{80}P_{40}$, while a very good supply (93 mg/kg) was achieved at the rate of $N_{160}P_{100}$.

After 41-year application of rates of 160 kg/ha nitrogen as ammonium azotize, pH decreased from 7.1 to 5.3.

After 41 years of experiences, in bean-wheat-sunflower-wheat-maize crop rotation, the content of organic carbon from soil has decreased by 22.5% (4.5 g/kg soil) at the unfertilized control, by 17.0% (3.4 g/kg soil) at the rate of $N_{80}P_{80}$ and by

13.5% (2.7 g/kg soil) at the rate of $N_{120}P_{80}$. After 41 years of experiences, in bean-wheat-sunflower-wheat-maize crop rotation, with high fertilizer rates ($N_{160}P_{80}$), the content of organic carbon from soil had close values to the initial ones, with a slight diminution of approximate 0.31 g / kg soil/ year.

REFERENCES

Ailincăi C., Jităreanu G., Bucur D., Ailincăi Despina, 2007 - *Influence of sewage sludge on maize yield and quality and soil chemical characteristics,* Journal of Food, Agriculture & Environment, Vol. 5 (1), 310-313, ISSN 1459-0255

Askegaard Margrethe and Eriksen J., 2008- *Residual effect and leaching of N and K in cropping systems with clover and ryegrass catch crops on a coarse sand,* Agriculture, Ecosystems & Environment Volume 123, January 2008, Pages 99-108

Balík J., Černý J., Tlustoš P., Zitková M., 2003 - *Nitrogen balance and mineral nitrogen content in the soil in a long experiment with maize under different systems of N fertilization,* Plant Soil Environ., 49, 2003 (12): 554–559

Blair Nelly, Faulkner R.D., Till A.R., Poulton P.R., 2006 - *Long-term management impacts on soil C, N and physical fertility,* Soil & Tillage Research 91 (2006) 30-38

Farahbakhshazad Neda, Dinnes Dana L., Li Changsheng, Jaynes D. B., Salas W., 2008- *Modelling biogeochemical impacts of alternative management practices for a row-crop field in Iowa,* Agriculture, Ecosystems & Environment Volume 123, January 2008, Pages 30-48

Hera Cr., Borlan Zn., 1980 - *Ghid pentru alcătuirea planurilor de fertilizare (Guide for drawing fertilization plans),* Edit. Ceres, Bucureşti

Jităreanu G., Ailincăi C. and Bucur D., 2007- *Soil fertility management in North-East Romania*, Journal of Food, Agriculture & Environment Vol.5 (3&4): 349 - 353

Krauss A., 2000 - *Balanced fertilization Integral part of sustainable soil management,* International Potash Institute, Basel, Switzerland

Lugato E., Paustian K. and Giardini L. 2007- *Modelling Soil Organic Carbon Dynamics in Two Long-Term Experiments of North-Eastern Italy,* Agriculture, Ecosystems & Environment Volume 120, May 2007, Pages 423-432

Marchetti A., Piccini C., Francaviglia R., Santucii S., Chiuchiarelli I., 2008 - *Spatial Distribution of Organic Matter to Assess Soil Quality: A Case Study in Central Italy,* 5th International Conference on Land Degradation, Valenzaro, Bari, Italy, 18-22 September 2008, ISBN 2-85352-399-2, Ideaprint- Bari, Italy, pp 169-173

Mihăilă V., Burlacu Gh, Hera Cr., 1996 – *Rezultate obținute în experiențele de lungă durată cu îngrăşăminte pe cernoziomul cambic de la Fundulea (Results obtained in long-term experiments with fertilizers on cambic chernozems from Fundulea)*, Anale ICCPT Fundulea,Vol.LXIII

Nelson D.W. and Sommers L.E., 1982- *Total carbon, organic carbon and organic matter.* In: A.L. Page, Editor, *Methods of Soil Analysis. Part 2*, American Society of Agronomy Madison, Wisconsin, USA (1982), pp. 539–579

Palumbo G., Sellitto V. M., Galuppo A., Dicilloand P., Colombo C., 2008- *Soil Spatial Variability Factors Influencing Nitrate Contamination in Groundwater in Molise (Southern Italy),* 5th International Conference on Land Degradation, Valenzaro,

Bari, Italy, 18-22 September 2008, ISBN 2-85352-399-2, Ideaprint- Bari, Italy, pp 115-118

Poulton P. R. 1996 – *Management and modification procedures for long-term field experiments,* Soil Science Department, IACR- Rothamsted, Harpenden, HERTS, UK

Russell A., E., Laird D., Mallarino A. P., 2006 - *Nitrogen Fertilization and Cropping System Impact on Quality in Midwestern Mollisols,* Soil Sci. Soc. Am. J. 70:249-255

Wright A. L., Dou F. and Hons F. M, 2007- *Soil organic C and N distribution for wheat cropping systems after 20 years of conservation tillage in central Texas,* Agriculture, Ecosystems & Environment, Volume 121, August 2007, Pages 376-382

Yadav V. and Malanson G., 2008- *Spatially explicit historical land use, land cover and soil organic carbon transformations in Southern Illinois,* Agriculture, Ecosystems & Environment, Volume 123, February 2008, Pages 280-292