Economic and environmental efficiency of fertilizers use for enhance the fertility of degraded soils in the Republic of Moldova

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ECONOMIC AND ENVIRONMENTAL EFFICIENCY OF FERTILIZERS USE FOR ENHANCE THE FERTILITY OF DEGRADED SOILS IN THE REPUBLIC OF MOLDOVA

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Abstract. *In recent decades, high fertility of soils in the Republic of Moldova are subjected to more intensive accelerated degradation due to anthropogenic activity. Situation created causing further intensive development of land desertification processes and leads to worsening of the ecological situation in the country. There are currently affected by degradation processes of different intensity 56.4 percent of agricultural land. One measure provides for local sources of organic fertilizers, along with the minerals. Agronomic, economic and ecological efficiency of fertilizers use in the agriculture of Moldova found that application of fertilizers has positive effects on soil fertility along with other measures to restore degraded soils.*

Key words: *economic efficiency, organic fertilizers, degraded soils, soil fertility*

INTRODUCTION

The current state of arable soil fertility in the intensification of the degradation processes is the worst in the last 30-40 years. 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 [5]. 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.

The current state of the actual fertility of the soil is unsatisfactory, and on approximately 10% of agricultural land - critical. In this scheme the nitric regime prevents expected harvests. 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 [6].

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 determines to a large extent the level of fertility. Intensive use of agricultural land, extensive use of heavy machinery have led to worsening their quality.

The aim of this research consists in assessing the effectiveness of fertilizers on arable soil to restoring their degraded properties and fertility.

MATERIAL AND METHODS

Agronomic effect was determined based on performance norms and technical recommendation of chemical and organic fertilizers in agriculture. Economic evaluation systems have undergone minimal and optimal fertilization of soils. Environmental assessment is a general aspect of the action of fertilizers on the environment. All measures agro-technical, agro-chemical and agro-biological are developed and aimed at ensuring the closed circuit of nutritive elements, especially nitrogen. Stabilization of organic matter in the soil can be ensured only by returning crop production, ancillary use manure, different organic composts, by increasing the share of perennial grasses in crop rotations.

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RESULTS AND DISCUSSIONS

One of the measures to improve the fertility of arable soils is necessary to use all local resources of organic matter and nutrients, while and industrial fertilizers.

Local sources of organic matter and substances necessary for plant nutrition are plant debris left on the ground after harvest, organic fertilizers, livestock, various organogenic waste from processing industry of agricultural raw materials, urban household, etc. Plant debris that not removed from cultivated land (stubble and plant roots) return to soil only half of humus consumed by harvests and only partially of the nutrients used by plants. Completing an essential source of organic matter in soil is ancillary plant production. On irrigated soils as a source of accumulation of crop residues can serve intercropping (crop stubble).

Waste from livestock are the most important and widespread local source of organic matter and nutrients to restore the soil fertility and increase crop productivity. The content of organic matter and nutrients in livestock waste is summarily 6-7 million tons per year.

In order to protect the environment is necessary to apply the waste from manufacturing and urban household as fertilizers, including sludge from wastewater treatment, household waste, defecation sludge from sugar factories.

A significant potential source for restoring productivity and less productive soils are delluvial (cumulic) soils, which occupy 100 thousand ha. Suitability of delluvial soils as fertilizers are judged by the content of humus, phosphorus, potassium, trace elements, etc. The nutrient rich delluvial soils can be used to improve fertility of heavily eroded soils by adding land.

The country has over 3500 artificial water storage tanks, of which about 1200 are excessive siltation or damaged. Recent research conducted by the Institute for Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo" showed that sludge lake, in most cases, have a thickness of 2.5-3.5 m, contain from 2.5 to 5.5% of humus, and are more rich in mobile forms of phosphorus than soils affected by erosion, often surpassing in this respect and the whole soil profile. The most effective way of using sludge lake is mixing with organic waste. Rich mud is recommended for use by stripping soils with low productivity [1, 3].

The livestock wastewater containing a large amounts of nutrients, especially potassium and nitrogen in available forms to plants. Their application for crop fertilization requires a complex test to avoid the pollution of soil and agricultural production with harmful substances.

Mineral fertilizers. Current natural fertility of soils allows obtaining only 25.6 q/ha of winter wheat, 30.7 q/ha of maize, 14.7 q/ha of sunflower. According to regulations, the application of fertilizer in optimal dose contributes to increase yields to 35-45% [4].

The optimal system of fertilizer application is intended for higher agriculture (optimized crop rotation, soil conservation work, integrated plant protection, irrigation expansion, development of animal husbandry, modern technologies of plant cultivation). It is based on the associated application of organic fertilizers and minerals, the wider use of biological nitrogen. Optimal dose of fertilizers to fertilize main crops are geared towards achieving maximum profit on a unit of land.

The annual necessary of total fertilizers for agriculture of Moldova during 2010-2020 years and after 2020 year will be 236.7 thousand of active substances [2], including 99.9 thousand of nitrogen, 91.0 thousand of phosphorus and 45.8 thousand of potassium (table 1).

Table 1.

The annual necessary of mineral fertilizers for optimal fertilization of crops in the years 2010-2020, thousand tons of active substances

Branch, culture	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_20)	Total NPK
Rotation crops	82,3	69,9	28,4	180,6
Vegetables and potatoes	6,8	9,0	6,8	22,6
Vineyards fruitful	1,5	1,5	1,5	4,5
Orchards fruitful	2,0	2,0	2,0	6,0
New vineyards	0	2,1	2,1	4,2

Branch, culture	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_20)	Total NPK
New orchards	0	1,0	1,0	2,0
Irrigated land	6,3	4,6	3,1	14,0
Other crops	1,0	1,0	1,0	3,0
Total	99,9	91,1	45,9	236,9

Effective use of organic and industrial fertilizers issues was determined agronomical, economical and environmental.

Agronomic efficiency was determined on the base of norms and regulations on the use of mineral and organic fertilizers in agriculture [6-8]. As shown in Table 2 the increase harvest from application of 1 kg NPK are: 5.2 kg of winter wheat, 5.8 kg of maize grain, 2.9 kg of sunflower seed, 38.0 kg for sugar beet roots. Systematic use of fertilizers in crop rotations in different field soils increased crop yields. The minimum system of fertilizer application growth the rate harvest for cereal crops is 8-13%, 11 to 16% for industrial crops, 18 to 28% for potatoes and vegetable crops.

Table 2.

Normative regarding mineral fertilizers efficiency in Republic of Moldova

Crops	Dose of fertilizers, kg/ha a.s.				Yield of the NPK, q/ha	Growth yields of NPK, q/ha	Growth yields of 1 kg NPK, kg
	total	inclusive					
		N	P_20_5	K_20			
Winter wheat without irrigation	228	96	74	58	37,3	11,8	5,2
Winter wheat with irrigation	212	103	80	29	51,9	13,9	6,3
maize silage	209	90	80	39	317	97	46,4
Perennial grasses with irrigation	230	30	120	80	102,9	50,2	21,5
Fruit trees without irrigation	238	80	79	79	241	61	25,6
Green peas with irrigation	208	90	84	34	146	43	20,7
Potatoes without irrigation	236	77	77	82	123	28	11,9
Potatoes with irrigation	247	92	99	56	200	88	35,6
Legumes	280	113	110	57	425	191	68,2
Sunflower	180	60	61	59	20,2	5,2	2,9
Tobaccos	240	60	94	86	25,9	8,4	3,5
Winter barley	180	60	60	60	33,4	10,7	5,9
Spring Barley	180	60	60	60	32,1	9,7	5,4
Maize	240	112	70	58	54,0	14,0	5,8
Maize by irrigation	270	134	76	60	78,6	22,2	8,2
Peas	112	22	57	33	21,9	3,9	3,5
Sugar beet without irrigation	359	131	124	104	348	138	38,0
Vineyards without irrigation	222	62	75	85	126	23	10,4

Implementation of the optimal system of mineral fertilization leads to higher grain yields by 23-26%, 23-42% - technical, 23-37% - vegetables and potatoes. Soil fertilization ensures an optimal dose increase the production of winter wheat 348 thousand tons, maize – 275 thousand tons, sunflower - 62 thousand tons, sugar beet – 548 thousand tons [6, 7].

Economic efficiency. Economic evaluation systems have undergone minimal and optimal fertilization system. The first phase is proposed fertilization of crops in minimal doses (NPK-60 kg/ha) on an area of 1 million 524 thousand ha. To purchase fertilizers would be needed annually about 633 million MDL (lei). Every dollar invested will recover 2.33 MDL and total net gain obtained harvest will be about 840 million MDL annually.

Through a very high economic efficiency will highlight: vegetables, potatoes, tobacco and vines. The lowest recorded yield is for sunflowers. From the economic analysis results, the fertilization of agricultural crops even in minimal doses is rentable (averaging 132% for the total agricultural area).

Optimal fertilization is expected to be applied after 2020 year on the 1 million 671 thousand ha. Fertilizer costs will be about 1 billion 374 million lei and total net income of the entire area is estimated at 1 billion 280 million MDL annually. Every MDL invested will be recovered by 1.95 MDL. Profitability of fertilizer use in recommended doses will be comparatively low (95%) than the minimum system, but rather high economic level. Vegetables, potatoes and vines in this system will have a very high efficiency. Profitability of winter wheat is 39%, corn - 26%, and sugar beet - 81%. Other crops will have a relatively low yield.

In the irrigation condition is programmed to fertilize with optimum dose the 93.5 thousand ha annually. It will fertilize winter wheat, maize, potatoes and vegetables. Fertilizers cost will be 142 million MDL annually. Recovery of costs for fertilizers with the cost of crop growth is high - 5.51 MDL. Annual net income from 1 ha will reach 6848 lei, and the entire area fertilized - 640 million lei. Profitability consists 451% and is within the range obtained in the intensive chemicalization period on the irrigated lands [8].

Economic and agronomic evaluation of proposed fertilization systems in different national programs developed and approved, allows to forecast a high economic efficiency of application of mineral fertilizers in agriculture of Moldova. Investing in buying and applying fertilizers is estimated at about 630 million to 1 billion 500 million MDL annualy for the minimum and optimum system properly. Annual net income that will create about 840 million to 1 billion 750 million lei. Every lei invested will recover by 1.9 to 2.3 additional agricultural production. Global agricultural output will increase by approximately 30-35% compared to the current one.

Environmental effectiveness. Forming a equilibrated or positive balance of nutrients reduces chemical degradation processes of soil and humus decreases by 20-30%.

Irrational use of chemical fertilizers in agriculture and their application in large doses is necessarily accompanied by negative consequences on the environment. They relate to soil, plant and water sources with chemicals. The main chemical pollution are nitrogen compounds, in decreasing order, chlorine, fluoride, heavy metals, etc. The general requirements to control and environmental protection are set out in the standards and norms which is required to meet.

All measures agro-technical, agro-chemical and agro-biological are geared towards ensuring closed circuit of nutritive elements and especially nitrogen, which has a very high mobility. Stabilization of organic matter in the soil can be ensured only by returning the full volume of production auxiliary, manure use, different organic composts and last but not least, perennial grasses in crop rotation rate hike. Stabilization or increasing the humus content in the soils contributes to the accumulation of nitrogen in organic form inorganic compounds account.

Every chemical fertilizer has its own environmental specific. Phosphate fertilizers are the most harmless. Their systematic application does not lead to migration of phosphates in the soil profile or groundwater pollution. Potassium compounds also are characterized by limited mobility. However, the main fertilizer potassium (KCI) contains about half of chloride ions. Chlorides easily washed, polluting the soil profile and groundwaters. To prevent environmental pollution with chlorine components is proposed to use the local maximum and minimum quantities of fertilizers chemical ones. When using chemical fertilizers priority must be complex fertilizers, in which potassium continues without concern for environmental pollution.

The biggest danger to the environment and human health posed nitrogen fertilizers. Given these fertilizers harm for the environment, mineral nitrogen doses recommended for use in agriculture of Moldova are 1.5-2 times lower as in countries with developed agriculture.

Minimal and moderate doses of nitrogen fertilizers applied in accordance with the recommendations in force and their phasial incorporation in 2-3 reprises not lead to environmental pollution and agricultural production by nitrates. Currently the focus is on maximizing the use of biological nitrogen (soil incorporation of crop residues and local fertilizers and use of atmospheric nitrogen by leguminous crops). The share of mineral nitrogen leached from soil root layer is 10-15%. To assess the degree of pollution of the soil with nutrients, development the forecast of measures to reduce environmental pollution by harmful substances necessary to perform agrochemical monitoring by soil agrochemical mapping of all agricultural land once in 10 years and the annual operational mapping on the stationary polygons in each area.

Minimum, moderate and optimal doses of fertilizers proposed for application in Moldovan agriculture poses no danger to the environment. It should be noted in the currently conditions are farms that after economic status applying the moderate and optimal fertilization of the main crops obtaining adequate yields.

Balanced ecological functioning of agro ecosystems under irrigation is entirely determined by the interaction of natural and anthropogenic factors. The main anthropogenic factors with negative implications on the environment and irrigation facilities in neighboring areas are:

- Large application of the irrigation rules and creating irrigational percolation regime;
- Excessive agricultural traffic aggregates and machines, and secondary soil compaction;
- Irrigational erosion;
- Reduced rate or the lack of perennial grasses in irrigated crop rotation;
- Applying minimal amounts of organic fertilizers and crop residues;
- Use of water with unsatisfactory quality indices.

In the Republic of Moldova a major threat to one of the main components of the environment - soil, presents the use of the water with high mineralization. Based on the criteria for assessing the quality of surface waters was found that only trans-boundary sources (Danube, Dniester, Prut) can be used without danger of soil degradation. Inland rivers are characterized by satisfactory qualitative indices, predominantly in the upper sector. Also, do not meet the use require water in most reservoirs (65%).

The use in irrigation, in particular the local water with a high degree of mineralization and alkalinity causing negative changes, often irreversible, of the soil characteristics. This is manifested by salinization and secondary alkalization, crust irrigation or compacted horizon, structure degradation and lacunar space reduction.

To prevent degradation of irrigated soils, especially chernozems is necessary:

- Application of complementary irrigation;
- Minimizing traffic through the combination of farming;
- Increase the share of perennial grasses to 20-25%;
- Management of organic fertilizer in an amount of 10 to 12 t/ha per year;
- Water quality testing especially at the local irrigation;
- Performance monitoring soil quality status in the irrigation facilities.

Implementation of measures will ensure the prevention of the degradation of irrigated soil, planned harvests and environmental protection.

CONCLUSIONS

Socio-economic development of the Republic of Moldova is possible only through long-term maintenance of agricultural production capacity of soils and forestry 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, balanced and sustainable land use.

Economic efficiency of fertilizers and nutrient balance was calculated based on soil fertilization system: minimal and optimal for North, Central and South zones of Moldova. The fertilizer minimum system, with average dose in 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 deep negative balance of potassium.

Optimal fertilization in the North zone with an average dose of 5 t/ha manure and $N_{60}P_{50}K_{20}$ ensures not only the high productivity of crops, but also an almost equilibrated balance of nitrogen, positive balance for phosphorus (+18-19) kg/ha and negative for potassium.

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

In the South zone the application of 4 tons/ha of manure and $N_{47}P_{43}K_{18}$ ensures the equilibrated balance of nitrogen (-10 kg/ha), phosphorus (+4 kg/ha), negative balance of potassium.

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

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