INFLUENCE OF SOME AGROPHYTOTEHNICAL PARAMETERS ON THE WHEAT AND MAIZE YIELDS AND SOIL FERTILITY IN THE MOLDAVIAN PLAIN

G. JITĂREANU[1], C. AILINCĂI[1], Despina AILINCĂI[2] Maria ZBANT[2]

[1]University of Agricultural Sciences and Veterinary Medicine of Iasi, Aleea M. Sadoveanu 3, Romania
e-mail: *gerardj@univagro-iasi.ro*

[2]Agricultural Research and Development Station of Podu-Iloaiei, Iasi str. Nationala 87, Romania
e-mail: scdapoduail@zappmobile.ro

The investigations conducted during 1998 – 2007 have followed the influence of different soil tillage systems on crop yield and soil chemical and physical characteristics. Experiments were set up in split –split plots on a typical Cambic Chernozem of clay-loam texture, mean humus content (3.3 %), weakly acid reaction and mean supply in mineral elements. The paper presented the results of investigations concerning the influence of long-term fertilization on some chemical characteristics of Cambic Chernozem from the Moldavian Plain and on the wheat and maize yields. On slope lands, the high rate fertilization of maize crop ($N_{140}P_{100}$) has determined, in the latest ten years, an average yield increase of 103% (3373 kg/ha), against the control, and applying a rate of $N_{70}P_{70}$+40 t/ha manure resulted in getting a very close yield increase (99%, 3258 kg/ha). The total carbon content in Cambic Chernozem from the Moldavian Plain has registered significant increases at higher rates than $N_{140}P_{100}$ and in case of organo-mineral fertilization. The annual fertilization of wheat and maize, at the rate of 70 kg N + 70 kg P_2O_5/ha + 6 t/ha stalks of wheat, has determined, compared to the unfertilized variant, the increase in the content of organic carbon from soil by 14.5% (2.4 g organic C/kg) on weakly eroded soils, and by 29.5% (4.2 g organic C/kg) on highly eroded soils. During the long-term fertilizing of wheat and maize with high rates of mineral fertilizers ($N_{140}P_{100}$), on highly eroded lands, the total content of carbon has increased by 16.9% (2.4 g organic C/kg soil), against the unfertilized control.

***Key words**: soil tillage, cropping systems, fertilization, organic matter, crop residue*

In the last period, the investigations conducted in different countries have followed the influence of improving technological elements on fertilization, soil tillage and crop rotations with legumes and perennial grasses, which determine the increase in the content of organic carbon from soil and the reduction of N_2O emissions. The N_2O emissions from soil increase linearly with the amount of mineral nitrogen applied by fertilization (0.0119 kg N_2O-N kg N^{-1}). The application of manure determines the diminution in nitrogen protoxide emissions (0.99 kg N_2O-N $ha^{-1}year^{-1}$), compared with the application of liquid manure (2.83 kg N_2O-N ha^{-1} $year^{-1}$) or mineral fertilization (2.82 kg N_2O-N ha^{-1} $year^{-1}$) [4]. The conventional system with annual ploughing, carried out at the same depth and with repeated treatments for seedbed preparation with disk- harrows, has negative consequences on some soil physical characteristics: mechanical and water stability of aggregates, porosity, infiltration capacity, hydraulic conductivity, water holding capacity, stratification of organic matter and nutrients, activity and diversity of edaphic flora and fauna, carbon biomass, soil water and temperature regime [7, 8, 12, 13, 17]. Environment deterioration is mainly caused by soil erosion, compaction, soil structure damage due to human activities and loss of organic matter, as well as to extreme climatic conditions, influenced by world changes. Because the farming conventional systems have caused soil degradation in many countries, the technologies concerning the mechanization of agricultural practices must be adapted to the requirements concerning soil and water protection, and in the areas with more sensitive soils to degradation, soil conservation practices are necessary [5, 6, 9, 15, 16]. Soils tilled at time, differentiated according to the requirements of crop rotations, to climatic conditions, contribute to the improvement of soil physicochemical characteristics, to diminution of weed infestation degree and allow manure and crop residue incorporation. Data got by Lal R. (2006) show that by diminishing the soil intensity and mobilization depth, the aggregation condition is improved and, therefore, the losses of organic carbon are diminished, as a result of humus decay, due to less aired environment and to better soil protection against erosion. The content of organic carbon in the shallow layer (0-10 cm) on Gleyc Luvisol with sandy loam texture from Halle, Germany, after 37 years of applying different soil tillage systems, differentiated from 10.0 g/kg under the conventional system, with 25 cm ploughing, to 14.9 g/kg at 25 cm chisel tillage and, respectively, to 13.2 g/kg under no-tillage[17]. At the depth of 0-20 cm, the content of organic carbon was of 10.2 g/kg at 25 cm ploughing, 12.7 g/kg at chisel tillage and 11.6 under no-tillage. The use of legumes for soil protection against erosion has resulted in fixing 105 kg from the atmospheric nitrogen and annual increasing of the carbon content from soil by 1055 kg, which is twice higher than the accumulation in the no-till system. [3]. In Austria, between 1994 and 2007, the mean soil losses at the three locations dropped from 6.1 t/ha/year to 1.8 t/ha/year with conservation tillage in cover crops, and to 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. [13].

MATERIALS AND METHODS

Investigations conducted during 1998-2007 on a Cambic Chernozem at the Agricultural Research and Development Station of Podu-Iloaiei, Iaşi County, have followed the influence of different soil tillage systems and fertilizers on yield, in soybean, wheat and maize crops, and of soil agrochemical characteristics.

The typical Cambic Chernozem from Podu-Iloaiei was formed on a loessy loam, has a mean humus content (3.1-3.4 %), is well supplied with mobile potassium (215-235 ppm) and moderately with phosphorus (28-35 ppm) and nitrogen (0.160-0.165 %). Experiments were set up in split-split plots with four replicates. Soil has a high clay content (39-41%) being difficult to treat when soil moisture is close to the wilting coefficient (12.2 %). In wheat, we have used Gabriela variety, and in maize, Oana hybrid.

Physical and chemical analyses of soil samples were carried out according to the methods established by the Research Institute of Bucureşti, which are applied by all agrochemistry laboratories from Romania.

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, 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

Rainfall registered during January- June (1998-2007) assured normal conditions for wheat growing in 5 years. Rainfall amounts were lower, compared to the multiannual mean on 80 years (248 mm) in 5 years, when rainfall deficit was between 53.3 and 119.0 mm. The climatic conditions during 1998-2007 were favorable to maize growing and development in 5 years and unfavorable, due to low rainfall amounts, in the other 5 years. In the last 10 years, the deficit of rainfall registered during January-August, compared to the multiannual mean of the area, was between 31.4 and 136.9 mm in 5 years. The drought registered in autumn and during January-August required the adjustment of soil preparation practices to the requirements of water conservation from soil. In the 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), determine the improvement in the content of organic matter from soil and may assure better conditions for the capitalization of nitrogen fertilizers.

A. Influence of Tillage Systems on Soil Physical, Chemical Characteristics and Crop Yield in Soybean, Wheat and Maize Grown in the Moldavian Plain

The mean wheat yields obtained during 1998-2007 at 20 cm ploughed variant were of 3265 kg/ha and in case of seedbed preparation by chisel + disk and by repeated disking, the yields obtained were lower by 4.0 % (122 kg/ha) and 6.0 % (223 kg/ha), respectively, as compared to 20 cm ploughing (*table 1*). At the same period, the mean wheat yields obtained under unfertilized were of 1818 kg/ha and the rates of N120 + 80 kg/ha P_2O_5 or N160 + 80 kg/ha P_2O_5 resulted in getting yield increases of 94 % (1714 kg/ha) and 110% (2006 kg/ha), respectively. The application in wheat of a rate of N80 + 80 kg/ha P_2O_5 + 30 t/ha manure has resulted in getting yield increases of 117 % (2122 kg/ha).

In wheat, found in a 3 year- crop rotation (soybean-wheat-maize), the percentage of hydrostable aggregates was less influenced by soil tillage system (54.7-62.8%) and more by applied fertilizers (50.3 – 61.3 %) (*table 2*). In wheat crop, the percentage of hydrostable aggregates has varied, according to applied fertilizer rates, between 49.2 and 58.6 % at 20 cm ploughing, between 53.3 and 59.9 % at 30 cm ploughing and between 56.2 and 68.8 % at chisel treatment. The highest percentage of hydrostable aggregates was registered at the rate of N160 + 80 kg P_2O_5 (58.2%) and at organo-mineral fertilization (61.3 %). The content of organic carbon in the shallow layer (0-20 cm) had values comprised between 18.43 and 20.08 g/kg at the fertilization with N_{120} + 80 kg/ha P_2O_5 and, respectively, $N_{80}P_{80}$+30 t/ha manure (*table 3*). At chisel and paraplow works, the content of organic carbon from soil was higher by 0.33 g/kg, as compared to 20 cm ploughing system. Applying for 10 years moderate mineral fertilizer rates ($N_{80}P_{80}$), together with 6 t/ha wheat straw, has resulted in increasing the organic carbon from soil by 1.7 g/kg, compared to unfertilized variant. The highest content of organic carbon was found at the rate $N_{80}P_{80}$+30 t/ha manure, where it increased by 2.67 g/kg, compared to the unfertilized control.

Table 1

Influence of soil tillage system and fertilization on wheat yield (kg/ha)

Soil tillage	N_0P_0	$N_{80}P_{80}$+6 t/ha wheat straw	$N_{120}P_{80}$	$N_{160}P_{80}$	$N_{80}P_{80}$+30 t/ha manure	Mean	%	Differ. kg/ha
20 cm ploughing + disk	1860	2960	3520	3890	4097	**3265**	100	0
30 cm ploughing + disk	1950	3213	3880	4232	4331	**3521**	108	256
Chisel + disk	1870	2587	3540	3840	3880	**3143**	96	-122
Paraplow + disk	1690	2823	3380	3640	3620	**3031**	93	-235
One year ploughing, one year disking	1720	2860	3340	3520	3770	**3042**	93	-223
Mean	**1818**	**2889**	**3532**	**3824**	**3940**	**3201**		
%	100	159	194	210	217			
Differ. kg/ha	0	1071	1714	2006	2122			
Mean		**Soil tillage (A)**		**Fertilizer (B)**		**Interaction AxB**		
LSD 5%		198		150		330		
LSD 1%		321		201		481		
LSD 0.1%		516		264		689		

Tabelul 2

The influence of soil tillage and fertilization on hydrostability of soil aggregates (%) of >0.25 mm

Soil tillage	N_0P_0	$N_{80}P_{80}$+6 t/ha wheat straw	$N_{120}P_{80}$	$N_{160}P_{80}$	$N_{80}P_{80}$+30 t/ha manure	Mean	%	Differ. kg/ha
20 cm ploughing + disk	49.2	55.2	53.1	55.2	58.6	**54.7**	100	0.0
30 cm ploughing + disk	53.3	58.3	56.8	58.3	59.9	**57.5**	105	2.8
Chisel + disk	56.2	65.1	61.9	65.1	68.8	**62.8**	115	8.1
Paraplow + disk	51.8	59.9	57.9	59.9	64.2	**58.8**	108	4.1
One year ploughing, one year disking	40.9	52.4	47.3	52.4	55.2	**49.6**	91	-5.1
Mean	**50.3**	**58.2**	**55.4**	**58.2**	**61.3**	**56.7**		
%	100	116	110	116	122			
Differ. kg/ha	0	8	5	8	11			
Mean		**Soil tillage (A)**		**Fertilizer (B)**		**Interaction AxB**		
LSD 5%		3.1		3.0		5.4		
LSD 1%		5.5		5.4		7.5		
LSD 0.1%		9.3		9.1		10.3		

B. **Effect of Cropping Systems and Organo - Mineral Fertilization on Production and Soil Fertility**

The crop rotation is also important under conditions of an intensive technology, being the main measure for soil protection, crop phytosanitary protection and efficient capitalization of all technological factors. Crop rotations with annual and perennial grasses and legumes have increased the biodiversity of agro-ecosystems, diminished the quantity of nitrogen-based fertilizers, contributed to the increase in soil fertility and diversified the options of farming management.

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. The diminution in the content of organic carbon from soil, due to mineral fertilization, was found in loam -sandy fields from Nashua, USA, where lower than 180 kg nitrogen/ha were applied in maize-soybean rotation [14] and in clay loam soils from Rothamsted, England, where lower rates than $N_{192}P_{35}K_{90}Mg_{35}$ were applied [1].

Table 3

Evolution of the organic carbon content from soil, 10 years after applying different rates of fertilizers and soil tillage systems

Soil tillage	N_0P_0	$N_{80}P_{80}$+6 t/ha wheat straw	$N_{120}P_{80}$	$N_{160}P_{80}$	$N_{80}P_{80}$+30 t/ha manure	Mean	%	Differ. kg/ha
20 cm ploughing + disk	17.33	19.07	18.27	18.97	19.97	**18.72**	100	0.000
30 cm ploughing + disk	17.27	19.03	18.43	18.93	20.00	**18.73**	100	0.013
Chisel + disk	17.67	19.33	18.73	19.23	20.53	**19.10**	102	0.380
Paraplow + disk	17.80	19.33	18.73	18.97	20.40	**19.05**	102	0.327
One year ploughing, one year disking	16.97	18.77	18.00	18.73	19.50	**18.39**	98	-0.327
Mean	**17.41**	**19.11**	**18.43**	**18.97**	**20.08**	**18.80**		
%	100	110	106	109	115			
Differ. kg/ha	0.00	1.70	1.03	1.56	2.67			
Mean		**Soil tillage (A)**		**Fertilizer (B)**		**Interaction AxB**		
LSD 5%		0.351		0.341		0.784		
LSD 1%		0.510		0.455		1.080		
LSD 0.1%		0.765		0.599		1.487		

On the Cambic Chernozem from the Moldavian Plain, growing wheat in 3 and 4-year crop rotations with annual and perennial legumes has determined yield increases of 34 – 39 % (832 – 963 kg/ha) as compared with maize continuous cropping. Maize growing in 4-year rotation (peas-wheat-maize-sunflower) + ameliorative field, cultivated with perennial grasses and legumes, has determined yield increases of 18 % and 808 kg/ha, respectively, compared with wheat-maize rotation (which is the most commonly used rotation by farmers) (*table 4*). Applying high fertilizer rates ($N_{140}P_{100}$) in wheat has determined, in the last 11 years, an average yield increase of 113 % (1874 kg/ha),while the use of low mineral fertilizer rates ($N_{60}P_{40}$), together with 30 t/ha manure, resulted in getting an yield increase of 128% (2123 kg/ha) (*table 2*).

The average yield increases, obtained in maize during 1997-2006, were between 10 and 28 % (468 – 1276 kg/ha), due to crop rotation, and between 32 and 92 % (1075 – 3107 kg/ha), due to applied fertilizer rates (*tables 4, 5*). Applying mean rates of mineral fertilizers ($N_{60}P_{40}$) with 30 t/ha manure has resulted in getting average yield increases comprised between 2123 kg/ha in wheat and 3107 kg/ha in maize, as compared with the unfertilized variant.

The mass of total carbon from Cambic Chernozem in the Moldavian Plain has registered significant increases at higher than $N_{140}P_{100}$ rates, in case of organo-mineral fertilization and in 4-year crop rotation, which included ameliorative plants of perennial grasses and legumes (*table 6*). In maize continuous cropping and wheat-maize rotation, very significant values of the carbon content was found only in the organo-mineral fertilization, in 4-year crop rotation + reserve field, cultivated with perennial legumes and in $N_{140}P_{100}$ fertilization. The 40-year use of 3 and 4- year crop rotations has determined the increase in the mass of total carbon and mobile phosphorus from soil by 13% (2.2 C g/kg) and, respectively, 40% (15 P-AL mg/kg), in comparison with maize continuous cropping. The mean rate mineral fertilization ($N_{60}P_{40}$), together with 30 t/ha manure, has determined the yield increase of 128% (2123 kg/ha) in wheat and 92% (3107 kg/ha) in maize, as compared with the unfertilized control. Applying the rate of $N_{140}P_{100}$ for 39 years has determined the pH decrease until the limit of moderately acid interval (5.1-5.8) in wheat continuous cropping and wheat-maize rotation, and was maintained within the weakly acid interval (5.9-6.8) in 3 and 4 –year crop rotations with annual and perennial legumes.

Table 4

Influence of rotation on wheat and maize yield during 1997 – 2007

Crop rotation	Wheat yield		Dif. kg/ha	Sign.	Maize Yield		Dif. kg/ha	Sign.
	kg/ha	%			kg/ha	%		
Continuous cropping	2454	100	0		4586	100		
Wheat – maize	2511	102	57		5054	110	468	x
Peas –wheat-maize	3286	134	832	xxx	5632	123	1046	xxx
PWMS+G	3417	139	963	xxx	5862	128	1276	xxx
LSD 5 %			204	kg/ha			460	kg/ha
LSD 1 %			375	kg/ha			632	kg/ha
LSD 0.1 %			587	kg/ha			844	kg/ha

Table 5

Influence of fertilizers on wheat and maize yield during 1997 – 2007

Fertilizer rate	Wheat yield		Dif. kg/ha	Sign.	Maize Yield		Dif. kg/ha	Sign.
	kg/ha	%			kg/ha	%		
N_0P_0	1662	100	0		3368	100	0	
$N_{60}P_{40}$	2492	150	830	***	4443	132	1075	***
$N_{100}P_{80}$	3110	187	1448	***	5733	170	2365	***
$N_{140}P_{100}$	3536	213	1874	***	6400	190	3032	***
$N_{60}P_{40}$+30 t/ha manure	3785	228	2123	***	6475	192	3107	***
LSD 5 %			204	kg/ha			552	kg/ha
LSD 1 %			375	kg/ha			740	kg/ha
LSD 0.1 %			587	kg/ha			976	kg/ha

Table 6

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

Fertilizer rate	*Mcc	Wcc	WM	PWM	PWMS+G	Average	Dif.	Signif.
N_0P_0	15.0	15.9	15.2	16.5	16.8	15.9	0	
$N_{60}P_{40}$	15.5	15.7	14.8	16.9	17.1	16.0	0.1	
$N_{100}P_{80}$	15.8	16.4	16.2	17.3	18.2	16.8	0.9	
$N_{140}P_{100}$	16.8	17.2	17.0	18.5	19.7	17.8	1.9	x
$N_{60}P_{40}$+30 t/ha manure	19.0	19.4	19.0	20.1	21.4	19.8	3.9	xxx
Average crop rotation	16.4	16.9	16.4	17.9	18.6	17.3		
Difference	0	0.5	0.0	1.5^{x}	2.2^{xx}			
	Crop rotation			Fertilizer		Interaction		
LSD 5 %		1.4		1.5		1.2	g/kg	
LSD 1 %		1.8		2.1		1.6	g/kg	
LSD 0.1 %		2.4		2.7		2.1	g/kg	

*Mcc= Maize continuous cropping, Wcc= Wheat continuous cropping, WM= Wheat-maize rotation, PWM= Peas –wheat-maize rotation, PWMS+G= Peas–wheat-maize – sunflower + reserve field, cultivated with legumes and perennial grasses.

C. Long-term effect of nitrogen and phosphorus fertilizer and crop residue on production and soil fertility in the Moldavian Plateau

In many countries, the investigations conducted on eroded soils have followed the establishment of crop rotations and soil tillage and fertilizing systems, which contribute to maintaining and recovery of soil fertility [2, 11, 18].

The negative impact of continuous cropping on the content of organic carbon from soil was shown by Clapp et al., 2000; Liu, 2006. In many areas, applying crop residues, together with moderate nitrogen rates, have resulted in improving physical, chemical and biological soil characteristics [1, 9, 10]. These studies show that establishing the amounts of crop residues, which must be applied for maintaining the content of organic carbon and for diminishing soil erosion should have in view the interactions between crop rotation, soil tillage, fertilization and soil and climate conditions. The amounts of applied crop residues must contribute to diminishing soil erosion, maintaining the content of organic carbon from soil and determining yield increases.

On weakly eroded lands, the mean maize yields obtained during 1997-2007, were comprised between 3287 kg/ha (100 %) at the unfertilized control and 7188 kg/ha (119 %) at rates of 70 kg N + 70 kg P_2O_5 + 60 t/ha manure (*table 7.)* In maize, the application of mean rates of mineral fertilizers (70 kg N + 70 kg P_2O_5) with 60 t/ha manure has resulted in getting yield increases of 134 % (3275 kg/ha), compared to the unfertilized variant. Applying rates of 100 kg N + 100 kg P_2O_5 resulted in getting yield increases of 84 % (2748 kg/ha) in maize, placed on weakly eroded lands, and 94 % (2306 kg/ha) in maize placed on highly eroded soil, compared to the unfertilized variant.

In maize placed on weakly eroded lands, the mean yield increases obtained for each kg of a.i. of applied fertilizers have varied according to applied fertilizers rates, between 7.2 and 14.1 kg grains ($N_{40}P_{40}$-$N_{140}P_{100}$). On highly eroded lands, the mean maize yield obtained under unfertilized was of 2452 kg/ha, while the mean yield increases, obtained by applying 40 or 60 t/ha manure, were of 36.4-34.2 kg grains per ton of applied manure. The mineral fertilizers ($N_{40}P_{40}$-$N_{140}P_{100}$) resulted in getting mean yield increases of 8.4- 11.7 kg grains/kg a. i. of applied fertilizer. Very close yield results were also obtained by applying, for 43 years, rates of 70 kg N + 70 kg P_2O_5/ha +3 t/ha stalks of pea or soybean, variants at which yield increases have varied, according to soil erosion, between 2550 and 2615 kg/ha (78-80 %) on weakly eroded lands and between 2161 and 2223 kg/ha (88-91 %) on highly eroded lands (*table 7*). The analysis of results obtained has shown that the erosion process, by decreasing soil fertility, has determined the differentiation of the mean maize yield, according to slope and erosion, from 576 (100 %) to 4538 kg/ha (78.8 %). Mean annual losses of yields registered in maize in the last 11 years, caused by erosion, were of 1218 kg/ha (21.2 %). 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. The mean annual yield losses, registered in wheat in the last 11 years, caused by erosion, were of 753 kg/ha (19.6 %).

The analysis of agro-chemical data shows that nitrogen fertilizers (ammonium nitrate) have determined the pH decrease. A significant diminution was registered in the ploughed layer, at rates of 140 kg/ha N, where pH value has reached 5.7, after 43 years (*table 8*). The analyses carried out on the evolution of soil response, after 43 years of experiencing, have shown that the significant diminution in the pH value was found at higher rates than 100 kg N/ha . The lowest pH values were found in maize at rates of $N_{140}P_{100}$ and 70 kg N + 70 kg P_2O_5/ha + 6 t/ha stalks of maize, which can be explained by the unfavorable conditions in which the processes of nitrification and crop residue decay developed.

Table 7

Influence of mineral and organic fertilizers on maize and wheat yields, in weakly and highly eroded soils

No.	Fertilizer rate	Weakly eroded soil				Highly eroded soil			
		Maize yields		Wheat yields		Maize yields		Wheat yields	
		Kg/ha	Differ. kg/ha	Kg/ha	Differ. kg/ha	Kg/ha	Differ. kg/ha	Kg/ha	Differ. kg/ha
1	N_0P_0	3287	0	1697	0	2452	0	1163	0
2	$N_{70}P_{70}$	5159	1872	3192	1495	4120	1668	2478	1315
3	$N_{100}P_{100}$	6035	2748	4078	2381	4758	2306	3248	2085
4	$N_{140}P_{100}$	6660	3373	4523	2826	5263	2811	3665	2502
5	$N_{70}P_{70}K_{70}$	5285	1998	3384	1687	4251	1799	2710	1547
6	$N_{100}P_{100}K_{100}$	6324	3037	4398	2701	5020	2568	3570	2407
7	$N_{140}P_{100}K_{100}$	6816	3529	4797	3100	5475	3023	3923	2760
8	20 t/ha manure	4150	863	2761	1064	3252	800	2165	1002
9	40 t/ha manure	5199	1912	3445	1748	3909	1457	2813	1650
10	60 t/ha manure	5953	2666	4018	2321	4505	2053	3294	2131
11	$N_{70}P_{70}$+20 t/ha manure	6119	2832	4102	2405	4719	2267	3304	2141
12	$N_{70}P_{70}$+40 t/ha manure	6545	3258	4619	2922	5261	2809	3669	2506
13	$N_{70}P_{70}$+60 t/ha manure	7188	3901	4894	3197	5727	3275	4011	2848
14	$N_{70}P_{70}$+6 t/ha hashed straw	5733	2446	3770	2073	4646	2194	3041	1878
15	$N_{70}P_{70}$+6 t/ha stalks of maize	5656	2369	3578	1881	4500	2048	2929	1766
16	$N_{70}P_{70}$+3 t/ha stalks of pea	5902	2615	4010	2313	4675	2223	3237	2074
17	$N_{70}P_{70}$+3 t/ha stalks of soybean	5837	2550	3911	2214	4613	2161	3164	2001
	Mean	**5756**	**100**	**3834**	**100**	**4538**	**78.8**	**3081**	**80.4**
	LSD 5%		315		340		336		310
	LSD 1%		444		450		450		430
	LSD 0.1%		593		580		605		570

Table 8

Effect of soil erosion and fertilization system on the organic carbon and mineral element content in 16% slope fields

No.	Fertilizer rate	Weakly eroded soil				Highly eroded soil			
		pH (H_2O)	Org. C g/kg	P-AL (ppm)	K-AL (ppm)	pH (H_2O)	Org. C g/kg	P-AL (ppm)	K-AL (ppm)
1	N_0P_0	7.3	16.5	17	216	7.2	14.2	8	192
2	$N_{70}P_{70}$	6.9	16.9	54	186	6.8	14.3	41	186
3	$N_{100}P_{80}$	6.3	17.5	86	178	6.2	15.5	62	174
4	$N_{140}P_{100}$	5.8	18.2	89	174	5.7	16.6	64	156
5	60 t/ha manure	7.4	21.3	74	276	7.1	19.9	66	259
6	$N_{70}P_{70}$ + 60 t/ha manure	7.2	21.8	96	292	6.9	20.2	74	289
7	$N_{70}P_{70}$ + 6 t/ha hashed of wheat	7.0	18.9	64	234	6.8	18.4	57	216
8	$N_{70}P_{70}$+6 t/ha stalks of maize	6.6	18.8	58	239	6.6	18.1	52	196
9	$N_{70}P_{70}$+3 t/ha stalks of pea	6.9	18.5	47	228	6.8	18.0	48	184
10	$N_{70}P_{70}$+3 t/ha stalks of soybean	6.8	18.3	51	234	6.7	18.0	49	182
11	**Mean**	**6.8**	**18.7**	**63.6**	**225.7**	**6.7**	**17.3**	**52**	**203**
12	LSD 5%	0.27	0.07	5.9	16.1	0.24	0.10	4.8	15.7
13	LSD 1%	0.38	0.10	8.2	24.0	0.35	0.14	6.9	22.6
14	LSD 0.1%	0.55	0.15	11.5	36.2	0.56	0.20	9.9	33.4

CONCLUSIONS

1. Soil preparation without furrow inverting has resulted in improving soil physical and hydro-physical characteristics and allowed a better capitalization of technological factors and, especially, of fertilizers, which determined greater yield increases in wheat by 3.6 % (271 kg/ha) (N160 +80 kg/ha P_2O_5), compared to 20 cm ploughing.

2. Soil tillage by chisel and disk allowed soil treatment under better conditions for wheat growing in dry autumns, which are very frequent in the area.

3. The results obtained made us assess that soil tillage system must be adjusted to plant requirements from crop rotation and to soil and climatic conditions of the area. Establishing the systems of soil tillage for the whole crop rotation (disking or chisel + disk work in wheat crop, 20 cm ploughing for soybean and 25-28 cm ploughing for maize) resulted in a better capitalization of the other

technological factors, water conservation in soil, maintaining soil physical condition and reduction, on the entire rotation cycle, in fuel consumption.

4. Applying moderate rates of mineral fertilizers ($N_{80}P_{80}$), together with 6 t/ha wheat straw or 30 t/ha manure, has determined, 10 years after using chisel, the increase in organic carbon content from soil by 1.66 and, respectively, 2.86 g/kg.

5. The 40-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 39% (963 kg/ha) in wheat and 28% (1276 kg/ha) in maize. On slope lands, the high mineral rate fertilization ($N_{140}P_{100}$) has determined, in the last 11 years, an average yield increase of 113% (1874 kg/ha) in wheat and 90% (3032 kg/ha) in maize, as compared with the unfertilized control.

6. The mass of total carbon in the Cambic Chernozem from the Moldavian Plain has registered significant increases at higher rates than $N_{140}P_{100}$, in case of organo - mineral fertilization and in 4-year crop rotation +reserve field, cultivated with perennial grasses and legumes.

7. On highly eroded lands, in maize after wheat, in a three year rotation, the mean yield obtained under unfertilized was of 2452 kg/ha, the mean yield increases obtained by applying 60 t/ha manure every two years, were of 34.2 kg grains per ton of manure applied and mineral fertilizers ($N_{140}P_{100}$) resulted in obtaining mean yield increases of 11.7 kg grains/kg a.i. of applied fertilizer.

8. On slightly eroded lands, keeping a good supply in soil nutritive elements was done by the annual use of some fertilizer rates of at least $N_{100}P_{100}$ or $N_{70}P_{70}$+ 40 t/ha manure applied once in two years or $N_{70}P_{70}$ + 6 t/ha straw; on highly eroded lands, keeping a good plant supply in mineral elements was done at rates of $N_{140}P_{100}K_{70}$ or $N_{70}P_{70}$ + 40 t/ha manure.

BIBLIOGRAPHY

1. 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.
2. Campbell, C.A., Janzen, H.H., Paustian, K., Greegorich, E.G., Sherrod, L., Liang, B.C., Zentner R.P., 2005 - *Carbon storage in soils of the North American Great Plains: Effect of cropping frequency.* Agron. J., *97*: 349–363.
3. Farahbakhshazada, Neda, Dinnes, Dana L., Changsheng, Li, Jaynes, Dan B. and Salas, William, 2008. Modeling biogeochemical impacts of alternative management practices for a row-crop field in Iowa, Agriculture, Ecosystems & Environment , Volume 123, Pages 30-48.
4. Gregorich, E.G., Rochette, P., VandenBygaart ,A.J. and Angers, D.A., 2005. Greenhouse gas contributions of agricultural soils and potential mitigation practices in Eastern Canada, Soil and Tillage Research, Volume 83, Issue 1, Pages 53-72.
5. Guş, P, Rusu, T., Bogdan, Ileana, 2006 – *Implications of Minimum Tillage Systems on Sustainability of Agricultural Production*, Advances in Geoecology, 38, CATENA Verlag, Reiskirchen, Germany, 546 - 549, ISBN 3-923381-52-2, US ISBN 1-59326-246-9, International Soil Tillage Research Organisation 17th Triennial Conference - Kiel, Germany.
6. Guş, P., Săndoiu, I. D., Lăzureanu, A., G. Jităreanu, G., 1988, - *Agrotehnica*, Ed. Rizoprint – Cluj-Napoca, 1988.

7. Jitareanu, G., Ailincai, C., and Bucur, D., 2007- *Soil fertility management in North-East Romania*, Journal of Food, Agriculture & Environment Vol.5 (3&4) : 3 4 9 - 3 5 3 . 2 0 0 7 www.world-food.net
8. Jitareanu, G. Ailincai, C. Raus, L. Ailincai, D. , 2008-*Long-Term Effect of Cropping Systems and Organo - Mineral Fertilization on Production and Soil Quality in the North-Eastern Romania* , 15th International Congres of ISCO 18-23 May 2008, Budapest, Published by the Geographical Research Institute, Hungary, ISBN 978 963 9545 205.
9. Lal, R., 2006 – *Enhancing crop yields in developing countries through restoration of the soil organic carbon pool in agricultural lands*. Land Degrad. & Develop. 17: 197-209
10. Lăzureanu, A., Cârciu, G., Manea, D., Alda, S., Ienciu ,Anişoara, 2003 – *Cercetări privind influenţa metodei de lucru asupra apei din sol la cultura de grâu de toamnă, în condiţiile Staţiunii Didactice Timişoara*, A XVII a Conferinţă Naţională Naţională Pentru Ştiinţa Solului25-30 august, 270-275
11. Liu, X., Herbert, S.J., Hashemi, A.M., Zhang, X., Ding G., 2006 - *Effects of agricultural management on soil organic matter and carbon transformation – a review*, Plant Soil Environ., 52, 2006 (12): 531–543
12. Oswaldo, Ernst, 2006, - *Soil Organic Carbon and Total Nitrogen in Relation to Tillage and Crop- Pasture Rotation,* Advances in Geoecology, 38, CATENA Verlag, Reiskirchen, Germany, 502 - 507, ISBN 3-923381-52-2, US ISBN 1-59326-246-9, International Soil Tillage Research Organisation 17th Triennial Conference - Kiel, Germany.
13. Rosner, J., Zwatz, E., Klik, A., Gyuricza, C., 2008 – *Conservation Tillage Systems – Soil – Nutrient – and Herbicide Loss in Lower Austria and the Mycotoxin Problem*, 15th International Congres of ISCO 18-23 May 2008, Budapest, Published by the Geographical Research Institute, Hungary, ISBN 978 963 9545 205.
14. Russell, A., E., Laird, D., A., Mallarino, A., P., 2006 – Nitrogen Fertilization and Cropping System Impact on Quality in Midwestern Mollisols, Soil Sci. Soc. Am. J. 70:249-255.
15. Rusu, Teodor, Gus, Petru, Bogdan, Ileana, Moraru, Paula Ioana, Pop, Adrian, Pacurar ,Ioan 2008 – *Minimum tillage systems and its effect on soil structure, humus conservation and water manage*, 15th International Congres of ISCO 18-23 May 2008, Budapest, Published by the Geographical Research Institute, Hungary, ISBN 978 963 9545 205.
15. Săndoiu, I. D., Boguslawski, E. V., Ileana Fulvia, Săndoiu, 1996 – *The effect of Cropping systems on yield, farm, produce quality, profitability and environement protection in the main crop and pasture lands*, Vol. Proceeding of the international Scientific Conference Bucharest, 7-12, 1996
16. Sin, Gh. şi colab. 2000 – *Tehnologii moderne pentru cultura plantelor de câmp*, Edit. Ceres, Bucureşti
17. Ulrich, S.A., Hofmanna, B. S. Tischerb, S. and Christena, O., 2006, - *Influence of tillage on soil quality in a long – term trial in Germany,* Advances in Geoecology, 38, CATENA Verlag, Reiskirchen, Germany, 534 - 539, ISBN 3-923381-52-2, US ISBN 1-59326-246-9, International Soil Tillage Research Organisation 17th Triennial Conference - Kiel, Germany.
18. Yadav, Vineet and Malanson, George, 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.