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SOIL FERTILIZATION IN THE INTENSIFICATION OF LAND DEGRADATION PROCESSES FROM REPUBLIC OF MOLDOVA

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Abstract

There are provides three levels to ensure the agriculture with industrial fertilizers. The first level (minimum) is intended for a short period, until 2015 year. Application of chemical fertilizers in minimal doses ensures maximum recovery of additional production costs. The minimum fertilization system under land degradation conditions is effective both agronomic and economic. The second (moderate) is the average (approximately 2015-2020), pointing to conservation (stabilization) the effective soil fertility. The third level (optimal) provides increasing the soil fertility and obtains the high harvests and will be implemented after the 2020 year. The optimal system of fertilization meets the requirements of maintaining economic and environmental equilibrated balance of nutrients in the soil, stabilization and reproduction of soil fertility.

Key words**:** *organic and chemical fertilizers, fertilization norm, harvest, soil degradation, soil fertility*

INTRODUCTION

The current state of arable soil fertility in the intensification of the degradation processes in the last 30-40 years is unsatisfactory and on approximately 1/3 of agricultural land – critical [7]. The annual loss of uncompensated humus from agricultural land after its mineralization exceeding the 700 kg/ha and the total deficit, given the erosion losses is equal to 1100 kg/year. The main factors that conditioned the establishment of a negative balance of soil organic matter are: lack of crop rotation designed to conserve soil fertility, water erosion and using very small amounts of local organic fertilizer to fertilize the crops. In this scheme the nitric regime prevents expected harvests [5]. The content of mobile phosphates is low and approaches to natural level. In the absence of fertilizers, phosphorus system degrades gradually over 5-6 years will also become a limiting factor [3].
Failure to comply the crop rotations, reducing the amount of organic fertilizers 20-30 times, the minerals - 15-20 times, the share of perennial grasses 5-6 times led to the formation of a negative balance of humus and nutritive elements in soils and their biological degradation. Physical properties of soils determine to a large extent the level of fertility. Intensive use of agricultural land, extensive use of heavy machinery has led to worsening their quality [2].
It should be noted that in the actual conditions of soil degradation are farms with economic status that applying the moderate and optimal fertilization of main crops and obtaining adequate yields.

MATERIALS AND METHODS

When calculating the required in fertilizers have been used: statistics data in recent years, recommendations and regulations on the application of fertilizers to various crops, models of crop rotation recommended for pedoclimatic zones of Moldova.
There are calculated and provides three levels to ensure the agriculture with industrial fertilizers. The minimum level is intended for a short period, until 2015 year. Application of chemical fertilizers in minimal doses ensures maximum recovery of additional production costs. The minimum fertilization system under present conditions is effective both agronomic and economic. The moderate level

is the average for period 2015-2020, pointing to conservation the effective soil fertility. The optimal level provides increasing the soil fertility and obtains the high harvests and will be implemented after the 2020 year.

RESULTS AND DISCUSSIONS

Crop yield depends on the soil fertility and water supply conditions. In the generalized aspect the soil fertility is expressed in points (notes) of creditworthiness. Creditworthiness point is - 0.40 q/ha of winter wheat, 0.48 - maize, 0.23 - sunflower, 2.92 q/ha - sugar beet [1, 6]. Average note of creditworthiness of soil fertility in the Republic of Moldova is 63 points, which can achieve 25.6 q/ha of winter wheat, 30.7 q/ha - corn, 14.7 q/ha - sunflower. Average fertility at the administrative district level ranges from 78 to 48 note of creditworthiness. In these limits vary and yields of the main crops. Potential yield indices are close to the real ones obtained in recent years by reducing the quantities of fertilizers acute (Table 1).

Table 1. Forecast harvest of crops depending on creditworthiness note and rainfall amount

Crops	Harvest (q/ha) depending on		Difference, q/ha
	amount of precipitation	note of credit-worthiness	
North Zone: annual of rainfall, 584 mm; average note of creditworthiness - 68			
Winter wheat	48,9	27,2	21,7
Corn for grain	62,6	32,6	30,0
Sunflower	30,1	15,6	14,5
Sugar beet	367	198	169
Central Zone: annual of rainfall, 568 mm; average note of creditworthiness - 59			
Winter wheat	44,1	23,6	20,5
Corn for grain	56,5	28,3	28,2
Sunflower	27,2	13,6	13,6
Sugar beet	332	172	160
South Zone: annual of rainfall, 517 mm; average note of creditworthiness - 57			
Winter wheat	37,8	23,6	14,2
Corn for grain	48,4	28,3	20,1
Sunflower	23,3	13,6	97

Potential yields can be calculated after providing the plants with water. Coefficients of productive use of rainfall by the plants consist: in the North - 0.8, at the Center - 0.7, in the South - 0.6, from annual quantity of rainfall. The amount of water to form 1 q of the base production forms: winter wheat – 82 tons, corn – 64 tons, sunflower – 133 tons, sugar beet - 10.9 tons. According to these estimates the yields calculated by the water supply to major crops are almost 2 times higher than those caused by natural soil fertility indices [2, 3].

This shows that in the first minimum are the soil nutrient regimes, in particular the nitrogen and phosphorus. In order to obtain an increase of yields of 40-50% is required to compensate for the deficiency of nutrients through the use of fertilizers.

The minimum requirement of fertilizers application involves using only the minimum dosage of fertilizers for the main crops. It provides for the administration of the seed (the starter) of phosphorus fertilizers in doses of P_{10-20}. This process ensures a high efficiency (2-3 times) of fertilizers than by scattering. Dose of phosphorus (P_{45}) is set to vegetable crops and potatoes [1]. The use of fertilizers to these cultures ensures a high economic effect (Table 2).

Table 2. Minimum doses of mineral fertilizers for fertilizing the main crops, kg/ha, in active substance

Crops	Recommended dose			Remark
	N	P205	K20	
Winter wheat	45	20*		* *with the seeding*
Winter barley	35	10*		-*-
Spring Barley	35	10*		-*-
Maize for grains	45	10*		-*-
Sugar beet	45	20*		-*-
Sun flower	35	20*		-*-
Tobacco	15	30	30	with water at planting
Potatoes	35	45	45	-
Vegetables	45	45	45	-
Vines in bearing	30	30	30	once in 3 years
New vineyards (foundation)	-	400	400	at the unclog
New orchards (foundation)	-	400	400	at the unclog

The minimum doses (N_{35-45}) of nitrogen fertilizers are recommended to apply once as supplementary nutrition to the main crops. Potassium fertilizers are recommended only for cultures that use much potassium as vegetables, potatoes, orchards and vineyards.

According to the norms the recommended doses increase the harvest of winter wheat, barley and maize with 4-6 q/ha, sugar beet - 60-80 q/ha [1, 8].

Minimum necessary for field crops, potatoes and vegetables in the nitrogen fertilizers makes up 58.2 thousand tons in active substance. Minimum requirements for field crops in the phosphorus fertilizer reach 25 thousand tons of P_20_5 per year. This will create about 15 kg P_20_5 per average 1 ha of arable land. The indicated quantity of fertilizers will not be sufficient to achieve a neutral phosphorus balance in agriculture, but will allow to return the level of 1966-1970 years, when per 1 ha was applied $P_{15,8}$. Annual minimum requirement of potassium fertilizers for potatoes, vegetables, tobacco until 2010 year constituted 5.7 thousand tons of K_20. During this period, potassium fertilizers have not been applied to other crops, ignoring the risk of reducing the yield and soil fertility [8].

The optimal requirement of fertilizers application is designed for a higher level of agriculture (optimized crop rotation, soil conservation work, integrated plant protection, irrigation expansion, development of animal husbandry, modern technologies of plant cultivation). This system relies on associated applying organic local and industrial fertilizers, with fuller account use of the biological nitrogen. Optimal dose of fertilizer to fertilize main crops are presented in Table 3.

Table 3. Optimal doses of mineral fertilizers for fertilizing the main crops, kg/ha, in active substance

Crops	Recommended dose			Remark
	N	P_20_5	K_20	
Winter wheat	80	60	40	annual
Winter barley	34	60	0	-*-
Spring Barley	34	60	0	-*-
Maize for grains	60	50	0	-*-
Peas bean	30	20	0	-*-
Sugar beet	105	80	40	-*-
Sun flower	45	40	40	-*-
Tobacco	35	40	40	-*-
Potatoes	60	60	60	-*-
Vegetables	90	60	60	-*-
Corn for silage	40	40	0	-*-
Vines in bearing	60	60	60	once in 3 years
Orchards in bearing	60	60	60	-*-
New vineyards (foundation)	-	400	400	at the unclog
New orchards (foundation)	-	400	400	-*-

The doses are equilibrated with insurance moisture conditions, soil fertility and country economy. Recommended doses are directed towards achieving maximum profit on a unit of agricultural land.

In the typical cropping of the north zone the recommended dose of nitrogen for winter wheat is N_{90}. Sugar beet has two versions of the manure application. When using manure (50 t/ha) is recommended supplementary fertilization with mineral nitrogen N_{60}. In the absence of manure the mineral nitrogen dose increases to N_{105} (basic fertilization - N_{45} and extra fertilization - N_{60}). The doses of phosphorus fertilizer ranging: from P_{20} (in the row) for vetch and peas to P_{80} for sugar beet. Priority is given to local use of phosphorus fertilizer (the starter). Potassium fertilizers in moderate doses K_{40} are recommended for sugar beet, winter wheat, tobacco and sunflower. Annual average dose in the crop rotation consists - $N_{61}P_{50}K_{20}$. According to the regulations indicated doses increase winter wheat yield by 11.8 q/ha, corn - 9.3, sunflower - 3.8, beet sugar - to 98 q/ha.

In the Central and South zones, where in the soil cover predominant ordinary and carbonate chernozems the recommended doses of 1 ha of crop rotation corresponding to $N_{54}P_{45}K_{18}$ and $N_{47}P_{43}K_{18}$ [1, 8].

Introduction of crop rotations with leguminous crops report will allow increasing soil nitrogen reserves by 30-35 kg per year on the 1 ha of sown area from biological nitrogen account. Manure provides additional 20-25 kg/ha of nitrogen. Contribution to the formation of available soil nitrogen reserves in the country on average makes up 70-75 kg/ha. Average dose of nitrogen fertilizers recommended in agriculture is 54 kg/ha. From this dose crops used from 27 to 30 kg. Annual reserves of plant available nitrogen from all sources will be 135-140 kg/ha, the enough quantity to obtain the harvest 40-42 q/ha of winter wheat, 58 q/ha of maize, 310 q/ha - sugar beet [1].

The average dose of K_{19} fertilizer will be sufficient to stabilize the potassium content in the soils. Potassium loss compensation will be covered, mainly on account of local organic sources of fertilizers.

The optimum requirement in the industrial nitrogen fertilizer for field crops after 2020 year will consist 82.3 thousand tons of active substance or an average of 1 ha N_{55}. For potatoes and vegetable crops cultivation will require 6.8 thousand tons N, the average dose to 1 ha – N_{60}. For fertilization of fruitful orchards will require 2 thousand tons of mineral nitrogen, for fruitful vines – 1.5 thousand tons. The phosphorus fertilizer required will be 69.9 thousand tones of field crops, vegetables and potatoes – 9 tons, fruitful vineyards – 1.5 tons, fruitful orchards - 2.0 tons. The annual necessary of potassium fertilizers will be 28.3 thousand tones for field crops, 6.8 thousand tons for vegetables and potatoes, extra fertilization - 3.1 thousand tons for irrigated land (Table 4).

Table 4. The annual industrial fertilizers for optimum crop fertilization in the 2016-2020, total tons of active substance

Branch, culture	Nitrogen, N	Phosphor, P205	Potassium, K20
Crops in rotation	82,3	69,9	28,4
Potatoes	6,8	9,0	6,8
Fruitful vineyards	1,5	1,5	1,5
Fruitful orchards	2,0	2,0	2,0
New vineyards	0	2,1	2,1
New orchards	0	1,0	1,0
Extra for irrigation land	6,3	4,6	3,1
Other crops	1,0	1,0	1,0
Total for Moldova	99,9	91,1	45,9

Annual total requirement of fertilizers for agriculture of Moldova after 2020 year will be 236.7 thousand tones in active substance, including 99.9 thousand tones of nitrogen, 91 thousand tons of phosphorus and 45.8 thousand tons of potassium.

The moderate necessary of fertilizer application in agriculture will cover the period of transition from minimal to optimal system (2010-2020). To argumentation the requirement of fertilizer for this period is needs to take into account the following considerations:

- The field crops, potatoes, vegetables are fertilized with medium dose of optimum and minimum system.
- The area of fruitful orchards of 100 thousand ha will be fertilized with dose $N_{30}P_{30}K_{30}$ every 3 years.
- Surfaces of fruitful vineyards in the period 2013-2015 will be about 64.4 thousand ha, including 2.1 thousand ha in North, 33.3 thousand ha in the Centre and 29 thousand ha in the South zone. For their fertilization is provided the moderate dose $N_{45}P_{45}K_{45}$, every 3 years.
-When cleaning the ground for the establishment of vineyards (35 thousand ha) will be applied $P_{400}K_{400}$ fertilizer, the annual dose will be 2.8 thousand of P_20_5 and K_20.
- For basic fertilization of the new orchards planned on the area of 2500 ha per year will be needed by 1000 tones of P_20_5 and K_20 ($P_{400}K_{400}$).

Total needs of the agricultural sector of Moldova in the fertilizers for the period 2013-2020 will compose 191 thousand tons in the active substance, including 83.2 thousand tons of nitrogen, 65.3 thousand tons of phosphorus, 42.5 thousand tons of potassium (Table 5).

Table 5. The annual requirement of industrial fertilizers during 2010-2020 period, tons of active substance

Crops	Nitrogen, N	Phosphor, P205	Potassium, K20	Total NPK
Field crops	67,3	44,9	26,9	139,1
Potatoes and vegetable	5,6	7,0	5,8	18,4
Fruitful vineyards	1,0	1,0	1,0	3,0
Fruitful orchards	1,5	1,0	1,0	3,5
New vines	0	2,8	2,8	5,6
New orchards	0	1,0	1,0	2,0
Extra irrigation	7,87	7,1	3,5	18,4
Other crops	0,5	0,5	0,5	1,5
Total	83,2	65,3	42,5	191,0

Microfertilizer requirements are determined by the degree of assurance of soil in micronutrients and plant physiological peculiarities.

The following necessary and procedures are developed for the implementation of microfertilizers: seed and leaf treatment processing and base incorporation to soil tillage (Table 6 and 7).

At the basic tillage is using the complex fertilizers: zinc ammophos ($N_{12}P_{53-54}Zn_{0,6-0,8}$); manganese ammophos ($N_{16}P_{16}K_{17}Mn_{1,8}$); boron ammophos ($N_{17}P_{17}K_{16}B_{0,18}$); double superphosphate boron ($B_{1,5}$); molybdenum superphosphate ($Mo_{0,1-0,2}$), [2, 3].

For seed and foliar treatment processing the micro fertilizers are used in the form of salts:

$CuSO_4 \cdot 5H_20$ ($Cu_{25,5}$), $Zn\ SO_4 \cdot 7H_20$ (Zn_{25}), H_3BO_3 ($B_{98,5}$), $Na_2B_4O_7 \cdot 10\ H_20$ ($B_{11,3}$), $(NH_4)_2MoO_4$ and helats.

Table 6. Guide for the application of micro doses of fertilizers to different crops

Crop group	Trace element	Application dose:		
		seed processing, g/t of seeds	Extra nutrition, g/ha	the basic tillage, kg/ha
Cereal	B	30-80	100-150	1-3
Technical		80-130	150-200	3-6
Cereal	Mn	100-150	150-200	3-5
Technical		150-200	200-250	5-8
Cereal	Cu	30-50	500-800	1-3
Technical		50-100	300-500	3-5
Cereal	Mo	300-600	600-900	3-6
Cereal	Zn	300-500	500-1000	3-5
Technical		300-600	300-600	0,5-1,0

Table 7. Micronutrients required for the formation of primary production in the cultivation of field crops in Moldova, g/t

Crops	Trace element quantity					
	B	Mn	Cu	Mo	Zn	Co
Winter wheat	4,0	22,4	7,2	1,8	22,4	0,39
Maize for grain	5,4	42,4	5,4	1,0	17,0	0,40
Sun flower	66,3	24,8	3,8	1,0	30,4	0,68
Sugar beet	30,1	80,9	14,7	0,20	48,2	0,22

Balance of nutrients (NPK) in soils was calculated based on the soil fertilization system: minimal and optimal for North, Central and South areas. The minimum system of fertilization, with average dose in crop rotation $N_{30}P_{20}K_{15}$ kg/ha, provides a negative balance 36-38 kg/ha of nitrogen, 27-34 kg/ha of phosphorus and a negative deep balance of potassium.

Optimal fertilization system in the North zone with an average dose of 5 t/ha manure and $N_{61}P_{50}K_{20}$ ensures not only high productivity of crops, but also an almost equilibrated balance of nitrogen, positive of phosphorus (+18-19) kg/ha and negative of potassium.

In the Center the optimum fertilization system (4 t/ha manure and $N_{54}P_{45}K_{18}$ kg/ha in average per rotation), provides easy deficit balance of 26 kg/ha of nitrogen, positive (+15 kg/ha) of phosphorus and negative of potassium.

In the South to the application of 4 t/ha of manure and $N_{47}P_{43}K_{18}$ it is ensure a equilibrated balance of nitrogen (minus 10 kg/ha), and phosphorus (+4 kg/ha) and a negative balance of potassium [4, 8].

Thus, the optimal system of fertilization meets the requirements of maintaining economic and environmental equilibrated balance of nutrients in the soil, stabilization and reproduction of soil fertility.

Basic principles of the strategy to combat land degradation

The first principle is to identify problems, causes and solutions to scheduling actions needed by the cadastre, and monitoring the quality of the soil cover. The state must provide objective data to landowners on the quality status of soils parcels of privatized farms, communes. This information is required for the actions of protection, improvement and sustainable use of land through appropriate projects, the correct determination of the amount of land tax, legal traffic operations, land transactions of sale, lease, inheritance etc. The realization of this principle is possible on the improvement of the national system of pedological and agrochemical researches, detailed cartography on large scale and cyclical performance of this research across the entire land.

The second principle of the strategy, based on the information system of cadastre and land monitoring and other research, is the use of land in accordance with the concept of "ecological limits of the territory", which characterizes the limit renovation of natural resources is achieved through norms and standards adopted by law. Prerequisite - restoring the economic injury caused by the degradation of soil quality and other natural resources.

Standards and "ecological limits" established criteria that take into account spatial ecological balance, protection, improvement and sustainable use of soil, providing agricultural and forestry activities, guaranteeing their sustainability and socio-economic stability in the long term.

The third basic principle of the strategy to combat land degradation and increasing their fertility throughout the country: to implement a sustainable agricultural system. The basic objectives of sustainable agriculture are the conservation of natural resources, primarily soil fertility, plant - animal adaptation system to the environment and maintaining a high level of long-term productivity.

Implementation of measures to prevent and combat soil degradation is only possible under the patronage of the state and for the active participation of the population. Measures designed to increase soil fertility requires large investment allocation of the state, businesses and organizations dealing with issues of environment protection and sustainable development. However these measures are actions performed in the spatial organization and at the household, community, and county. In order to fulfill their need to perform pedological researches and drafted the corresponding soil projects.

CONCLUSIONS

Socio-economic development of the Republic of Moldova is possible only through long-term maintenance of agricultural and forestry production capacity of soils towards preventing and combating degradation processes. The magnitude of the current crisis in agricultural production and its interaction with macroeconomic processes requires an integrated approach to protection, moderate and sustainable land use.

In the transition conditions from driven centralized economy to the market economy, the objectives of protection, improving and sustainable use of soil cover can be made to the extent that the state will provide the necessary support for the integration of agricultural policy within a national policy for the protection of soil resources based on ecological principles. To manage land resources it is necessary to implement a permanent legal, institutional and economic mechanism to regulation of land relations. Only thus profitability of agriculture will reach a sufficient level to expand the production of agricultural products and increasing the soil fertility.

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