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SOIL FERTILITY EVOLUTION INFLUENCED BY CROPPING SYSTEMS AND SOIL EROSION IN THE MOLDAVIAN PLATEAU

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ABSTRACT – The goal of the experiments carried out during 1980-2009, at the Podu-Iloaiei Agricultural Research Station, Iasi County, was the study of water runoff and soil loss, caused by erosion, in different crops and the influence of water and soil erosion on loss of organic matter and mineral elements from soil. The results on runoff and soil losses in different crops from the Moldavian Plateau have shown that, during 1980-2009, of the total amount of 570.2 mm rainfall, 366.1 mm (64.2%) produced water runoff, which was between 6.3 mm in perennial grasses and 29.6 - 35.4 mm in maize and sunflower crops. The annual soil loss by erosion was between 0.246 t/ha in perennial grasses and 8.976 t/ha in sunflower. Erosion has affected soil fertility by removing once with eroded soil, high amounts of mineral elements, which reached 16.1-17.5 kg/ha nitrogen, 1.2-1.3 kg/ha phosphorus and 2.0-3.2 kg/ha potassium, in maize and sunflower crops. The crop structure, which determined the diminution in mean soil losses by erosion until 3.206 t/ha, included 20 % straw cereals, 20% annual legumes, 20% row crops and 40 % perennial grasses and legumes.

Key words: cropping systems, water erosion, organic carbon, nutrient losses, water quality

REZUMAT – **Evoluţia fertilităţii solului sub influenţa sistemelor de cultură şi a eroziunii solului în Podişul Moldovei.** Experienţele, realizate la Staţiunea de Cercetare-Dezvoltare Agricolă Podu-Iloaiei, judeţul Iaşi, în perioada 1980-2009, au urmărit studiul scurgerilor de apă şi de sol prin eroziune, la diferite culturi agricole şi influenţa scurgerilor de apă şi a eroziunii solului asupra substanţei organice şi a elementelor minerale din sol. Rezultatele obţinute privind scurgerile de apă şi sol prin eroziune, la diferite culturi în Podişul Moldovei, arată că, în perioada 1980-2009,

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din totalul de 570.2 mm precipitații înregistrate, 366.1 mm (64.2%) au determinat scurgeri, care au fost cuprinse între 6.3 mm la ierburile perene şi 29.6-35.4 mm la culturile de porumb şi floarea-soarelui. Pierderile anuale de sol prin eroziune au fost cuprinse între 0.246 t/ha la ierburile perene şi 8.976 t/ha la floarea-soarelui. Eroziunea a influențat fertilitatea solului prin îndepărtarea, odată cu solul erodat, a unor cantități mari de elemente minerale care, la culturile de porumb şi floarea-soarelui, au ajuns la 16.1-17.5 kg/ha azot, 1.2-1.3 kg/ha fosfor şi 2.0-3.2 kg/ha potasiu. Structura culturilor, care a determinat reducerea pierderilor de sol prin eroziune sub 3.206 t/ha, a cuprins 20% cereale păioase, 20% leguminoase anuale, 20% culturi prăşitoare şi 40% leguminoase şi graminee perene.

Cuvinte cheie: sisteme de cultură, eroziunea produsă de apă, carbon organic, scurgeri de elemente nutritive, calitatea apei

INTRODUCTION

Land use changes and soil management practices with potential for SOC sequestration include judicious use of fertilizers and manures, use of crop residues, diverse crop rotations and erosion control measures. In all the countries, the investigations carried out in the last period have followed the establishment of some technological solutions that maintain the productivity of agro ecosystem and the protection of environment factors. The Soil Protection Framework Directive of EU includes the necessary legislative proposals, taken into account by all the Member States concerning the three main threats on the decline in organic matter, soil erosion and contamination and some additional aspects regarding compaction, diminution of biodiversity, floods and landslides. In the EU, more than 150 million hectares of soil are affected by erosion and 45% of the European soils have a low content of organic matter (Montanarella, 2008).

In Austria, during 1994-2007, the mean soil loss in three locations dropped from 6.1 t/ha to 1.8 t/ha, by using conservation tillage in cover crops until 1.0 t/ha/year with direct drilling. Nitrogen (9.2, 3.7, 2.5 kg/ha/year) and phosphorus (4.7, 1.3, 0.7 kg/ha/year) losses showed similar tendencies (Rosner et al., 2008). Of the total Italian area, 51.8% is considered to be at potential risk of desertification. Soil erosion is the most relevant soil degradation system that affects at least 19% of the territory at the potential risk of desertification, while aridity is the second desertification risk (19.0%) (Constantini *et al.* 2008). The Directive 2006/42/EC proposes the identification of zones with erosion-degraded soils and organic matter in decline, for meeting the requirements of the United Nations Convention to Combat Desertification (UNCCD) in Northern Mediterranean and Central and Eastern European Country Parties.

The main problems requiring agro-environment measures in Romania are the degradation degree of fields by erosion (6.3 million ha), deterioration of soil structure and compaction (on 44% of the total farming area) (Jităreanu *et al.,* 2007). In Romania, soil erosion is the most expensive degradation process, which affects almost 63% of the total area and 56% of the arable area from Romania. Investigations on the potential erosion, conditioned by geomorphologic, soil and climatic factors, have shown that in NE Romania, the mean soil losses by erosion were of 18.3 t/ha. The studies carried out on the effective erosion, based on direct determinations and complex analyses, have shown that in the entire NE zone, the effective erosion had a mean value of 4.8 t/ha/year. The north-eastern region has 15.45% (2,131,421 ha) of the farming area of Romania (14,836, 585 ha) and includes very great areas with soils affected by erosion (over 60%), acidification, compaction, landslides and other degradation forms (Project of North-East Regional Development 2007-2013).

In Bulgaria, the investigations showed that the mean annual rate of erosion on the arable lands was of 4.76 t/ha and of 2.69 t/ha on improved arable lands. Soil losses by erosion on the fields ploughed on the upstream-downstream direction, which are cultivated with maize, are of 7.48 t/ha. In sunflower, cultivated with conventional tillage, the annual eroded soil was of 3.044 t/ha, and by wheat straw and green fertilizer incorporation into soil, erosion has decreased at 2.327 t/ha and 0.937 t/ha, respectively (Totka M. *et al.,* 2006). The favorable influence of reduced tillage system and of crop residues on soil erosion was also signaled by Lal (2006). He showed that in no-tillage system, soil losses by erosion were close to the ones found in case of soil protection with 6 t/ha of mulch. On 8.5% slope fields from SW Finland, annual soil losses by erosion are of 5-6 t/ha and leached nitrogen and phosphorus amounts are of 15.0 and 1.1 kg/ha/year, respectively (Muukkonen, 2007). The investigations conducted by Lindstrom, in Minnesota, USA, have shown that 927, 1853 and 3706 kg/ha of crop residues, applied in maize crops, have determined the decrease of soil erosion until 6.177, 1.730 and 0.988 t/ha respectively, and water runoff decreased until 35.6, 25.4 and 22.9 mm, respectively. The results obtained concerning erosion in the Coshocton USA, made according to measurements of Izaurralde (2007) carried out in the North Appalachian Experimental Watershed, near Coshocton, showed that in the areas annual mean soil losses by erosion were of 1.18 t/ha (range, 0.35 in wheat and 7.36 in maize).

MATERIALS AND METHODS

Investigations conducted during 1980-2009 on a Cambic Chernozem at the Agricultural Research and Development Station of Podu-Iloaiei, Iaşi County, followed the influence of different crop rotations on water runoff and nutrient losses, due to soil erosion. Experiments were conducted on the hydrographical basin of Scobîlţeni, with a reception area of 159 ha, a mean altitude of 119.4 m, and a mean slope length of 250 m. The area of the watershed has been anti-erosion set up since 1983, being used combined cropping systems made of sod rewetting and strip cultivation. The width of cultivated strips is 200-250 m on 5-10% slopes, 100-150 m on 10-15 % slopes and 50-100 m on 15-18 % slopes (*Figure 1*).

Figure 1- Geographic presentation of the Scobîlțeni, Iaşi watershed, set up with anti-erosion works, where the experimental devices were placed

The determination of runoff and soil losses by erosion was carried out by means of loss control plots with a collecting area of 100 m^2 (25x4 m) and by means of a hydrological section equipped with spillway and limn graph and devices for sampling water and soil loss by erosion. Total nitrogen, nitrate, phosphorus and potassium content were determined in soil and water samples, lost by erosion in different crops, thus establishing the losses of nutritive elements. The climate is temperate continental with large thermal amplitude and uneven and commonly torrential rainfall prevalent during the vegetative season. 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 559.2 mm, of which 161.2 mm during September-December, and 398 mm during January-August. Within the experiment, the following rotation scheme was followed: wheat and maize continuous cropping, 2-year crop rotation (wheat-maize), 3-year crop rotation (peas-wheat-maize) and 4-year crop rotation + outside field cultivated with legumes and perennial grasses (*Medicago sativa* + *Lolium perene*). The content of organic carbon was determined by the Walkley-Black method, to convert SOM into SOC 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. ANOVA was used to compare the effects of treatments. %). In wheat, we have used Gabriela Variety, and in maize, Podu-Iloaiei 110 Hybrid.

RESULTS AND DISCUSSION

On slope lands, soil nutrient losses being very high, due to leaching, runoff and element fixing, the establishment of rates and time of fertilizer application must be done differently, according to soil characteristics, cultural practices and climatic conditions. On eroded slope lands, the growing systems ensure the reduction in soil losses below the allowable limit of 3-4 t/ha/year and allow getting efficient yields from the economic point of view.

The results on water runoff and soil loss in different crops from the Moldavian Plateau, determined by control plots, have shown that, during 1980-2009, of the total amount of 570.2 mm rainfall, 366.1 mm (64.2%) produced water runoff, which was between 6.3 mm in perennial grasses, in the second year of vegetation, and 29.6 - 35.4 mm, in maize and sunflower crops (*Table 1*).

Table 1 - Mean annual runoff and soil losses due to erosion, recorded in different crops

Crop	Rainfall causing runoff (mm)	Runoff (mm)	Eroded Soil (t/ha)	Runoff coefficient	Mean turbidity (g/l)
Field	366.1	59.7	18.240	0.16	30.5
Sunflower	366.1	35.4	8.976	0.10	25.3
Ist year perennial grasses	366.1	18.7	1.914	0.05	10.2
IInd year perennial grasses	286.5	6.3	0.246	0.02	3.9
Maize	366.1	29.6	8.425	0.08	28.4
Peas	366.1	21.3	3.789	0.06	17.7
Wheat	336.4	11.4	1.662	0.03	14.5
Beans	366.1	23.6	4.519	0.06	19.1
Soybean	366.1	19.8	3.854	0.05	19.4

The annual soil loss due to erosion, recorded at the same period, was between 0.246 t/ha/year in perennial grasses, and 8.425 - 8.976 t/ha/year in maize and sunflower crops. The obtained results on the potential erosion (conditioned by geo-morphological, soil and climate factors) have shown that on the fields uncovered by vegetation from the Moldavian Plateau, the mean soil losses due to erosion were of 18.24 t/ha, values corresponding to a moderate erosion risk. The protection degree of soil against erosion, expressed by the ratio between the value of the effective erosion (under specific technological conditions) and of the potential erosion (soil eroded under conditions of uncovered soil, which was not set up with soil erosion control works) is an indicator of erosion risk that shows soil vulnerability to erosion. It is given by the ratio between the value of the effective erosion and that of mean allowable erosion, which corresponds to soils from the studied watershed. Taking into account that the erosion process cannot be avoided and that the tolerance level of soil annual losses is 3 - 4 t/ha/year, which corresponds to the annual rate of soil renewal, the mean annual soil losses due to erosion, recorded during 1980-2009 in maize (8.425 t/ha) and sunflower (8.976 t/ha), may result in destructing the fertile soil layer in a few decades. Erosion has affected soil fertility by removing once with eroded soil, high amounts of organic carbon and mineral elements, which reached 17.54 - 16.14 kg/ha nitrogen, 1.15 - 1.29 kg/ha phosphorus and 2.03 - 3.18 kg/ha potassium, in maize and sunflower crops (*Table 2*).

Table 2 - Mean water runoff, soil, organic carbon and mineral element losses, due to erosion, in the Moldavian Plateau

Crop	Organic carbon and mineral elements lost by erosion, kg/ha						
	Organic carbon	N at water runoff	N in eroded soil	Total N	P-AL	K-AL	Total NPK
Field	362	5.325	26.083	31.408	2.098	4.378	37.884
Sunflower	181	4.708	12.836	17.544	1.293	3.178	22.015
Ist year perennial grasses	38	2.113	2.833	4.946	0.220	0.477	5.643
IInd year perennial grasses	5	0.712	0.362	1.074	0.028	0.061	1.163
Maize	167	4.174	11.964	16.138	1.154	2.030	19.322
Peas	75	2.663	5.646	8.309	0.413	0.758	9.480
Wheat	33	1.505	2.427	3.932	0.186	0.416	4.534
Beans	90	3.115	6.598	9.713	0.497	0.904	11.114
Soybean	77	2.693	5.627	8.320	0.439	0.840	9.599

On 16% slope lands, the mean annual nitrogen, phosphorus and potassium leaches, due to erosion, recorded during 1980-2009, were comprised between 9.59 and 22.02 kg/ha in row crops (soybean and sunflower) and between 4.53 and 9.48 kg/ha/years in wheat and peas crops (*Table 2*). The obtained results on erosion in different crop rotations have shown that under conditions of 16% slope lands from the Moldavian Plateau, the diminution in soil losses below the allowable limit of 3-4 t/ha/year was done only in 3-4 year crop rotations with one or two outside fields, cultivated with perennial grasses and legumes that protect better soil against erosion (*Table 3*).

From the investigations carried out on effective erosion, based on direct determinations, we found out that the effective erosion in the Moldavian Plateau, in peas-wheat-maize rotation, had a mean value of 4.625 t/ha. At 3- and 4-year crop rotations, which included good and very good cover plants for protecting soil against erosion, the amounts of eroded soil and nutrients lost by erosion were very close to the allowable limit for this area. These elements were necessary for establishing the crop structure and dimensioning the anti- erosion works, which determined the diminution of soil erosion and water runoff, soil and nutrient losses below the limit corresponding to the natural capacity of annual soil recovery, of 3-4 t/ha/year of eroded soil.

The results concerning water runoff, soil and mineral element losses from crops, placed in different rotations, have shown that on 16% slope lands, the use of peas-wheat-maize rotation + 2 outside fields, cultivated with legumes and perennial grasses, resulted in soil losses, which diminished by 46.2 %, as compared to wheat-maize rotation (*Table 3*). On 16% slope lands, the mean annual losses of nitrogen due to erosion were comprised, during 1980-2009, between 16.138 kg/ha in maize continuous cropping and 5.911 kg/ha/year in peas - wheat - maize rotation + three outside fields cultivated with perennial grasses (*Table 4*). If phosphorus and potassium losses are low (0.76-1.6 kg/ha/year), the nitrogen losses should be diminished by using rotations with crop structures that protect soil against erosion. The highest losses of nutrients were recorded in 2-year rotation (wheat-maize) (10.034 kg/ha nitrogen and 11.927 kg/ha total NPK). These amounts decreased very much at the same time with the increase in the rotation structure of cover crops, such as peas, wheat, alfalfa and perennial grasses.

Table 3 - Average annual water and soil runoff by erosion registered in different crops rotation

Crop rotation	Water Runoff		Erosion		Organic carbon (kg/ha)	Row plants (%)
	(mm)	%	t/ha/year	%		
[1]Mcc	29.6	100	8.425	100	167	100
BWMSfW	22.3	75	5.049	60	101	60
WM	20.5	69	5.044	60	100	50
PWMSf+G	21.6	73	4.731	56	94	40
PWM	20.8	70	4.625	55	92	33
PWMSf+2G	19.8	67	4.076	48	81	33
BWM+ 2G	17.1	58	3.242	38	64	40
PWSf+2G	17.8	60	3.206	38	64	20
SWM+ 2G	16.3	55	3.096	37	62	40
PWM + 3G	15.6	53	2.714	32	54	17

[1]Mcc= Maize continuous cropping, BWSfMW = Beans-wheat-sunflower-maize-wheat rotation, WM= Wheat-maize rotation, PWM= Peas -wheat-maize, PWMSf+G = Peas-wheat-maize -sunflower + reserve field, cultivated with legumes and perennial grasses, BWM+ 2G = Beans-wheat-maize + 2 reserve field, cultivated with legumes and perennial grasses, SWM = Soybean- wheat-maize + 2 reserve field, cultivated with legumes and perennial grasses.

Table 4 - Mean annual losses of nutritive elements in different crops rotations, kg/ha

Crop rotation	N, in runoff water	N, in eroded soil	Total N	P-AL	K-AL	Total NPK	Row plants, %
*Mcc	4.174	11.964	16.138	1.154	2.030	19.322	100
BWMSfW	3.001	7.250	10.251	0.663	1.389	12.303	60
WM	2.840	7.194	10.034	0.670	1.223	11.927	50
PWMSf+G	2.846	6.811	9.657	0.628	1.316	11.601	40
PWM	2.781	6.678	9.459	0.584	1.068	11.111	33
PWMSf+2G	2.568	5.873	8.441	0.538	1.130	10.109	33
BWM+ 2G	2.230	4.672	6.902	0.404	0.750	8.056	40
PWSf+2G	2.247	4.655	6.902	0.415	0.950	8.267	20
SWM+ 2G	2.146	4.486	6.632	0.393	0.737	7.762	40
PWM + 3G	1.980	3.931	5.911	0.338	0.634	6.883	17

Data are very important for establishing and regulating the fertilizer rates applied in crops and for controlling the environment pollution with nitrogen, phosphorus and potassium. During 1980-2009, the use of crop rotations with a percent until 20% of row plants, which also included outside fields cultivated with perennial grasses, has determined the diminution in soil and mineral element losses by 36.5% and, respectively, 30.7%, as compared to 2-year crop rotation (wheat-maize). On 16% slope lands, the crop structure, which determined, during 1980-2009, the diminution in mean soil losses by erosion until 3.206 t/ha/year included 20 % straw cereals, 20% annual legumes, 20% row crops and 40 % perennial grasses and legumes.

During 1980-2009, on 16% slope fields, the increase from 20 to 40% of the percent of row crops (maize and sunflower) used in rotations determined the increase in mean annual losses of eroded soil by 47.5% (1.525 t/ha) and the use of crop rotations with 60% row crops resulted in the increase by 57.5% (1.843 t/ha) of the mean annual quantities of eroded soil. According to these results concerning the contribution of melioration plants to the diminution of soil and mineral element losses due to erosion, the technical elements were established for anti-erosion works, such as width of cultivated strips and of sod rewetting, crop structure, crop rotations and assortment of legumes and perennial grasses used on slope lands. This scientific information is a source of creating a database necessary to the elaboration of land improvement projects, to watershed setting up and grounding the methods of protecting soil and water resources. The crop rotation is also important under conditions of an intensive technology, being the main measure for soil protection, crop and efficient capitalization of all technological factors. 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). In clayey-loam Mollisol from Kanawha, the value of the organic carbon mass has increased from 33.3 to 37.3 g/kg soil, when using the rate of 270 kg/ha nitrogen against the unfertilized control, only in maize-oats-alfalfa-alfalfa rotation (Russell, 2006).

On 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 ensure better conditions for the valorisation of nitrogen fertilizers. 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. The mass of total carbon from cambic chernozem in the Moldavian Plain has registered significant increases at higher than $N_{160}P_{100}$ rates, in case of organic and mineral fertilization and in 4-year crop rotation, which included ameliorative plants of perennial grasses and legumes (*Table 5*). In maize continuous cropping and wheat-maize rotation, very significant values of the carbon content was found only in the organic and mineral fertilization, in 4-year crop rotation + reserve field, cultivated with perennial legumes and in $N_{160}P_{100}$ fertilization.

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

Treatment	*Mcc	WM	PWM	PWMSf+G	Average	Difference
N_0P_0	15.0	15.2	16.5	16.8	15.9	0
$N_{80}P_{60}$	15.5	14.8	16.9	17.1	16.1	0.1
$N_{120}P_{80}$	15.8	16.2	17.3	18.2	16.9	0.9
$N_{160}P_{100}$	16.8	17.0	18.5	19.7	18.0	1.9^{x}
$N_{80}P_{60}$+30 t/ha manure	19.0	19.0	20.1	21.4	19.9	3.9^{xxx}
Average	**16.4**	**16.4**	**17.9**	**18.6**	**17.3**	
Difference	0	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

In Cambic Chernozem, on the slope lands from the Moldavian Plain, a good supply in mobile phosphorus of field crops (37-46 mg/kg) was maintained in annual application of a rate of $N_{120}P_{80}$ and a very good supply (69-78) at the rate of $N_{80}P_{60}$+30 t/ha of manure, applied in crops from 3 or 4 -year crop rotations with perennial grasses and legumes (*Table 6*). After 42 years of testing, the lowest rate of mobile phosphorus accumulation in soil was recorded in wheat-maize rotation, and the highest one, in 3 and 4- year crop rotations, including annual and perennial legumes, which leave in soil easily degradable crop residues.

Table 6 - Influence of long-term fertilization and crop rotation on the content of mobile phosphorus from soil (P-AL, mg/kg)

Treatment	^{1}Mcc	WM	PWM	PWMSf+G	Average	Difference
N_0P_0	13	10	14	15	13.0	0
$N_{80}P_{60}$	29	26	35	40	32.5	19.5^{xxx}
$N_{120}P_{80}$	41	38	49	56	46.0	33.0^{xxx}
$N_{160}P_{100}$	58	52	63	69	60.5	47.5^{xxx}
$N_{80}P_{60}$+30 t/ha manure	67	58	69	78	68.0	55.0^{xxx}
Average	**41.6**	**36.8**	**46.0**	**51.6**	**44.0**	
Difference	0	-4.8^{0}	4.4^{x}	10.0^{xxx}		
	Rotation		Fertilizer		Interaction	
LSD 5%		3.8		3.3	4.3	mg/kg
LSD 1%		5.1		4.4	5.7	mg/kg
LSD 0.1%		6.7		5.8	7.5	mg/kg

CONCLUSIONS

Mean annual loss of soil by erosion, recorded during 1980-2009, was of 0.246 t/ha in perennial grasses in the second growth year, 4.519 t/ha in beans, 8.425 t/ha in maize and 8.976 t/ha in sunflower.

Erosion affects soil fertility by removing together with eroded soil, significant mineral element amounts, which in maize and sunflower crops reach 16.1 - 17.5 kg/ha nitrogen, 1.2 - 1.3 kg/ha phosphorus and 2.0-3.2 kg/ha potassium, representing, on the average, 12-14 % of the chemical fertilizers necessary for these crops.

On 16% slope fields, the use of soybean - wheat - maize rotation + two outside fields, cultivated with perennial grasses, determined the diminution by 63.3% (5.329 t/ha) in the mean annual losses of eroded soil and by 58.9% (9.506 kg/ha) in nitrogen leakages, compared with maize continuous cropping.

From the results obtained on erosion in different crop rotations, we have found that in 16% slope fields from the Moldavian Plateau, soil losses by erosion diminished below the allowable limit of 3-4 t/ha only in case of 3 or 4 year-crop rotations with two or three reserve fields, cultivated with legumes and perennial grasses, which protect soil.

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

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