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AGROCHEMICAL SERVICE OF AGRICULTURE IN THE REPUBLIC OF MOLDOVA: PAST AND PRESENT

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Abstract

The paper presents the brief history of the agrochemical service development and its importance for Moldovan agriculture. According to this study, agrochemical service assisted methodical agriculture in the period 1956-1990. In this period were created 33 specialized laboratories were established long- and short-term experiments to test the mineral and organic fertilizers, were performed 4 cycles agrochemical soil mapping. According to the results was determined the balance of nutrients in soils, were developed soil agrochemical research for farms. After 1990 agrochemical cyclic mapping is not performed, the soils are fragmented into many plots, land degradation has accelerated. In this context agricultural policies are targeted at land consolidation, implementing action plans include measures to halt land degradation and land protection.

Key words**:** *agriculture, agrochemical service, fertilizers, nutrient regimes, soil properties*

INTRODUCTION

The development stages of Agrochemical Service in Moldova. Agrochemical Service of agriculture was officially started in 1956. In the next year was created the 19 agrochemical laboratories. Their tasks are to carry out experiments with mineral and organic fertilizers for kolkhozes and, to determine their efficiency and quality assessment of soil fertility status. The field experiments schemes were consisted from 4-5 variants, which studied the separate action of phosphorus fertilizers and common action with manure. Fertilizer application rates were very low, which indicates a low chemical treatment of agriculture in that period. In 1960, the agrochemical laboratories were created in the other 14 districts.. Its broad research themes, fertilizers management is carried out taking into account the climatic zones, diagnoses and prospects of fertilizers. Technical and material base does not meet the time requirements, was specialists lack. Laboratories was subordinate to districts, but were routed methodical and scientifically by research institutions. Thus was established the link between science and production. [4, 13]. In connection with the accelerated increase of fertilization, in 1964 was created Agrochemical Service. Thus in the Republic of Moldova have created 3 zonal agrochemical laboratories: North (Balti), Central (Chisinau), South (Cahul).

Northern Laboratory served area of 10 districts in the north part with an area of 780 thousand ha of agricultural land, of which 86% were occupied by perennial crops and pastures. In this area was concentrated 95% of sugar beet, 45% of cereals.

Central Laboratory served area of 12 districts in the Central part with a total land area of 900 thousand ha. The arable and perennial crops made up 83%. During this period, households producing zone consist the 35% of the total grape quantity and a significant proportion of cereals and industrial crops.

Southern Laboratory comprising 8 districts with an area of 850 thousand ha of agricultural land, of which 86% were occupied by arable land and perennial crops. The main activities of the farming households were vegetable, fruit, grapes [4].

In 1988 the zonal agrochemical laboratories were reorganized into the Chemical Stations of design and prospecting, in which 150 employees were working. Each station was made up of 5-6 units: design and pedoagrochimical studies, experimental researches, control over use of fertilizers, chemical, radiological, toxicology analyzes

amelioration and technical-material services. Scientific and production activities of Service heads by a single program.

Main activities in 1965-1990 yrs. were:

- Pedoagrochimical investigation of land and protected areas with vegetable to the rational organization of fertilizer use and soil quality status assessment;
- Drafting, cartograms and other documents on the effectiveness of fertilizers;
- Planning the necessary quantities of fertilizers and distributing them according to the requirements of households;
- Founding experiences with fertilizers for developing norms and dozes;
- Determination of humus content and nutrient balance in the soils;
- State control of quality and fertilizer use, the terms and application rates;
- Determining the economic efficiency of fertilizer given by households and district;
- Development of agrochemical maps of soils;
- Processing and generalization of data on the chemical composition and nutrients;
- Control of environmental pollution by nutrients from agriculture;
- Dissemination and implementation in agricultural practice the scientific and technical achievements of agrochemistry and pedology [8].

The main scientific results of the 1965-1990. Over this period were performed 4 cycles of agrochemical researches on the content of humus, mobile phosphorus, exchangeable potassium, nitrification capacity, trace of the soils. In order to obtain the expected yields with high quality, from 1980 the Agrochemical Service performed the complex diagnostic of mineral soil-plant nitrogen nutrition. The results obtained were developed in the recommendations on the application of fertilizers for each crop and field [5, 6].

A major activity of the Agrochemical Service was the foundation of field experiences with application of mineral and organic fertilizers and conducting research in order to establish the optimal doses. During this period the Agrochemical Service founded and researched 3200 experiences with fertilizer (stationary, short and long-term factors, production). The results were elaborated and presented in the recommendations on the application of fertilizers, norms and legislation on household needs, district, and country.

During agrochemical servicing were performed analyzes on soils, plants, feed and fodder, mineral fertilizers, organic wastes, pesticides. The results were used to develop the bulletins on the nutritional quality of feeds, based on 10 indicators: content of dry matter, protein, ash, fat, fiber, carbohydrates, calcium, phosphorus, carotene, trace elements, acetic and oleic acids.

In the 1971-1990 yrs were made about 70 thousand of analysis on the content of pesticides in the soils and plants. Systematic monitoring of the state of toxicological farm fields and the application of plant protection systems has substantially reduced the risk of soil and plant pollution with residues of chemicals. Zonal agrochemical laboratories were managed by the Chemical Division of Ministry of Agriculture, the methodical and scientifically by the Research Institute for Soil Science and Agrochemistry "Nicolae Dimo".

In 1995 the Chisinau Branch was reorganized in Scientific Production Center for Agrochemical Service. Currently this Center does not meet a service center for agriculture, has no scientific methodological plan. Agrochemical zonal and district laboratories have been closed.

RESULTS AND DISCUSSIONS

The use of fertilizers and nutrients balance in the soil. Moldovan soils are characterized with a high fertility. The research carried out in the 1950-1960 yrs. demonstrated that the chernozems of Moldova contained in that period 340 t ha^{-1} of humus in the layer of 100 cm. In the composition of organic matter was contained 20 t ha^{-1} of nitrogen and 5 t ha^{-1} of phosphorus. The total quantity of P_20_5 in the plowed layer was about 160-180 mg and at 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^{-1}. Moldovan soils are rich in minerals containing potassium. 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^{-1} [1, 12]. In the period 1950-1960 the plant crop harvests were modest and constituted (Table 1).

Table 1.The dynamics of the harvest of the main crops in the Republic of Moldova, t ha^{-1}

Years	Winter wheat	Maize grains	Sun-flower	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: the moisture insufficiency and the low level of nutrients in the soils. The possible harvests calculated according to the degree of humidity were by 60-70% higher than those obtained of that time (Table 2).

Table 2. Field crop harvests forecast in function of the degree of water supply, t ha^{-1} [8]

Crop plants	Water consum-ption for 1 tone of production, t	Soil humidity, t/ha		
		North	Center	South
		4010	3620	2920
		Harvest, t/ha		
Wheat	820	4.9	4.4	3.6
Maize	640	6.3	5.6	4.7
Sunflower	1330	3.0	2.7	2.2

By the 1965 the input of fertilizers was insignificant.

Table 3. Dynamics of the use of mineral and organic fertilizers in the agriculture of Moldova

Years	Mineral and organic fertilizers (in active substances) t ha^{-1}, arable land and perennial plantations		
	N	P_2O_5	K_2O
1961-1965	12.7	12.0	11.4
1966-1970	22.7	19.3	15.6
1971-1975	49.9	33.4	33.4
1976-1980	66.1	50.4	52.5
1981-1985	101.4	65.1	92.6
1986-1990	52.0	37.0	42.0
1991-1995	28.0	17.5	17.2
1996-2000	4.2	0.4	0.9
2001-2005	6.5	0.32	0.3
2006-2010	18.5	2.7	2.0

According to the statistic data, in the 1961-1965 period on the 1 ha of arable land and perennial plantations the 6.2 kg ha^{-1} N, 8.7 kg ha^{-1} P_2O_5 and 3 kg/ha K_2O were introduced with mineral fertilizers. The average dose of organic fertilizers was 1.3 t ha^{-1} (Table 3).
As a result, in the agriculture of Moldova was formed a deeply deficient of nutrients. During the considered period the deficits of nutrients per hectare were annually: 59 kg of N, 14 kg of P_20_5 and 80 kg of K_20 (Table 4).

Table 4. Balance of nitrogen, phosphorus and potassium in the Moldovan soils, kg ha^{-1} [8, 20]

Years	Sum of NPK
1913	-92
1940	-99
1945	-82
1950	-108
1951-1955	-102
1956-1960	-136
1961-1965	-132
1966-1970	-130
1971-1975	-103
1976-1980	-69
1981-1985	-4
1986-1990	-8
1991-1995	-113
1996-2000	-134
2001-2005	-128
2005-2010	-132

The volume of mineral fertilizers applied to the arable lands and the perennial plantations grew rapidly. In 1970 the agrarian sector 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^{-1} 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 of this period per 1 ha 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^{-1}. As a result the productivity of crop plants increased significantly. The average harvest of the winter wheat amounted to 3.8 t ha^{-1}, of the maize for grains was 2.4 t ha^{-1} and for sunflower was 2.0 t ha^{-1}. 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 were exported 2300 kg of nitrogen, 1000 kg of phosphorus and 5000 kg of potassium [2, 9].

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, 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 5).

Table 5. 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

In the recent years (2006-2014) the volume of 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 preponderantly applied. Practically, the fertilizers with phosphorus are not applied - the first necessary element in the soils. In the last 10-12 years the dose of the applied manure in Moldova's agriculture constitutes 0.02 t ha^{-1}, the optimal rule being about 10 t ha^{-1} [1, 3, 14]. *In the 2005-2014yrs. the average norm of fertilizers applied in Moldova's agriculture amounted to 25 t ha^{-1} of the 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^{-1}, respectively. The insufficient quantities of NPK fertilizers is applied to the cultivation of winter wheat -27 kg, maize and sunflower - 7-12 t ha^{-1}. *The soil nutrient balance is negative the chemical degradation of the soil takes place and as a result the harvests are small and of low quality.*

Humus It has been experimentally determined that increasing the content of humus with 1% gives 0.5 t ha^{-1} of the winter wheat [5, 7, 10].

Since the 1953 the research institutions 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 6).

Table 6. The evolution of the humus balance in arable soils, kg/ha [15]

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^{-1} of organic matter is mineralized [11, 15]. The systematic use of fertilizers, including 5-7 kg ha^{-1} 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 yrs to a slightly deficient balance of humus in soils of about minus 100 kg ha^{-1}.

Over the past 10-15 years the insufficient quantities of manure (0.01-0.6 t ha^{-1}) has been incorporated into the soil. The balance of organic matter is negative, minus 700 kg ha^{-1}, while with the losses by erosion is minus 1100 kg ha^{-1}.

Nitrification capacity. According to the Agrochemical Service [4] 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%. As

a result, about 80% of soils are characterized 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^{-1} of nitrogen is accumulated and the soils with 3.0-4.5% of organic matter – up to 75-110 kg ha^{-1} of the mineral nitrogen. These quantities of the mineral nitrogen are sufficient for the formation of 1.7-2.0 t ha^{-1} and 2.5-3.7 t ha^{-1} respectively of the winter wheat [1, 6, 12]. *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^{-1} of nitrogen. This quantity of nitrogen is sufficient for the formation of 2.4 t ha^{-1} of the wheat.*

Phosphorus. Chernozems as well as the grey soils are characterized by the low content of phosphorus in soil [7, 8, 14]. The intensity of phosphate regime has been confirmed by the research results carried out by the Agrochemical Service [4, 14]. In the 1971-1975 yrs the soils areas with low phosphorus content was quite large and constituted approximately 68% [4, 12].

In the period of 1965-1990 yrs about 960 kg ha^{-1} of phosphorus was incorporated into the soils. 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 (2000-2014) in Moldova's agriculture insufficient quantities of P_2O_5 (up to 1 t ha^{-1}) were applied. The export of phosphorus with the harvest is high and constitutes annually about 25-30 kg ha^{-1}. The balance of this nutrient element is negative. Currently the post action 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^{-1} of the winter wheat.*

Potassium. It was found experimentally that the potassium content for 15-20 mg per 100 g of soil is sufficient for the optimal growth and development of plants [10, 15]. According to data [6] only 13% of the farmlands are characterized 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 yrs provided an equilibrated balance of potassium in soil. Therefore, the quantity of exchangeable potassium increased average by 2 mg per 100 g of soil [2]. Nowadays, the potassium 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 (50-100 years) may be exhausted. Hence, it is necessary to maintain an optimal regime of potassium already present in the soil by applying fertilizers.*

The requirement of mineral fertilizers for soil application. In conditions of Moldova the natural factors which limited 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 using the fertilizers and rational utilization of the soil moisture [1, 3, 13, 15].

In determining the amount of fertilizers for agriculture of Moldova, were used the Government decisions 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 zones have been used.

The optimal application of fertilizers is required for a modern agriculture, soil no-till with respecting of 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. The system is based on the combined application of fertilizers in couple with fuller use of the biologic nitrogen.

The norms of fertilizers vary depending on the crop from 50 kg ha^{-1} NPK for peas up to 225

kg ha^{-1} NPK for sugar beets. According to the Programme [5, 6] the average annual dose of fertilizers on the crop rotation of the agropedoclimatic zones constitutes: North – 5 t ha^{-1} manure and $N_{61}P_{50}K_{20}$; Center – 4 t ha^{-1} manure and $N_{54}P_{45}K_{18}$; South – 4 t ha^{-1} 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^{-1} per year by the biological nitrogen fixation. The systematic application of fertilizers and organic minerals in doses of P_{55-60} will allow forming into a multiannual cycle a positive balance and an optimal level of phosphorus in the soils 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^{-1}), manure (25-30 kg ha^{-1}) and mineral fertilizers (50-60 kg ha^{-1}). 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.

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 winter wheat, 3.6 t of grain maize and will form an equilibrated nutrient balance in Moldova's agriculture.

CONCLUSIONS

Priority measures for conservation and enhancement of soil's effective fertility include [10, 12]:

- optimization of crop rotation and their implementation in each pedoclimatical zone;
- increasing the quota of perennial grasses (alfalfa, sainfoin) in field cropping up to 20%; annual legume crops (peas, beans, soya) in field cropping up to 20%.
- annual incorporation into soil of 5-6 t ha^{-1} of manure; a total of 9-10 million tons;
- application of 100 thousand t of nitrogen and 90 thousand t of phosphorus;
- minimizing the soil erosion in the admissible limits about 5 t/ha.

Over the past years the State Programs have been developed in order to remediates the chemical, physical and biological soil properties as well as soil and water protection by the pollution with nutrients and substances of plant protection. The documents determine goals, actions (measures), performance indices, terms of implementation and those responsible for implementation.

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