STUDYING THE RESEARCH RESULTS REGARDING FERTILIZERS USED IN THE REPUBLIC OF MOLDOVA

Tamara Leah[a], Igor Povar[b*], Tudor Lupascu[b], Serafim Andrieş[a], and Vladimir Filipciuc[a]

[a]*Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", 100 Ialoveni str., Chisinau MD-2070, Republic of Moldova*
[b]*Institute of Chemistry, Academy of Sciences of Moldova, 3 Academiei str., Chisinau MD-2028, Republic of Moldova*
**E-mail: ipovar@yahoo.ca, phone: +(373 22) 73 97 36*

Abstract: This paper represents an analysis of the research concerning the use of fertilizers and nutrients balance in the soils of the Republic of Moldova. The nature and effectiveness of fertilizers, their influence on the agrochemical properties of soils, the protection of the environment from the pollution by nutrients in addition to the regulatory normatives of our country developed in order to determine the necessary in fertilizers for obtaining the expected crops have been as well discussed.

Keywords: active substance, fertilizer, humus balance, pollution, soil protection

1. Introduction

According to the Statistical Yearbook of Moldova [1], on January 1, 2012 the total area of lands was 3.38 million ha, including the agricultural lands – 2.50 million ha (73.8%), forest lands – 463.1 thousand ha (13.7%). Of the total area of agricultural lands (farmlands) of 2.50 million ha, the arable lands constitute 1.81 million ha (72.6%), orchards occupy 133,3 thousands ha (5.3%), vineyards – 149.6 thousands ha (6.0%) and pastures – 350.4 thousands ha (14.0%).

The presented data shows that the share of farmlands is inadmissible large (73.8%) and for forest is of 2 - 3 times less than optimal ones. The imbalance between natural and anthropogenic ecosystems causes the amplification of the various forms of land degradation.

2. The nature and effectiveness of fertilizers

The territory of the Republic of Moldova is characterized by a rugged relief. Thus, the predominance of the slopes on 80% of the territory creates favorable conditions for the expansion of erosion processes. The average absolute altitude of the surface of the Republic of Moldova is 147 m, the maximum altitude is 429 m, and the minimum one is 5 m. The soil eroded area, which missed from 20 up to 70% of their initial fertility, is about 36% [2].

The climate of the Republic of Moldova is temperate continental [3], with a mild and short winter (the average temperature of January is -3 ÷ - 5^0C) and a warm and long summer (the average temperature of July 20 ÷ 22^0C). In relation to the climatic indices, the territory of Moldova was divided into three areas, which are at the same time and agro-pedoclimatic areas: North, Center and South.

The quantity of atmospheric precipitation varies within the limits of 500-630 mm in the North area and 450-500 mm in the South area [4]. The sum of temperatures higher than 10^0C constitutes 2750-2850^0C in the North zone and 3100-3350^0C in the South zone. The hydrothermal coefficient (*K* after Ivanov – Vîsoțchi) is 0.7-0.8 in the North zone and 0.5 -6 in the South zone of the country. The frequency of droughts in ten years is: once in the North zone, 2-3 times in the Centre zone and 3-4 times in the South zone.

The soil structure is quite complex. The main soil types and subtypes are: chernozems ("black earth"), occupying 70%; brown and grey soils – 10.2%; alluvial soils – 10.2% and the delluviale soils – 4,0% [5-7]. Soils with a high fertility coupled with the thermal favorable regime allow cultivating a wide range of valuable crops: vines, ethero-oleaginous plants, fruits, nuts, vegetables, sunflower, etc. to yield the production with a high quality taste. The current state of the quality of soil is shown in Table 1. The soils with the note of creditworthiness between 80 and 100 points occupy approximately 27% of the total area of the agricultural lands [7].

Table 1

The state of quality of the soil in the Republic of Moldova

The class of the note of creditworthiness	Note of creditworthiness, points	% from the area of agricultural lands	Area, thousands ha	Harvest of winter wheat, t/ha
I	81-100	27	689	3.2-4.0
II	71-80	21	539	2.8-3.2
III	61-70	15	382	2.4-2.8
IV	51-60	15	382	2.0-2.4

V	41-50	9	303	1.6-2.0
VI	21-40	6	153	0.8-1.6
VII	□20	7	178	-
Average for the Republic of Moldova	**65**	**100**	**2556**	**2.6**

On these soils with a high productivity, presented as a general rule by the typical chernozems and landfill leachate (standard soils) containing organic matter of 3.6-4.5%, can be achieved at the expense of actual fertility 3.2-4.0 t/ha for the autumn wheat. The class II and III of the lands contained within the note of creditworthiness of 60-80 points is 36% or 918 thousand ha. The productivity of these soils is also quite high and constitutes 2.4-3.2 t/ha for the autumn wheat. These two classes of soils of the note of creditworthiness are often affected by the processes of humification, their diminuation in nutrient contents, destructuration and compactisation, biologycal degradation and the partial surface erosion. The soils of classes IV, V and VI of the note of creditworthiness occupy 30% from the total surface and have a note of creditworthiness of 20-60 points and a low productivity of 0.8-2.4 t/ha of the autumn wheat respectively. These soils are weak, moderately and severely degraded, especially by the erosion processes.

At present, according to the Land Cadastre of the Republic of Moldova on 01.01.2011 [2] the note of creditworthiness is 63 points. The efficient fertility of the soil assures the formation of 2.5 t/ha of winter wheat.

In the conditions of the Republic of Moldova, the soil moisture (rainfall) is one of the factors determining the formation of high and stable yields. The calculations carried out by the Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" [14] shown that in a multiannual cycle the average potential harvest of the winter wheat formed from precipitations constitutes 4.3 t/ha. The difference in yield, obtained in function of the amount of rainfall and the note of creditworthiness is great and constitutes (4.3-2.5 t) 1.8 t/ha. In the conditions of insufficiency of nutritive elements, the unsatisfactory state of physical and biological characteristics of the soil, plants consume unproductively the moisture reserves accumulated in the soil fot the organic compound synthesis and as a result, harvests are small and of low quality. Those were confirmed by the research carried out in field experiences of long periods of time. It was established that for the variants fertilized optimally, the crop plants consumed 20-25% less water compared to the non-fertilized version [8]. Krupenikov I. [9] by analyzing the main forms of soil degradation (total for the 11 forms) arranged under number 1 the humic degradation and under number 2 – the agrochemical degradation agrochimică (the reduction of nutritive elements in soil). These two forms of degradation occur continuously and for all the farmlands.

The results of the multiannual field experiences have shown that in the conditions of the Republic of Moldova the use of fertilizers in the optimal doses provide a harvest enhance of 66% for sugar beet, 48% for the winter wheat and 35% for the cultivation of maize for grain and sunflower (Table 2). The productivity of the plants for the fertilized variants was 4.3 t/ha of the winter wheat, 5.4 t/ha maize for grains, 2.0 t/ha of sunflower seeds and 34.8 t/ha of sugar beets [8].

Table 2

The effectiveness of fertilizers in the Republic of Moldova [8]

Crop plants	Harvest, t/ha		The increase in harvest	
	non-fertilized soil	fertilized soil	t/ha	%
Winter wheat	2.9	4.3	1.4	48
Maize for grains	4.0	5.4	1.4	35
Sunflower	1.5	2.0	0.5	35
Sugar beets	21.0	34.8	13.8	66

In the Republic of Moldova the regulatory normatives were developed in order to determine the necessary in fertilizers for obtaining the expected crops [10]. It was established that the use of the optimal doses of fertilizers gave a raise in the harvest of 1.2 t/ha for the winter wheat, 1.4 t/ha of maize for grains, 13.8 t/ha of sugar beets and 0.5 t/ha for sunflower seeds. From the presented data that soil fertilization and mineral nutrition of plant optimization of culture is an important factor for obtaining high crops.

3. The use of fertilizers and nutrients balance in the soil

Moldovan soils are characterized with a high fertility [6, 7, 11-13, 15, 16]. The research carried out in the 1950-1960 yrs. demonstrated that the chernozems of Moldova contained in that period 340 t/ha of humus in the layer of 100 cm. In the composition of organic matter was contained 20 t/ha of nitrogen and 5 t/ha of phosphorus. The total quantity of $P_2 0_5$ the plowed layer was approximatively 160-180 mg and to the depth of 90-100 cm – up to 100 mg in 100 g of soil. The reserve of the total phosphorus in the layer of 1 m was 17 t/ha. Moldovan soils are rich in minerals containing potassium [17]. The total content of these soils is 10-15%. The reserve of the total potassium in the layer of 1 m of chernozems constitutes 170-290 t/ha.

In the period 1950-1960 the plant crop harvests were modest and constituted: 1.6 t/ha of winter wheat, 2.8 t/ha maize for grains, 1.5 t/ha of sunflower seeds and 11.9 t/ha of sugar beets (Table 3).

Table 3

The dynamics of the harvest of the main crops in the Republic of Moldova, t/ha

Years	Winter wheat	Maize for grains	Sunflower	Sugar beet
1963-1965	1.6	2.8	1.5	19.2
1966-1970	2.0	3.4	1.6	25.6
1971-1975	3.4	3.6	1.8	27.9
1976-1980	3.5	3.6	1.7	27.8
1981-1985	3.4	2.7	1.8	28.7
1986-1990	3.8	3.9	2.0	24.8
1991-1995	3.5	2.7	1.4	24.8
1996-2000	2.6	3.0	1.1	19.0
2001-2005	2.2	2.8	1.2	22.7
2006-2010	2.2	2.7	1.3	27.1

Obtaining the high crops was limited by two natural factors: 1) the insufficiency of moisture and 2) the low level of nutrients in the soil. The possible harvests calculated according to the degree of humidity were by 60-70% higher than those obtained of that time (Table 4).

Table 4

Field crop harvests forecast in function of the degree of water supply, t/ha [8]

Crop plants	Water consumption for obtaining 1 tonne of production, t	Soil humidity reserves (by zones), t / ha		
		North	Center	South
		4010	3620	2920
		Harvest, t/ha		
Winter wheat	820	4.9	4.4	3.6
Maize for grains	640	6.3	5.6	4.7
Sunflower	1330	3.0	2.7	2.2

These data allowed presuming that of limitative factors the first place belonged to the insufficiency of nutrients in the soil.

Generally, the effectiveness of fertilizers [E] is expressed by the equation:

$$E = R\ w.s. - R\ n.,$$ where

R w.s. – the harvest quantity is limited by the extent of water supply;
R n. – the harvest quantity is determined by the contents of nutrients in the soil.

By the 1965 year, the input of fertilisers in the agriculture of Moldova was insignificant. According to the statistic data, in the period of 1961-1965 yrs. on the 1 ha of arable land and perennial plantations 6.2 kg/ha of N, 8.7 kg/ha of P_2O_5 and 3 kg/ha of K_2O that were introduced with mineral fertilizers. The average dose of organic fertilizers was 1.3 t/ha (Table 5).

Table 5

Dynamics of the use of mineral and organic fertilizers in the agriculture of Moldova

Years	Mineral fertilizers						Organic fertilizers, t/ha	Mineral and organic fertilizers (in active substances) t/ha arable land and perenian plantations		
	thousand tons (in active substances)			kg/ha (in active substances) arable land and perennial plantations						
	N	P_2O_5	K_2O	N	P_2O_5	K_2O		N	P_2O_5	K_2O
1961-1965	13.0	19.0	8.0	6.2	8.7	3.6	1.3	12.7	12.0	11.4
1966-1970	33.8	34.2	15.4	15.7	15.8	7.2	1.4	22.7	19.3	15.6
1971-1975	75.6	56.0	34.2	35.4	26.2	15.9	2.9	49.9	33.4	33.4
1976-1980	99.6	84.2	59.8	46.6	39.4	27.9	4.1	66.1	50.4	52.5
1981-1985	148.2	102.4	111.4	70.4	48.6	53.0	6.6	101.4	65.1	92.6

1986-1990	76.0	61.0	50.0	36.5	29.3	24.0	3.0	52.0	37.0	42.0
1991-1995	38.0	28.20	13.3	18.8	13.1	6.1	1.8	28.0	17.5	17.2
1996-2000	8.0	0.3	0.1	3.6	0.14	0.04	0.06	4.2	0.4	0.9
2001-2005	13.6	0.6	0.2	4.6	0.3	0.1	0.02	6.5	0.32	0.3
2006-2010	16.1	1.9	1.0	17.5	2.1	0.9	0.02	18.5	2.7	2.0

The export of nutrients from the soil by crops was significant. As a result, in the agriculture of Moldova was formed a deeply deficient of nutrients. During the considered period the deficit of nutrients per hectare was annualy: 59 kg of N, 14 kg of P_20_5 and 80 kg of K_20 (Table 6).

Table 6

Balance of nitrogen, phosphorus and potassium in the Moldovan soils, kg/ha [8, 20]

Years	N	P_2O_5	K_2O	Sum of NPK
1913	-22	-13	-52	-92
1940	-26	-15	-62	-99
1945	-15	-15	-52	-82
1950	-27	-13	-68	-108
1951-1955	-27	-12	-62	-102
1956-1960	-40	-14	-82	-136
1961-1965	-59	-14	-80	-132
1966-1970	-36	-9	-84	-130
1971-1975	-22	-1	-79	-103
1976-1980	-15	+11	-66	-69
1981-1985	+9	+22	-33	-4
1986-1990	-15	+25	-49	-8
1991-1995	-18	-11	-80	-113
1996-2000	-30	-21	-83	-134
2001-2005	-24	-23	-81	-128
2005-2010	-26	-22	-84	-132

The research carried out in the 1955-1970 years showed that fertilizers were effective for all the cultures and for all the soils [13,18]. That conditioned the accelerate rhythms of the agriculture chimization. The volume of mineral fertilizers applied to the arable lands and the perennial plantations grew rapidly. In 1970 the agrarian sector of the Republic of Moldova received fertilizers by 2.5 times more in comparison with the 1963 year. The dose of used fertilizers accounted for 62.7 kg/ha NPK. As a result, the balance of nutrients was rapidly improved.

In the period of 1981-1988 yrs for the first time in the history of Moldova's agriculture the nutrient balance became positive.

During this period per a hectare of the arable lands and plantations of fruits, with mineral and organic fertilizers, 100 kg N, 66 kg P_2O_5 and 87 kg K_2O were applied. The average dose of manure applied in the agriculture was 6.0-6.6 t/ha. As a result the productivity of crop plants increased significantly. The average harvest of the winter wheat amounted to 3.8 t/ha, of the maize for grains was 2.4 t/ha and for sunflower was 2.0 t/ha. During the period of chimization, which lasted for 25 years (1965-1990) there were applied 1200 kg of nitrogen, 960 kg of phosphorus and 860 kg of potassium. The accumulation of nutrients in the soil was relatively small in comparison with their export throughout the entire history of agriculture. Just for 100 years on each arable land with the harvest there were exported 2300 kg of nitrogen, 1000 kg of phosphorus and 5000 kg of potassium [20].

After the 1998 year, the volume of fertilizers increased substantially, reaching the minimum level in the period of 1996-2005 yrs. During that period, there were applied about 4-6 kg of nitrogen, 0.3-0.4 kg of phosphorus and 0.3-0.9 kg of potassium per hectare. The nutritional balance again became deeply negative (Table 4), of minus 30 kg of nitrogen, 21 kg of phosphorus and 83 kg of potassium. As a result, the productivity of crop plants dropped to the level of the 60 years of the last century (Table 3).

In the recent years (2006-2012) the volume of mineral fertilizers has increased in comparison with the 1996-2006, but it has not been touched even the 1961-1965 years. Currently the fertilizers with nitrogen are preponderently applied. Practically, the fertilizers with phosphorus are not applied - the first necessary element in soils. In the last 10-12 years the dose of the applied manure in Moldova's agriculture constitutes 0.02 t/ha, the optimal rule being about 10 t/ha [13-15,18].

In the recent years (2005-2013) the average norm of fertilizers applied in Moldova's agriculture amounted to 25 kg/ha. Of fhe total dose of fertilizers about 90-95% is nitrogen one.

The largest quantities of fertilizers are applied to the production of potatoes, sugar beets and vegetable crops – 193, 70 and 52 kg/ha, respectively. The insufficient quantities of NPK fertilizers is applied to the cultivation of winter wheat (27 kg), maize and sunflower (7-12 kg/ha) (Table 7).

Table 7

Doses of mineral fertilizers applied to the crop plant fertilization, kg/ha

Crop plants	Dose of NPK, kg/ha	Harvest, t/ha
Potatoes	193	9.5
Sugar beets	70	27.0
Vegetables	52	9.0
Winter wheat	27	2.2
Maize for grains	12	2.7
Sunflower	7	1.2

The soil nutrient balance is negative (Table 6), the chemical degradation of the soil takes place and as a result the harvests are small and of low quality.

4. The influence of fertilizers on the agrochemical properties of soils

Humus is one of the main indices of the soil fertility. This fundamental component of soils determines to a great extent its chemical, physical and biological properties. The preservation of crops and biota with the mineral nutrition depends directly on the organic matter in the soil. It has been experimentally determined that increasing the content of humus with 1% gives 0.5 t/ha of the winter wheat [8].

Since the 1953 year the research institutions and universities have been carried out the agrochemical monitoring. At the same time the balance of humus in the soils has been calculated. It was established that before the period of the intensive chimization (1965-1990) the humus balance was negative (Table 8).

Table 8

The evolution of the humus balance in arable soils, kg/ha [19]

Years	Organic fertilizers applied, t/ha	Balance of humus	
		without erosion losses	with erosion losses
1971-1975	2.9	500	-900
1976-1980	3.9	400	-800
1981-1985	6.0	100	-500
1986-1990	5.6	100	-500
1991-1995	2.6	400	-800
1996-2000	0.1	700	-1100
2001-2005	0.1	700	-1100
2006-2010	0.01	700	-1100

Annually 500 kg/ha of organic matter is mineralised [18,19]. The systematic use of fertilizers, including 5-7 t/ha of manure, the cultivation of perennial grasses on about 10% of the arable land (180-210 thousand ha) contributed to the formation during the 1975-1990 years to a slightly deficient balance of humus in soils of about minus 100 kg/ha.

Over the past 10-15 years the insufficient quantities of manure (0.01-0.6 t/ha) has been incorporated into the soil. The balance of organic matter is negative, minus 700 kg/ha, while with the losses by erosion is of -1100 kg/ha.

The nitrification capacity According to the Agrochemical Research Service [24] approximately 39% of farmlands are characterized with a low content of organic matter (less than 2%), 40% with moderate (2-4% of humus) and only 20% with the humus content higher than 3.0% (Table 9).

Table 9

Agrochemical characteristics of the lands of Moldova [24]

Years of the agrochemical mapping	Contents		
	low	**moderate**	**high**
Humus			
1986-1990	41	39	20
Nitrification capacity			
1986-1990	77	17	6
Mobile phosphorus			
1971-1975	68	21	11
1980-1985	50	27	23
1986-1990	31	34	35
Exchangeable potassium			
1971-1975	0	13	87
1986-1990	0	5	95

As a result, about 80% of soils are characterised by a very low and low nitrification capacity. On agricultural lands with the humus content of less than 2% by the nitrification processes in the soil only 50-60 kg/ha of nitrogen is accumulated and the soils with 3.0 - 4.5% of organic matter – up to 75 - 110 kg/ha of the mineral nitrogen. These quantities of the mineral nitrogen are sufficient for the formation of 1.7 - 2.0 t/ha and 2.5 - 3.7 t/ha respectively of the winter wheat [8, 23].

At present the content of organic matter in the soils of Moldova is about 3.0%. As a result of the mineralization of organic matter, the soils produce annually about 70 kg/ha of nitrogen. This quantity of nitrogen is sufficient for the formation of 2.4 t/ha of the winter wheat.

Phosphorus has a special role in the metabolism of plants and in the formation of the elevated harvest. Chernozems as well as the grey soils are characterized by the low content of phosphorus in soil [8, 13]. The intensity of phosphate regim has been confirmed by the research results carried out by the State Agrochemical Service [20]. In the 1971-1975 years the surface of soils with low phosphorus content was quite large and constituted approximately 68% [8].

In the period of 1965-1990 yrs about 960 kg/ha of phosphorus was incorporated into the soils [22]. This agrochemical measure influences beneficially on the phosphorus regime of soils. To the 1990 year the surface of soils with low phosphorus content decreased by 2.0 times, while that with a high phosphorus content increased by 3.0 times. On average per republic the mobile phosphorus content in the soil increased by 2.0 times, as a result the productivity of crop plants has been increased.

In the recent years (2000-2012) in Moldova's agriculture insufficient quantities of P_2O_5 (up to 1 kg/ha) were applied. The export of phosphorus with the harvest is high and constitutes annually about 25-30 kg/ha. The balance of this nutrient element is negative. Currently the postaction with phosphorus fertilizers is practically exhausted. With the natural low background of the mobile phosphorus in soil it is possible to get about 2.5 t/ha of the winter wheat. This level of harvest, usually, has been obtained within the country in recent years.

Potassium The crops for the high harvest formation extract from the soil significant quantities of potassium - 100-200 kg/ha. The soils of Moldova are rich in the total potassium. But the main reserve of available potassium for the plants constitutes the exchangeable form. It was found experimentally that the potassium content for 15-20 mg/100 g of soil is sufficient for the optimal growth and development of plants [13, 25]. According to data [24], only 13% of the farmlands are characterised with a moderate content (10-20 mg) of exchangeable potassium; 87-95% of the total area – with a high content.

The systematic use of fertilizers in the 1965-2000 years provided an equilibrated balance of potassium in soil. Therefore, the quantity of exchangeable potassium increased average by 2 mg/100 g of soil [24]. Currently, the potassic and organic fertilizers are applied in very small doses. The balance of the K_2O in soil is negative.

The soils of Moldova are rich in accessible potassium to plants, but these reserves in a quite long period (150-200 years) may be exhausted. Hence, it is necessary to maintain an optimal regime of potassium already present in the soil by applying fertilizers.

5. The requirement of mineral fertilizers in the Republic of Moldova

In the conditions of Moldova the natural factors which limit the production of high harvests are the insufficiency of nutrients in the soils as well the moisture deficit. In order to achieve the growth rate in harvest of 40-50% it is necessary to compensate the deficit of nutrients by the use of fertilizers and rational utilization of the soil moisture [8,18,19,22,25].

In determining the amount in fertilizers for agriculture of Moldova, were used the decisions of the Government of

the Republic of Moldova, of the Ministry of Agriculture and Food Industry on the development of the various branches of agriculture by the year 2020, the statistical data for the recent years, the recommendations and norms concerning the application of fertilizers, typical crop rotations models of pedoclimatic zones of the Republic of Moldova have been used. The optimal level of fertilization provides the increase of the fertility of soils, obtaining high crops and a maximum profit from a unit of agricultural land, the protection of the environment from the pollution by nutrients [18-22].

The optimal application of fertilisers is required for a level of the modern agriculture soil no-till with respecting zonal crop rotations, the soil no-till, the integrated protection of plants, extension of irrigation, the development of the livestock sector, the implementation of intensive technologies of plant cultivation. This system is based on the combined application of organic and mineral fertilizers in couple with fuller use of the biologic nitrogen.

Table 10

The optimum doses of mineral fertilizers for the fertilization of the main crop plants, kg/ha of the active substance

Crop plants	Recommended dose			Remark
	N	P_2O_5	K_2O	
Winter wheat	80	60	40	annual
Winter barley	34	60	0	*
Spring barley	34	60	0	*
Porumb pentru boabe	60	50	0	*
Maize for grains	30	20	0	*
Sugar beet	105	80	40	*
Sunflower	45	40	40	*
Tobacco	35	40	40	*
Potatoes	60	60	60	*
Vegetables	90	60	60	*
Maize for silage	40	40	0	*
Fruitful vineyards	60	60	60	once in 3 years
Fruitful orchards	60	60	60	once in 3 years
New vineyards (founding)	-	400	400	to the founding
New orchards (founding)	-	400	400	to the founding

The norms of fertilizer vary depending on the crop from 50 kg/ha NPK for peas up to 225 kg/ha NPK for sugar beets. According to the Programme [18] the average annual dose of fertilizers on the crop rotation of the agro-pedoclimatic zones constitutes:

- North – 5 t/ha manure and $N_{61}P_{50}K_{20}$;
- Center – 4 t/ha manure and $N_{54}P_{45}K_{18}$;
- South – 4 t/ha manure and $N_{47}P_{43}K_{18}$.

The implementation of the crop rotation with the optimum share of leguminous will allow the accumulation in soil of 30-35 kg/ha per year by the biological nitrogen fixation. The systematic application of fertilizers and organic minerals in doses of $P_{55\text{-}60}$ will allow forming into a multiannual cycle a positive balance and an optimal level of phosphorus in the soil for obtaining high crops. The average dosage of K_{19} fertilizers will be insufficient for the stabilization of potassium in soil. The compensation of the potassium loss will be covered by the local fertilizers and the application of the secondary production as organic fertilizer. The nitrogen deficit will be compensated by the biologic nitrogen (30-35 kg/ha), manure (25-30 kg/ha) and mineral fertilizers (50-60 kg/ha). The share of nitrogen from mineral fertilizers will constitute about 50% of the total content.

The optimal demand for nitrogenous fertilizers for the crop rotation will be 82.3 thousand t of the active substance or N_{55} on average per 1 ha (Table 11).

Table 11

The annual mineral fertilizer requirements for the optimal crop fertilization, thousand tons of the active substance

Branch, crop plants	Nitrogen, N	Phosphorus, P_2O_5	Potassium, K_2O
Crop rotation	82.3	69.9	28.4
Vegetables and 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
In addition to irrigated lands	6.3	4.6	3.1
Other crop plants	1.0	1.0	1.0
Total for the Republic of Moldova	**99.9**	**91.1**	**45.9**

For potatoes and vegetable crops will be needed 6.8 thousand tons of nitrogen with the average dose for 1 ha - N_{60}. For the fruitful orchard fertilization will be needed 2.0 thousand tonnes of nitrogen, for the fruitful vineyards 1.5 thousand t. The phosphatic fertilizer requirements will constitute 69.9 thousands t for the field crops, 9.0 thousand tonnes for vegetables and potatoes, 1.5 thousand t – for the forfruitful vineyards, 1.2 thousand t for the fruitful orchards. The annual requirement of potassic fertilizers will be 28.3 thousand t for field crops, 6.8 thousand t for vegetables and potatoes and 3.1 thousand tonssuplimentary for the irrigated lands.

The total annual demand of fertilizers for the agriculture of the Republic of Moldova after 2020 will constitute 236.7 thousand tons of the active substance, including 99.9 t of nitrogen, 91.0 thousand t of phosphorus and 45.8 thousand t of potassium. This level of fertilization was reached in the 1976-1985 years by applying annually 243.6-362.0 thousand t (Tabel 5).

The use of the optimal fertilization system coupled with other technological links of cultivation of the crop plants will allow to get 4.0-4.2 t of the winter wheat, 3.6 t of grain maize and will form an equilibrated nutrient balance in Moldova's agriculture.

6. Priority measures for conservation and enhancement of soil's effective fertility

For the conservation and enhancement of soil fertility, the reasearchers of the Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" developed a complex of fitotechnical, agrotechnical and agrochemical measures, which include [7,8,18,22,25,26]:

- optimization of crop rotation and their implementation in each pedoclimatic zone;
- increasing the quota of perennial grasses (alfalfa, sainfoin) in field cropping up to 10-12%;
- increasing the quota of annual legume crops (peas, beans, soya) in field cropping up to 10-12%. These changes in the structure of the crop rotation will allow to accumulate annually about 40-50 thousand tonnes of nitrogen or 30-35 kg/ha;
- annual incorporation into soil of 5-6 t/ha of manure; a total of 9-10 million tons;
- application of 100 thousand t of nitrogen and 90 thousand t of phosphorus; a total of 190 thousand tons;
- minimizing in the admissible limits of about 5 t/ha of the soil erosion.

Over the past few years the State Programs have been developed in order to remedy the chemical, physical and biological characteristics of the soil as well as for the protection of soil and water by the pollution with nutrients and substances of plant protection, including:

- The complex Program of valorification of the degraded lands and improvement of the soil fertility. Part I. Soil improvement approved by the Decision No. 636 of the Government of the Republic of Moldova from 26 May 2003;
- The complex Program of valorification of the degraded lands and improvement of the soil fertility. Part II. The improvement of the soil fertility approved by the Decision No. 841 of the Government of the Republic of Moldova from 26 July 2003;
- The Program for the conservation and enhancement of the soil fertility for the 2011-2020 years, approved by the Decision No. 626 of the Government of the Republic of Moldova from 20 August 2011.

These documents determine goals, actions (measures), performance indices, the terms of implementation and those responsible for implementation.

7. Acknowlegments. This work was supported by the Joint Operational Programme "Black Sea Basin 2007-2013".

8. References

[1]. Statistical Yearbook of the Republic of Moldova; Tipografia Centrala: Chişinău, 2012; pp. 210-216 (Rom.).
[2]. Land Cadastre of the Republic of Moldova; Tipografia Centrala: Chişinău, 2009; 985 p. (Rom.).
[3]. Lase, G. A. Climate of the Moldavian Soviet Socialist Republic; Leningrad, 1978; 378 p. (Rus.).
[4]. Agroclimatic resources Moldavian CCP; Gidrometeoizdat: Leningrad, 1982; 198 p. (Rus.).
[5]. Krupenikov, I. A.; Podymov, B. P. Classification and the systematic list of the soil of Moldova; Ştiinţa: Chisinau, 1987; 157 p. (Rus.).

[6]. The soil of Moldova; Ştiinţa: Chisinau, 1984; 352 p. (Rus.).
[7]. Complex Program of valorification of degraded lands and improvement of the soil fertility. Part I. Improvement of soils; Pontos: Chişinău, 2004; 212 p. (Rom.).
[8]. Andrieş, S. Optimization of soil nutritive regimes and the productivity of crop plants; Pontos: Chişinău, 2007; 374 p. (Rom.).
[9]. Krupenikov, I. A. Chernozems. Occurrence, perfection, tragedy of degradation, ways of protection and revival; Pontos: Chişinău, 2008; 285 p. (Rus.).
[10]. Normatives on the use of mineral and organic fertilizers in the agriculture of the Moldavian Soviet Socialist Republic; Chişinău, 1987; 37 p. (Rus.).
[11]. Krupenikov, I. A. Chernozems of Moldova; Cartea Moldovenească: Chişinău, 1967; 427 p. (Rus.).
[12]. Krupenikov, I. A. Soil cover of Moldova. The past, present, management, forecast. Ştiinţa: Chisinau, 1992; 263 p. (Rus.).
[13]. The soils of Moldova; V.3. Ştiinţa: Chisinau, 1986; 336 p. (Rus.).
[14]. Rusu, V.; Postolachi, L.; Povar, I.; Alder. A. C.; Lupascu, T. Environ. Sci. Pollut. Res., 2012, 19, 3126-3131.
[15]. Lupascu, T. Buletinul ASM Seria ŞBCA 2004, 1, 170-175 (Rom.).
[16]. Lupascu, T.; Teodorescu, M. NATO Science Series. Volume "Methods and Techniques for eaning –up contaminated Sites", ESP 982358, 2008, 71-79.
[17]. Nastas, R.; Rusu, V.; Giurginca, M.; Meghea, A.; Lupascu, T. Revista de Chimie (Bucharest) 2008, 59 (2), 159-164 (Rom).
[18]. The complex Program of valorification of the degraded lands and improvement of the soil fertility. Part II. The improvement of the soil fertility; Pontos: Chişinău, 2004; 212 p. (Rom.).
[19]. Monitoring soil quality. (Bank data, forecasts, conclusions, recommendations); Pontos: Chişinău, 2010; 475 p. (Rom.).
[20]. Ursu, A. Soils of Moldova; Ştiinţa: Chişinău, 2011; 321 p. (Rom.).
[21]. Alexeev, V.E. Mineralogy of the soil formation in forest-steppe and steppe zones of Moldova; Chişinău, 1999; 87 p. (Rus.).
[22]. Bulletin of ecopedologic monitoring (Agrochemistry); The VII Edition, Pontos: Chişinău, 2000; 67 p. (Rom.).
[23]. Burlacu, I. Agrochemical preservation of the agriculture in the Republic of Moldova; Pontos: Chişinău, 2000; 228 p. (Rom.).
[24]. Zagorcea, C. The evolution of the circuit and balance the biofile elements in agrofitochenozes from the Republic of Moldova over the last century. Land and water resources. Superior valorification and their protection; V.2. Pontos: Chişinău, 1989; pp. 121-125. (Rom.).
[25]. Andrieş, S.; Lungu, V.; Donos, A. et al. Recommendations for the application of fertilizers on different types and subtypes of soil for the field crops; Pontos: Chişinău, 2012; 68 p. (Rom.).
[26]. Programme for the conservation and improvement of soil fertility for the years 2011-2020, approved by decision of the Government of the Republic of Moldova No. 626 from 20 August 2011. Published on 26.08.2011 in the Official Gazette, pp. 139-145, Article No: 696. (Rom.).