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THE CHANGE OF PHYSICAL AND CHEMICAL CHARACTERISTICS IN CAMBIC CHERNOZEM, AS INFLUENCED BY SOIL EROSION, IN THE MOLDAVIAN PLAIN

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ABSTRACT *– The analyses carried out on soil profiles, at the beginning of testing period and after 36 years, on a 16% slope, with length of 310 m, have shown that on the entire slope length, soils had a very different fertility. Soils were influenced by erosion and silting processes. On weakly eroded land, the percentage of hydrostable aggregates was comprised, according to rates and type of applied fertilizers, between 38.9 and 53.6 %; on highly eroded land, the ratio of hydrostable aggregates has increased from 34.4 in unfertilized control to 52.0% at the fertilized variant with 40 t/ha manure. On eroded slope lands, poor in organic matter and nutritive elements, applying rates of 40 t/ha manure has determined yield increases in maize of 1835-2340 kg/ha, respectively, 45.9 – 58.5 kg grains/ t of manure, compared to unfertilized control. The combined use of mean rates ($N_{70}P_{70}$) of mineral fertilizers, together with 40 t/ha manure, has improved soil physical and chemical characteristics. Yield increases were of 3150 kg/ha in wheat and 3771 kg/ha in maize, compared to unfertilized variant.*

Key Words: cambic chernozem, erosion, fertilization

Rezumat - Modificarea unor însuşiri fizice şi chimice la cernoziomul cambic sub influența eroziunii solului, în Câmpia Moldovei. *Analizele efectuate pe profilurile de sol, la începutul perioadei de experimentare şi după 36 de ani, pe un teren cu panta de 16% şi lungimea versantului de 310 m, arată că pe întreaga lungime a versantului, solurile au fertilitate foarte diferită, fiind influențate de procese de eroziune şi colmatare. Pe terenul afectat de eroziune slabă, procentul de agregate hidrostabile a fost cuprins, în funcție de dozele şi tipul de îngrăşăminte aplicate, între 38,9 şi 53,6% iar pe terenul puternic erodat, proporția de agregate hidrostabile a crescut de la 34,4%, la martorul nefertilizat, la 52,0 la varianta*

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fertilizată cu 40 t/ha gunoi. Pe terenurile în pantă erodate, sărace în materie organică şi elemente nutritive, aplicarea unor doze de 40 t/ha gunoi a determinat obţinerea unor sporuri de producţie la porumb, faţă de martorul nefertilizat, de 1835-2340 kg/ha, respectiv 45,9 - 58,5 kg boabe pe tona de gunoi. Folosirea combinată a unor doze mijlocii ($N_{70}P_{70}$) de îngrăşăminte minerale, împreună cu 40 t/ha gunoi, a determinat îmbunătăţirea însuşirilor fizice şi chimice ale solului şi obţinerea unor sporuri de producţie, faţă de varianta nefertilizată, de 3150 kg/ha la grâu şi 3771 kg/ha la porumb.

Cuvinte cheie: cernoziom cambic, eroziune, fertilizare

INTRODUCTION

For increasing the efficiency of fertilizers and diminishing the losses of mineral elements, by leaching, runoff or elements fixing, the applied rates must be established differentiate according to soil characteristics, plant management, climatic conditions and demands of grown genotypes.

Applied fertilizer rates must complete the stock of mineral substances from soil to the level necessary for creation of good quality and economically efficient yields, under conditions of improving water and soil resources. Among the factors influencing yield and soil fertility, the fertilization and tillage systems have the greatest contribution to the improvement in the balance of soil nutritive elements. These elements change in time according to climatic conditions and technological factors.

Fertilizers contribute to yield increase and improvement in the quality of farming produce and, indirectly, to the augmentation of plant resistance to weeds, pests and pathogens. However, because of nitrate losses and ammonia emissions, maximum nitrogen rates were limited in certain areas to 150-170 kg/ha. Ammonia emissions in the centre of Europe vary between 10-15 kg/ha nitrogen, but also reach 40 kg/ha nitrogen, next to animal breeding farms (Johnston, Poulton, 2003).

Urea and ammonia sulphate fertilization causes NH_3 losses, by volatilization, when they are not incorporated in soil and are applied in vegetation on crops. N_2O produced by denitrification destroys the ozone layer, which protects against ultraviolet radiations. Phosphorus losses, by leaching, lower than 1 kg/ ha P, are not significant, but erosion losses determine water pollution (Tunney, 1995; Charles, 2001).

Applying fertilizers must be grounded on data of soil analyses from farms, and on those obtained in long-term stationary experimental devices with fertilizers. In case of farms, soil samples for analyses are not representative for the entire field (the nucleus sample is not made up of 16-25 individual samples). The effect of fertilizers on yield depends on many factors: soil characteristics and moisture, weeds, pests, pathogens, fertilizer type and mixture degree with soil explored by plant roots, which have a great importance to the determination of fertilizer rates (Goulding, 2000; Bruinsma, 2003; Fresco, 2003; Hera, 2005; Lixandru, 2006).

The effect of phosphorus and potassium fertilizers depends greatly on land preparation and soil structure, because the root system depends greatly on lower than 2 mm aggregate fractions, of which phosphorus and potassium are extracted. Therefore, when carrying out analyses, we must take into account the preparation of soil samples, which must be passed through 2 mm sieves. Increasing in the utilization efficiency of phosphorus and potassium fertilizers, and following the balance of these elements from soil, plant and environment, we must have in view soil structure, because economic and ecological efficiency depends on structural fractions, present at the exploration depth of root system. Once with yield intensification and extension of soil and environment degradation processes, the importance of preoccupations for the study of interactions between production and environment factors has also increased (Barrios, 1998; Norse, 2003).

MATERIALS AND METHODS

The results obtained in stationary experiments, which were set up in 1964, gave us the opportunity of carrying out analyses on the evolution tendencies of soil fertility, as influenced by climatic conditions and technological factors (soil tillage, fertilizers, pesticides, etc).

Experiments were situated on a 16% slope, according to the method of Latin rectangle, with split plots. They were carried out in two stages: 1964-1980 (Petrovici, 1971), when wheat-maize rotation was used. We have studied the influence of mineral fertilizers, manure and residues from these crops on yield and soil chemical characteristics.

The second period was 1980 – 2006, when the great experiments from the first stage were split, in order to investigate the influence of rotation and other fertilizer categories and crop residues (pea and soybean stalks) on yield, soil erosion and fertility. The experiments were located on the direction of contour lines and on the entire length of slope (at the bottom of slope with silted soil, at the lower third of weakly eroded slope, the mean third with moderate erosion, and at the upper third of highly eroded slope), in order to investigate the influence of erosion degree on soil fertility.

Bulk density and capillary and total water capacity of soil were determined on soil, sampled in natural sites, in metallic cylinders of 200 cm^3, both under moisture and dry condition, according to the method recommended by the National Research and Development Institute for Soil Science, Agrochemistry and Environment Protection of Bucharest (1980).

The analysis of distribution and water stability of structural macro-aggregates was done according to Tiulin-Ericson Method.

Chemical analyses were done according to the following methods: pH – potentiometrically, with combined electrode of glass and horn mercury, in watery suspension, at ratio between soil and water of /2.5; humus – by wet oxidation, according to Walkely-Black, modified by Gogoaşă; carbonates – by Scheibler gasovolumetric Method; total nitrogen by Kjeldahl Method, with disintegration with H_2SO_4 at 350^0 C, catalyst potassium sulphate and copper sulphate; mobile phosphorus – by extraction, in solution of ammonia lactate acetate (P-AL); mobile potassium – by extraction in solution of ammonia lactate acetate (P-AL), according to Egner-Riehm-Domingo Method and dosing by flame photometry.

The investigation methods used in field and laboratory are typical of each field: eco-soil science, soil microbiology, entomology, edaphic mesofauna. We have used tools, apparatus and software equipments from the laboratories of the Agricultural Research and Development Station of Podu-Iloaiei, University of Agricultural Sciences and Veterinary Medicine of Iaşi and National Research and Development Institute for Soil Science, Agrochemistry and Environment Protection of Bucharest.

RESULTS AND DISCUSSION

The analyses conducted on cambic chernozem soil, on which wheat-maize and pea-wheat-maize rotations were used for 42 years, have shown that these crop structures were not sufficient for erosion control and maintaining soil fertility. Analyses conducted on soil profiles, at the beginning of testing period and after 36 years, on a slope of 16% and the length of valley side of 310 m, demonstrated that on the entire length of valley side, soils had a very different fertility, being influenced by erosion and silting (*Tables 1, 2*).

Table 1

Influence of erosion on granulometric composition and total capacity of cationic exchange in cambic chernozem, on a 16% slope and a length of valley side of 310 m

Horizon	Depth cm	Granulometric composition, %				Sum of basic cations me/100 g soil (Sb)	Exchange capacity for hydrogen (SH) me/100 g soil	Total capacity of cation exchange (T) me/100 g soil	Base saturation degree (V%)
		Rough sand	Thin sand	Dust	Clay				
P. 1.Weakly eroded cambic chernozem situated at the lower third of slope									
Am	0-21	0.2	36.9	25.6	37.3	25.8	2.0	27.8	93
Am	21-61	0.1	30.9	29.6	39.4	28.5	0.6	29.1	98
A/B	61-78	0.1	35.3	29.1	35.5	27.4	1.0	28.4	96
Bv	78-115	0.2	38	26.4	35.4	24.1	0.5	24.6	98
C	115	0.1	38.9	30.6	30.4	-	-	-	-
P. 2. Meanly eroded cambic chernozem situated at the mean third of slope									
Am	0-20	0.3	32.2	30.7	36.7	27.1	0.5	27.6	98
Am	21- 47	0.2	32.4	31.3	36.1	26.4	0.0	26.4	100
A/B	48 - 60	0.2	27.5	28.8	43.5	29.4	-	29.4	100
Bv	60 - 93	0.2	33.3	27.9	38.6	26.4	-	26.4	100
C	93 - 150	0.2	40.1	27.3	32.1	-	-	-	-
P. 3. Highly eroded cambic chernozem situated at the upper third of slope									
Am	0 - 30	0.4	32.0	24.2	43.4	28.3	-	28.3	100
A/C	30 - 54	0.2	33.0	29.6	37.2	41.2	-	41.2	100
C1	54 - 95	0.2	38.2	28.4	33.1		-	-	-
C2	95 – 100	0.2	39.6	27.1	33.1	-	-	-	-
P 4. Highly eroded chernozem slope situated at the upper third of slope, in the critical erosion zone									
A/C	0 – 16	0.2	38.9	24.5	36.3	41.5	-	41.5	100
C1	16 – 41	0.2	38.0	25.3	36.4	-	-	-	-
C2	41 – 69	0.3	37.0	24.5	38.2	-	-	-	-

The 36 year - utilization of three year - rotation (legumes – wheat – maize), on 16-18% slope, has resulted in the diminution in humus content and base saturation degree, because of erosion processes. The diminution in base saturation degree was higher, if we consider that it was produced under conditions where sub-layers containing calcium carbonates reached the surface, because of erosion. Erosion determined the diminution in thin particles at soil surface and growth of rough fractions; therefore, soil structure and texture worsened (*Table 2*).

Table 2

Change of granulometric composition and total capacity of cation exchange on a 16% slope, as influenced by soil erosion and rotation grain legumes-wheat-maize

Horizon	Depth cm	Granulometric composition, %				Sum of basic cations me/100 g soil (Sb)	Exchange capacity for hydrogen (SH) me/100 g soil	Total capacity of cation exchange (T) me/100 g soil	Base saturation degree (V%)
		Rough sand	Thin sand	Dust	Clay				
P 1. Weakly eroded cambic chernozem situated at the lower third of slope									
Ap	0 - 20	0.1	29.2	29.8	37.4	24.7	2.1	26.8	92.2
Am	20 - 35	0.0	26.5	31.4	39.5	23.8	1.6	25.4	93.7
A/B	35 - 52	0.0	30.5	29.5	35.6	23.9	1.3	25.2	94.8
Bv	52 - 71	0.0	32.4	29.7	41.2	23.8	1.0	24.8	96.0
C	71	0.0	30.4	34.4	30.5	-	-	-	-
P 2. Meanly eroded cambic chernozem situated at the mean third of slope									
Am	0 - 16	0.3	33.1	29.5	37.1	25.4	1.5	26.9	94.4
A/B	16 - 36	0.2	29.7	31.1	39.0	25.0	1.2	26.2	95.4
Bv	36 - 62	0.2	32.4	28.4	39.0	26.4	0.9	27.3	96.7
C	62 - 80	0.3	32.5	27.3	39.9	27.6	0	27.6	100.0
P 3. Highly eroded cambic chernozem situated at the upper third of slope									
Am	0 - 15	0.5	34.5	24.1	40.9	26.8	0.8	27.6	97.1
A/B	15-29	0.4	34.6	28.4	36.6	32.1	0.4	32.5	98.8
Bv	29 - 40	0.3	38.4	27.1	34.2		-	-	-
C	40 - 62	0.2	39.7	26.5	33.6	-	-	-	-
P.4. Highly eroded cambic chernozem situated at the upper third of slope, in the critical erosion zone P_4									
A/C	0 – 16	0.6	38.6	24.1	36.7	38.7	0.2	38.9	99.5
C1	16 – 30	0.3	37.2	24.5	38.0	-	-	-	-
C2	30 – 60	0.2	36.4	24.2	39.2	-	-	-	-

Removal of upper layers, diminution in organic matter and change of structure and texture have favoured soil settling and diminution in water intake capacity and capillary water capacity of soil.

Many investigations have shown that humus stock from soil diminished by 10%, when A horizon was half eroded, and by 30%, when the entire A horizon was eroded.

Investigations, carried out under different climatic conditions, have shown that the use of crop rotations with legumes and perennial grasses determined a very good capitalization of fertilizers and contributed to the improvement of physical, chemical and biological characteristics of soil (Adams, 1984; Lixandru., 2006; Russell., 2006).

In the experiments conducted in 1954, by Russell A.E., at Kanawha, and at Nashua, in 1979, it was found that high nitrogen rate mineral fertilization has diminished cationic exchange capacity. At Nashuma, the content of exchangeable Mg diminished once with the increase in nitrogen rates (0, 90, 180, and 270 kg/ha) from 333 mg/kg soil to 325, 302, and 283 mg/kg.

On eroded slope lands with acid soils, in the center of Greece, which have a content of 15.2% clay, a pH of 5.0 and 1.8% organic matter, applying different organic materials contributed to the growth of wheat yield, of the content of organic matter and the improvement of soil reaction, in comparison with mineral fertilization with 160 kg N/ha + 80 kg P_2O_5/ha (Tsadilas, 2002; Sgouras, Tsadilas, 2007).

Table 3

Main agrochemical indices in cambic chernozem on which experiments were placed, with different rotations and fertilization systems, in 1970

Horizon	Depth cm	pH (H_2O)	Carbonates %	Humus %	N total %	P_2O_5 total %	P_{-AL} mobile ppm	K_{-AL} mobile ppm
P1 - Weakly eroded cambic chernozem situated at the lower third of slope								
Am	0-21	7.0	-	3.12	0.16	0.34	196	448
Am	21-61	7.2	-	2.83	0.16	0.39	196	448
A/B	61-78	7.5	-	1.87	-	0.21	196	448
Bv	78-115	7.5	-	1.20	-	-	196	448
C	115	8.6	9.7	0.82	-	-	113	448
P 2 - Meanly eroded cambic chernozem situated at the mean third of slope								
Am	0-20	6.8	-	2.6	0.14	0.16	28	191
Am	21- 47	7.1	-	2.3	0.13	0.15	7.4	165
A/B	48 - 60	7.2	-	1.9	-	-	7.0	138
Bv	60 - 93	7.4	-	1.7		-	11.3	120
C	93	8.5	9.7	0.7				
P 3 - Highly eroded cambic chernozem situated at the upper third of slope								
Am	0 - 30	7.9	0.5	2.2	0.12	0.11	21.5	149
A/C	30 - 54	8.1	1.0	1.4	0.08	0.11	8.1	93
C1	54 - 95	8.5	10.6	0.8	-	-	8.52	73
C2	95	8.6	10.6	0.6	-	-	8.52	57
P 4 - Highly eroded cambic chernozem situated at the upper third of slope, in the critical erosion zone								
A/C	0 - 16	8.4	4.0	1.9	0.1	0.1	15.7	133
C1	16 - 41	8.3	13.0	0.8	-	-	4.4	80
C2	41 - 69	8.5	11.0	0.6	-	-	4.4	80

The results on the evolution of humus and mineral elements content from soil, after 36 years of using the rotation grain legumes-wheat-maize, have shown that a good supply in mineral elements was found only at the bottom of the slope. On 2/3 of slope length, erosion has caused the diminution in humus content, from 0.04 to 0.34%, according to runoff (*Table 4*). At the same time with the increase in erosion process, the content of mobile potassium and phosphorus from soil diminished from 49 to 15 ppm P and, respectively, from 296 to 142 ppm K. These data have shown that on 16-18% slope lands, the use of three-year rotation, with crop mineral fertilization was not enough to maintain soil fertility under favourable limits.

In the critical erosion zone on valley side, once with the erosion of the horizon from soil surface, soil degradation processes intensified, even on chernozems, which were more resistant to erosion (*Table 4, Profile 4*).

Table 4

Change of main soil chemical characteristics on a 16% slope, as influenced by soil erosion and rotation grain legumes-wheat-maize

Horizon	Depth cm	pH, (H_2O)	Humus %	N total %	P $_{-AL}$ mobile ppm	K $_{-AL}$ mobile ppm
P 1 - Weakly eroded cambic chernozem situated at the lower third of slope						
Ap	0 - 20	6.8	2.98	0.158	49	296
Am	20 - 35	6.9	2.38	0.129	35	264
A/B	35 - 52	7.0	1.29	0.114	4	98
Bv	52 - 71	7.2				
P 2 - Meanly eroded cambic chernozem situated at the mean third of slope						
Am	0 - 16	6.4	2.56	0.146	33	182
A/B	16 - 36	7.3	1.72	0.124	7	132
Bv	36 - 62	7.6	0.8			
P 3 - Highly eroded cambic chernozem situated at the upper third of slope						
Am	0 - 15	7.2	2.18	0.138	26	158
A/B	15-29	7.4	2.06	0.129	5	124
Bv	29 - 40	7.6	0.8			
C	40 - 62					
P 4 - Highly eroded cambic chernozem situated at the upper third of slope, in the critical erosion zone						
A/C	0 – 16	7.4	1.76	0.124	15	142
C1	16 – 30	7.6	1.16	0.112	6	131
C2	30 – 59	8.2				

Determinations concerning the influence of chemical and organic fertilizers on eroded soil structure have shown that the rate of hydrostable aggregates on non-eroded land at the bottom of slope, after wheat harvesting, varied between 42.0 and 61.5%, according to applied fertilizers (*Table 5*).

Table 5

Influence of fertilization system and erosion on water stability of structural macro-aggregates

Fertilizer rate	Depth cm			Average
	0 - 10	10 - 20	20 - 30	0 - 30
Non-eroded soil at the bottom of slope				
Unfertilized control	40.2	42.5	43.2	42.0
$N_{70}P_{70}$	41.5	49.5	52.9	48.0
N_{140} P_{100}	39.7	49.8	51.6	47.0
20 t/ha manure	42.5	52.4	58.9	51.3
40 t/ha manure	54.2	64.2	66.1	61.5
20 t/ha manure + $N_{70}P_{70}$	43.8	49.5	54.2	49.2
40 t/ha manure + $N_{70}P_{70}$	44.6	63.4	63.8	57.3
Weakly eroded soil				
Unfertilized control	38,4	38,6	39,8	38,9
$N_{70}P_{70}$	39,4	48.6	49.8	45.9
N_{140} P_{100}	37.9	44.8	45.8	42.8
20 t/ha manure	42.3	46.8	47.8	45.6
40 t/ha manure	49.3	54.7	56.9	53.6
20 t/ha manure + $N_{70}P_{70}$	41.2	46.5	48.1	45.3
40 t/ha manure + $N_{70}P_{70}$	42.6	54.3	56.2	51.0
Moderately eroded soil				
Unfertilized control	29.6	37.4	36.2	34.4
$N_{70}P_{70}$	34.2	41.3	44.9	40.1
N_{140} P_{100}	34.7	36.2	44.7	38.5
20 t/ha manure	38.7	43.9	45.3	42.6
40 t/ha manure	47.6	52.3	56.1	52.0
20 t/ha manure + $N_{70}P_{70}$	37.5	44.8	54.2	45.5
40 t/ha manure + $N_{70}P_{70}$	42.5	47.5	48.3	46.1

On weakly eroded land, the rate of hydrostable aggregates was between 38.9 and 53.6%, according to rates and type of applied fertilizers. Fertilizer application resulted in increasing the rate of hydrostable aggregates, at the depth of 0-30 cm.

On highly eroded soil, the effect of fertilizers on the recovery of soil structure was obvious; the rate of hydrostable aggregates has increased from 34.4% in unfertilized control to 52.0 in the variant fertilized with 40 t/ha manure. Erosion has determined structure degradation, with negative impact on all the other physical, chemical and biological soil characteristics. In weakly and moderately eroded soils with the slope of 16%, the rate of hydrostable aggregates diminished by 9.2 and, respectively, 15.9%, compared to non-eroded soil at the bottom of slope (*Table 6*).

In wheat crop placed on weakly eroded lands, the high rate mineral fertilization (N140P100) resulted in getting yield increases of 173%, compared to unfertilized variant (*Table 7*). The fertilization of wheat crop with 40 t/ha manure

+ 70 kg N/ha + 80 kg P_2O_5/ha has determined yield increases of 174% on weakly eroded soils and 216% on highly eroded soils, compared to unfertilized variant.

Table 6

Percentage of hydrostable aggregates (0.25 mm, %) from arable slope lands with different erosion degrees

Treatment	Non-eroded soil at the bottom of slope	Weakly eroded soil at the middle of slope	Moderately eroded soil, in the upper third of slope
Unfertilized control	42.0	38.9	34.4
$N_{70}P_{70}$	48.0	45.9	40.1
N_{140} P_{100}	47.0	42.8	38.5
20 t/ha manure	51.3	45.6	42.6
40 t/ha manure	61.5	53.6	52.0
20 t/ha manure + $N_{70}P_{70}$	49.2	45.3	45.5
40 t/ha manure + $N_{70}P_{70}$	57.3	51.0	46.1
Mean	50.9	46.2	42.8

Table 7

Mean wheat and maize yields obtained on slope lands with different erosion degrees, during 1997-2006

Fertilizer rates	Wheat yield				Maize yield			
	Weakly eroded soil		Highly eroded soil		Weakly eroded soil		Highly eroded soil	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Unfertilized control	1806	100	1219	100	3227	100	2346	100
$N_{70}P_{70}$	3494	193	2650	217	5526	171	4241	181
N_{140} P_{100}	4922	273	3890	319	7089	220	5600	239
20 t/ha manure	2907	161	2320	190	4439	138	3464	148
40 t/ha manure	3671	203	2937	241	5567	173	4181	178
20 t/ha manure + $N_{70}P_{70}$	4391	243	3464	284	6543	203	5042	215
40 t/ha manure + $N_{70}P_{70}$	4956	274	3848	316	6998	217	5625	240
Mean	3735	100%	2904	77.8%	5627	100%	4357	77.4%
LSD 5%	310		300		340		320	
LSD 1%	420		410		460		440	
LSD 0.1%	550		560		610		590	

The mean yields obtained during 1997-2006 on 16% slope, in the area affected by high erosion, were lower by 22.2% (831 kg/ha) in wheat and by 22.6% (1270 kg/ha) in maize, compared to the lower third of slope (*Table 7*).

CONCLUSIONS

Applying nitrogen fertilizers has determined the diminution in the sum of bases (SB) and increase in hydrolytic acidity (Ah), resulting in slight decrease in base saturation degree.

The organo-mineral fertilization has determined the pH maintenance in the field of weakly acid to neuter reaction, both on weakly eroded and highly eroded soils (6.8-7.3).

Soil supply with mineral elements on slope lands depended on humus content from soil, which influenced soil structure and conditions of organic matter mineralization, as influenced by microorganisms, moisture, temperature and aeration.

On weakly eroded soil, the rate of hydrostable aggregates was, according to rates and type of fertilizers, between 38.9 and 53.6%, and on highly eroded land, the rate of hydrostable aggregates increased from 34.4% in unfertilized control to 52.0 in the fertilized variant with 40 t/ha manure.

On eroded slope lands, poor in organic matter and nutritive elements, applying rates of 40 t/ha manure resulted in getting yield increases in maize of 1835-2340 kg/ha, respectively 45.9 – 58.5 kg grains/ t of manure, in comparison with the unfertilized control.

The combined utilization of mean rates ($N_{70}P_{70}$) of mineral fertilizers with 40 t/ha manure has resulted in improving soil physical and chemical characteristics and getting yield increases of 3150 kg/ha in wheat and 3771 kg/ha in maize, compared to unfertilized variant.

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