Complexul Muzeal de Ştiinţele Naturii „Ion Borcea” Bacău

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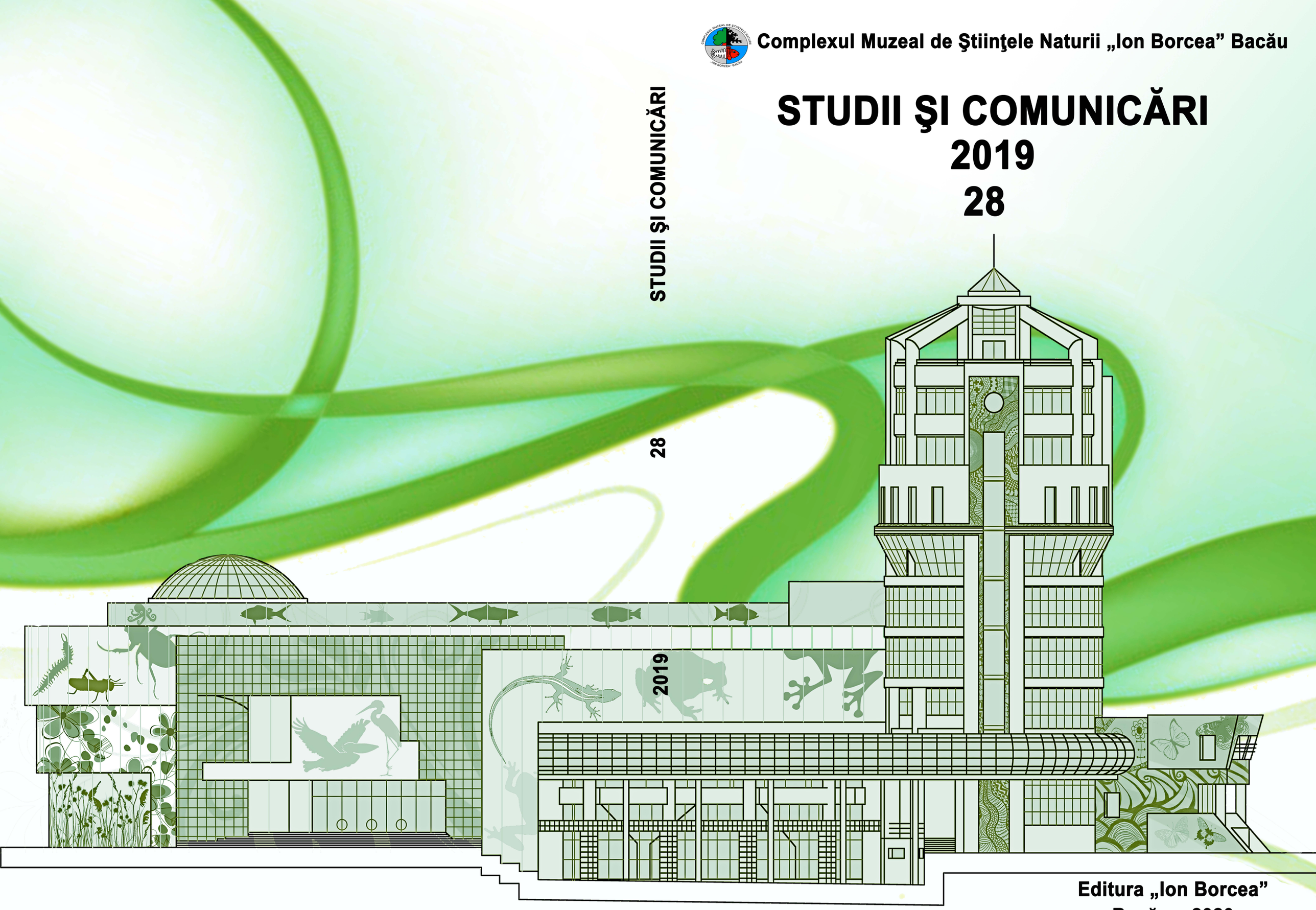

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CUPRINS

PART I – *PEDOLOGY, AGROCHEMISTRY, BIOTECHNOLOGY, PLANT PROTECTION*

PART II – *ANIMAL BIOLOGY*

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COMPLEXUL MUZEAL DE ŞTIINŢELE NATURII „ION BORCEA” BACĂU

STUDII ŞI COMUNICĂRI 2019	Vol. 28: 7 - 12

PART I – *PEDOLOGY, AGROCHEMISTRY, BIOTECHNOLOGY, PLANT PROTECTION*

AGROCHEMICAL STATE OF SOILS ON THE AGRICULTURAL LAND WITH CONSERVATIVE TILLAGE OF THE FIELD SCHOOLS FOR FARMERS

NICOLAI LEAH*

ABSTRACT

The agrochemical parameters of the soils were analyzed on the fields with conservative no-till and mini-till in 10 field schools. The parameters of the agrochemical indices define the level of the effective fertility of the soils, which in turn are very different and depend on the genesis and their form of degradation. In the Republic of Moldova, the humus content in the arable layer (0-30 cm) of soil varies from 0.8-1.2% (very degraded soil) to 4.2-5.0% (full profile soil), mobile phosphorus - from 0.6-0.8 mg to 6-8 mg/100g of soil and potassium exchangeable - from 14-16 mg to 50-60 mg/100g of soil. According to the classification of soils for chernozem with a humus content of 3.1-4.0%. mobile phosphorus (P_2O_5) of 3.1-5.0 mg/100g and potassium (K_2O) of 20.1-30.0 mg/100g of soil in the arable layer (0-30 cm) is optimally insured. Soils with less than 2% humus, less than 1.5-2.0 mg/100 g of mobile phosphorus and potassium less than 10 mg/100 g of soil have a low effective fertility. The soils of high and very high humus, mobile phosphorus and exchangeable potassium have a high potential for effective fertility, on these soils high crops can be obtained. For lands of each school, recommendations for improving the quality status and nutrients regimes of the soils were given.

Key words: conservative agriculture, soil quality, agrochemical indices, humus

Introduction

The Republic of Moldova is in the area of risk of droughts, which occur more frequently and significantly reduce the productivity of agricultural crops. Conserving soil moisture, increasing soil water yield is one of the priorities of raising the level of crops. Conservative agriculture (CA) includes a number of complementary agricultural practices that reduce the impact of drought and improve soil fertility: minimal soil disturbance (through a reduced tillage system or direct sowing in stubble) to preserve the structure, fauna and soil organic matter; permanent soil cover (cover crops, residues and mulch) to protect the soil from compaction and erosion, to preserve water and stabilize the temperature in the soil, to prevent weed growth; various crop rotations and combinations that stimulate soil microorganisms and eliminate plant pests, weeds and diseases.

Conservative agriculture aims to increase agricultural production by optimizing the use of agricultural resources and by helping to reduce the widespread degradation of land through integrated management of soil, water and biological resources combined with external raw materials. Mechanized tillage is minimized or replaced by biological soil mixing, soil microorganisms, soil roots and fauna taking over the function of working and balancing soil nutrients. Soil fertility (nutrients and water) is controlled by soil cover management, crop rotation and weed control.

The implementation of the CA is carried out by organizing field schools for farmers, by creating demonstration plots with minimal tillage. Conservative agriculture is applied, first of all on demonstration plots, in the following stages, each of them having a duration of at least two years.

• *The first stage:* the inversion of the layers is stopped, applying instead a reduced system of soil works or direct sowing in the stubble. At least one third of the soil surface must remain covered with crop residues and cover crops must be introduced after harvesting the main crop. Disc tooth or rotary harrows are used (direct sowing in the case of direct sowing techniques in stubble). In the first stage, crop productivity may decrease.

• *The second stage:* the condition and fertility of the soil improve naturally due to the organic matter coming from the natural degradation of the residues. Weeds and pests tend to multiply and this must be controlled chemically or by other means.

• *The third stage:* the diversification of the cultivation method (crop rotation) can be introduced. The general system is gradually stabilizing.

• *The fourth stage:* the agricultural system is balanced and productivity can be improved compared to traditional agriculture. This process

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reduces the need to use chemicals to control weeds and pests or to increase fertility.

Farmers must be trained for each stage. Experience in the field can be gained, but productivity and profits can be lower in the short term. The system is not suitable for compacted soils, which may require loosening first. On compacted soils, a loosening with the scarified (chisel) at a depth of 35-45 cm is recommended every three years.

Material and method

The research materials served the soils of the demonstration plots of 10 field schools for farmers located in different pedoclimateric areas of the Republic of Moldova. The agrochemical parameters of the soils with conservative agriculture were compared: ploughing and mini-till. As an example of evaluating the chemical (agrochemical) properties of the 0-30 cm soil layer on the observation plots, in this paper, the IPAPS field school "N. Dimo" from Ivancea commune, Orhei district was taken (SCF IPAPS "N.Dimo") . Variant 1. Demonstration plot with mini-till; Variant 2. Demonstrative lot with ploughing.

The 6 mixed soil samples were collected and analyzed. Soil agrochemical indices were analyzed according to the methods. Soil sample preparation - GOST 5180-84; Humus - Tiurin method, GOST 26213-84; Mobile phosphorus - Macighin method, GOST 26205-84; Exchangeable potassium - Macighin method, GOST 26205-84; Nitric nitrogen - Grandvali-Leaju method with phenoldisulfonic acid; Soil reaction (pH) - potentiometric method in aqueous extract, GOST 26483-85.

Results and discussions

The parameters of agrochemical indices define the level of effective soil fertility, which in turn are very different and depend on their genesis and form of degradation. In the Republic of Moldova the humus content in the arable layer (0-30 cm) of soil varies from 0.8-1.2% (very degraded soil) to 4.2-5.0% (full profile soil), mobile phosphorus - from 0.6-0.8 mg to 6-8 mg/100g of soil and exchangeable potassium - from 14-16 mg to 50-60 mg/100g of soil (4, 5, 6).

According to the soil classification the chernozems with humus content of 3.1-4.0% mobile phosphorus (P_2O_5) of 3.1-5.0 mg/100g and potassium (K_2O) of 20.1-30.0 mg/100g of soil in the arable layer (0-30 cm) is optimally ensured (Table 1). Soils with less than 2% humus content, less than 1.5-2.0 mg/100 g of mobile phosphorus and less than 10 mg/100g of soil potassium have poor effective fertility. Soils with high and very high content of humus, mobile phosphorus and exchangeable potassium have a high potential for effective fertility on these soils high yields can be obtained.

The results of the agrochemical researches from 2020 of the two demonstration fields of SCF IPAPS "N. Dimo", Ivancea com., Orhei district are presented in Table 2.

Table 1 - Classification of soils according to humus and NPK content in the arable soil layer (3)

Soil insurance class	Humus, %	Mobile phosphorus (P_2O_5), *Macighin method*			Exchangeable potassium (K_2O)		Nitric nitrogen ($N\text{-}NO_3$)
		Chernozioms		*Gray soils*	*Ciricov*	*Macighin*	
		carbonatic. ordinary. tipical	*leaced. argillic*				
		mg/100 g sol					
1. Very low	less 1.1	less 1.1	less 1.6	less 2.1	less 5.1	less 5	less 0.5
2. Low	1.1 - 2.0	1.1 - 1.5	1.6 - 2.0	2.1 - 2.5	5.1 - 10	5.1 - 10	0.6 - 1.2
3. Moderate	2.1 - 3.0	1.6 - 3.0	2.1 - 3.5	2.6 - 4.0	10.1 - 15	10.1 - 20	1.3 - 1.9
4. Optimal	3.1 - 4.0	3.1 - 4.5	3.6 - 5.0	4.1 - 5.5	15.1 - 20	20.1 - 30	2.0 - 2.6
5. High	4.1 - 5.0	4.6 - 6.0	5.1 - 6.5	5.6 - 7.0	20.1 - 25	30.1 - 40	2.7 - 3.3
6. Very high	over 5.0	over 6.0	over 6.5	over 7.0	over 25	over 40	over 3.3

Table 2 - The parameters of the soils chemical properties of the demonstration plots

Depth. cm	pH (H_2O)	Humus, %	Phosphorus (P_2O_5)	Potassium (K_2O)	Nitric nitrogen ($N\text{-}NO_3$)
			mg/100g of soil		
Demonstration plot 1. Mini-till					
0-10	7.60	3.53	3.0	36	0.36
10-20	7.72	3.0	0.6	24	0.14
20-30	7.87	2.88	0.5	21	0.14
0-30	**7.73**	**3.14**	**1.37**	**27**	**0.21**
Demonstrative plot 2. Ploughing					
0-10	6.74	3.52	3.1	38	0.32
10-20	6.80	3.32	0.8	26	0.12
20-30	6.82	3.0	0.7	24	0.16
0-30	**6.79**	**3.28**	**1.53**	**29**	**0.20**

It was found that the parameters of agrochemical indices in the arable layer (0-30 cm) on the demonstration fields vary within the following limits: soil reaction (pH): from 6.74 to 7.87 units; humus: from 2.88% to 3.53%; mobile phosphorus: from 0.5 mg to 3.1 mg P_20_5 in 100 g of soil; exchangeable potassium: from 21 mg to 38 mg K_20 in 100 g of soil; nitric nitrogen content: from 0.12 to 0.36 mg N in 100 g of soil.

Soil reaction (pH) is an index which characterizes the soil reaction - the acid-alkaline properties of the soil-plant system. The concentration of free H^+ ions expresses the magnitude of the pH defined by the negative logarithm of the concentration of hydrogen ions. Soil pH values equal to 7 units characterize their reaction as neutral pH <7 - acidic and pH> 7 - basic (alkaline). Crops react differently to soil pH. The most favorable is the reaction of the soil between slightly acidic to neutral and weakly alkaline to neutral. A negative impact on plant development has the reaction of strongly acidic soil solutions (pH <4) and especially - strongly alkaline (pH> 9).

The soil pH on the demonstration plot with mini-till is weakly alkaline (7.60-7.87), on the demonstration plot with ploughing it is weakly acidic (6.74-6.82) in the soil layer 0- 30 cm. The weakly alkaline reaction of the soil with mini-till is due to the application of wastewater from the pig complex at a dose of 80 t/ha. The average soil pH is 7.73 units per lot with mini-till and 6.79 units per lot with ploughing (Table 2).

Therefore the soil pH of the demonstration plots of SCF IPAPS „N.Dimo" are favorable for the growth of agricultural crops and will not limit the level and quality of crops.

Humus is one of the main indicators of soil fertility. It contains about 94-96% nitrogen, 40-45% phosphorus, 60-70% sulphur etc. of the total amount of soil. The humus content largely determines the agro- physical, chemical and biological properties of the soil, provides agricultural plants and soil biota with mineral nutrition. The higher the humus content, the better the plants are provided with nutrients. Increasing the humus content by 1% ensures the obtaining of an additional 1.0 t/ha of corn or 0.8 t/ha of winter wheat (1, 3).

On the investigated demonstration fields, the humus content in the arable soil layer varies depending on the natural peculiarities of the solification and the erosion process. The humus content in the layer of 0-30 cm of soil on the demonstration plot (mini-till) is within the limits of 2.88-3.53%, on the traditional work (ploughing) - 3.0-3.52% and the average amount of humus is 3.14-3.28% (Table 2). According to the soil classification (Table 1) the amount of humus of 3.14-3.28% corresponds to the optimal insurance class.

Experimentally was determined (4) that in the process of mineralization of the organic matter in the soil, 1% of humus produces on average 24 kg/ha of nitrogen per year. It follows that depending on the humus content in the soil, the productive level of the soil and the need for nitrogen fertilizers to obtain the expected yields can be forecast (Table 3).

The average humus content of 3.14-3.28% of the soil of the demonstration fields will provide annual nitrogen crops with an average of about 75-79 kg/ha. This amount of nitrogen is sufficient to obtain harvests of 2.3-2.8 t/ha of winter wheat. In order to obtain higher yields, it will be necessary to apply additional nitrogen fertilizers and organic fertilizers.

Most of the Moldovan soils are characterized by a low content of mobile phosphorus (P_2O_5) forms accessible to plants. The content of mobile phosphorus in full-profile non-fertilized soils is 1.0-1.5 mg per 100 g of soil. During the chemicalization period (1970-1990) due to the systematic application of fertilizers, the phosphorus regime in some households improved considerably (6). In the last 30 years in the republic, phosphorus fertilizers are practically not applied, only partially in some households under more profitable crops (vegetables. sugar beet. etc.). As a result, the reserves of mobile phosphorus accumulated in the soil during the intensive chemicalization decrease, returning to the natural background. The results obtained regarding the amount of mobile phosphorus in the arable soil layer (0-30 cm) for the researched demonstration fields are presented in Table 2.

The content of mobile phosphorus in the demonstration field (mini-till) in the 0-30 cm soil layer varies from 0.5 mg to 3.0 mg/100 g soil. On the demonstration field with classical tillage system (ploughing), the content of mobile phosphorus in the arable layer is within the limits of 0.7-3.1 mg/100g soil. Phosphorus content in the other depths 10-20 and 20-30 cm for both systems remaining at the natural concentration of 0.5-0.8 mg/100g mobile phosphorus soil. The average value of mobile phosphorus content in the 0-30 cm soil layer is 1.37 mg with the mini-till tillage system and 1.53 mg/100g soil with traditional ploughing system (Table 2). According to the soil insurance gradation (Table 1) the demonstration fields of SCF IPAPS „N. Dimo" have a very low mobile phosphorus content.

Therefore, the very low content of mobile phosphorus in the soil on the lands of SCF IPAPS

„N.Dimo" will limit the level and quality of crops. Measures will need to be taken to radically improve the phosphorus regime in the soil by applying phosphorus fertilizers over time.

The soils of the Republic of Moldova are rich in potassium, especially those with heavy particle size composition. The main reserve of potassium accessible to plants is presented in the changeable form. It is largely restored based on the breakdown of potassium-containing minerals in the soil. According to agrochemical research data, up to 90% of the republic's soils contain more than 20 mg, 64% - more than 30 mg and 23% - more than 40 mg of K_2O in 100 g of soil in exchangeable form (6). It is already established that in Moldova field crops react positively to the application of potassium fertilizers, when the exchangeable potassium content in the soil is less than 20 mg per 100 g of soil, and for beets, potatoes, vegetables and fruit trees - more less than 25 mg (2).

According to the investigations. the exchangeable potassium content in the 0-10, 20-30 and 20-30 cm soil layers of the demonstration fields of SCF IPAPS „N. Dimo" varies from 21 mg to 38 mg/100 g soil. According to the insurance gradation, the level of exchangeable potassium varies from optimal to high. The average in the 0-30 cm soil layer is 27-29 mg/100 g of soil corresponding to the fields (Table 2). According to the soil classification, soils with a changeable amount of potassium of 27-29 mg/100 g of soil are optimal insurance (Table 1).

Therefore, the soil of the demonstration fields with the optimal content of exchangeable potassium are provided with this nutrient for the growth and development of agricultural crops. We consider that for a period of 5-7 years the state of potassium supply of these soils will not limit the obtaining of high yields.

The main source of nitrogen in the soil, which determines the nutrition of plants is nitrates. Nitric nitrogen is found in the soil in the form of water-soluble salts. Nitrogen can be, both of mineral origin from mineral fertilizers and organic from humus, organic fertilizers (manure etc.), but also from the atmosphere, produced by symbiotic bacteria - nitrogen fixers with legume crops.

The content of nitric nitrogen in the soil depends a lot on the nitrification capacity of the soil as well as on the amount of nitrogen remaining after the previous crops. Nitrification is a process of reducing nitrogen-containing organic compounds from soil to nitrates by nitrifying bacteria. The nitrification capacity of the soil largely depends on the amount of organic matter in the soil, on the vitality of the soil biota. The higher the nitrification capacity, the more nitric nitrogen is found in the soil and is accessible to plants.

Within the SCF IPAPS „N.Dimo" nitric nitrogen content in soil layers 0-10, 20-30 and 20-30 on the demonstration fields varies from 0.12 mg to 0.36 mg $N\text{-}NO_3$ in 100 g soil. The average being 0.20-0.21 mg/100 g of soil - very low insurance class for both lots (Table 2). Converted into reserve, the amount of nitric nitrogen in the arable soil layer will be about 7 kg/ha nitrogen. Under optimal conditions of humidity and temperature, the amount of nitric nitrogen in the soil produced by nitrifying bacteria in the fields will increase according to the humus content in the soil. Therefore, the nitrogen nutrient regime of the soils of the demonstration fields is in the first place. As a result of agrochemical research, it was established that from the researched nutritional regimes (nitrogen, phosphorus, potassium) of soils in SCF IPAPS „N.Dimo" in the first minimum is nitrogen and phosphorus.

Nitrogen. Leached chernozem within SCF IPAPS „N.Dimo" with an average humus content of 3.14-3.28% will provide agricultural crops with annual nitrogen on average 75-79 kg per 1 ha. This amount of nitrogen is sufficient to obtain a harvest of 2.3-2.8 t/ha of winter wheat. but to obtain crops of 4.5-5.0 t/ha of autumn wheat for baking (22-24% gluten) and 6.0-6.5 t/ha ha corn for grain on a background without organic fertilizers, when the share of legume crops is low, it is necessary to incorporate in the soil 115-120 kg/ha nitrogen, about 335-350 kg/ha ammoniac siliter (Table 3).

The need for nitrogen fertilizers will depend on the agro-climatic conditions of each year and the level of crops. Doses of nitrogen fertilizers for agricultural crops are recommended to be determined in the spring, depending on the need for the crop and nitric nitrogen reserves in the active area (0-100 cm) of the root system of plants. In order to obtain high and stable crops, measures are needed to regulate the nitrogen regime. First of all, it is necessary to increase the content of organic matter in the soil. This can be done by implementing scientifically argued crops with a share of legumes of 20-25% (alfalfa, sparceta, peas, beans, vetch, etc.), the application of manure and secondary agricultural production (straw, stems etc.).

Phosphorus. According to the phosphorus insurance gradation (Table 1) currently the soils of the demonstration fields have a very low content (1.37-1.53 mg/100g soil) of mobile phosphorus (Table 2). In order for the normal growth and development of agricultural crops to form a quintal of grains, wheat and corn for grains consume about

1.0-1.2 kg of P_2O_5. So, in order to obtain the harvest of 4.5-5.0 t/ha of winter wheat and 6.0-6.5 t/ha of corn, the export of phosphorus during the vegetation period will constitute about 60-65 kg/ha of phosphorus. Against the optimal background of mobile phosphorus in the soil the dose P_{60-65} will be indicated to compensate the export of phosphorus with the annual harvests. However, for soils with a very low level of mobile phosphorus in the soil, it will be necessary to compensate the export of phosphorus with the annual production, as well as to raise the level of phosphorus in the soil over a period of time. In these fields in the next 4-5 years it is necessary to incorporate in the soil the dose of $P_{100-120}$ or $P_{190-230}$ kg/ha amophos (Table 4). After the stabilization of the optimal levels of phosphorus in the soil (year 2027), the export of phosphorus with the harvests will be compensated with the doses of P_{60-65} or $P1_{15-125}$ kg /ha amophos (mark 12:52). Thus, on the demonstration fields of SCF IPAPS „N. Dimo" radical measures will be taken to improve the phosphate regime in the soil, by applying phosphorus fertilizers in the next 4-5 years at a dose of 100-120 kg/ha.

Potassium regime in the researched soils are favorable for obtaining high yields. In the next 5-7 years the application of chemical fertilizers with potassium is not necessary. In order to maintain a equilibrated potassium balance, the annual export of K_2O can be offset by crop residues and the secondary production of agricultural crops (spike, straw, maize stalks and sunflower). Being crushed and incorporated, the straw leaves in the soil about 70-80 k/ha K_2O (each ton of wheat straw requires an additional 10 kg/t of nitrogen), corn stalks - 90-100 kg, sunflower stalks - 200-360 kg/ha K_2O (5, 6). Soils with optimal exchangeable potassium content are optimally provided with this nutrient for the growth and development of agricultural crops. We consider that in the next 5-7 years the state of potassium supply of these soils will not limit the obtaining of high yields. Therefore, for the stable maintenance of the potassium regime on the demonstration fields of SCF IPAPS „N.Dimo" in a multi-annual cycle, local fertilizers can be used in optimal recommended doses: manure, compost, secondary agricultural production etc.

Table 3 - Planned harvest of field crops and nitrogen fertilizer requirements for soils of SCF IPAPS „N. Dimo"

Humus. %	Soil nitrification capacity, N kg/ha	Predicted fertilizer-free harvest, t/ha			Planned crop harvest; required in nitrogen fertilizers, kg/ha		
		Autumn wheat	Corn grain	Sun flower	Wheat 4.5-5.0 t/ha	Corn 6.0-6.5 t/ha	Sun flower 2.7-3.0 t/ha
3.0	72	2.2-2.7	2.9-3.1	1.8-1.9	130	130	70
3.2-SCF	77	2.3-2.8	3.1-3.3	1.9-2.0	120	120	60
3.4	81	2.4-3.0	3.3-35	2.0-2.1	115	115	55
3.6	86	2.6-3.1	3.4-3.7	2.1-2.2	105	105	45
3.8	91	2.7-3.3	3.6-3.9	2.2-2.3	100	100	40
4.0	96	2.9-3.5	3.8-4.2	2.3-2.4	90	90	30

Table 4 - The need for phosphorus fertilizers for the formation and stabilization of the optimal level of mobile phosphorus in SCF IPAPS soils „N.Dimo" in order to obtain the expected harvests in the years 2021-2027

Soil insurance class	Mobile phosphorus, mg/100 g soil	2021		2022		2023		2024		a.2025		a.2026		a.2027	
		kg/ha		kg/ha		kg/ha		kg/ha		kg/ha		kg/ha		kg/ha	
		P_2O_5	amo-phos	P_2O_5	amo-phos	P_2O_5	amo-phos	P_2O_5	amo-phos	P_2O_5	amo-phos	P_2O_5	amo-phos	P_2O_5	amo-phos
Very low	less 1.5	120	230	120	230	0	0	0	0	0	0	0	0	0	0
Low	1.6 - 2.0	0	0	0	0	120	230	100	190	0	0	0	0	0	0
Moderate	2.1 - 3.5	0	0	0	0	0	0	0	0	100	190	90	175	0	0
Optimal	3.6 - 5.0	0	0	0	0	0	0	0	0	0	0	0	0	60	115
High	5.1 - 6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Very high	over 6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

** Amophos (12:52) with active substance content:: N – 12%; P_2O_5 – 52%.*

Conclusions

Within the SCF IPAPS "N.Dimo" the content of nitric nitrogen in the layer 0-30 cm of soil on the demonstration fields varies from 0.12 to 0.36 mg N-NO_3 in 100 g of soil. The average - constituting 0.20-0.21 mg N-NO_3 per 100 g. According to the insurance grade, the average nitric nitrogen content is very low for both fields. Nitrogen nutrient regime of demonstration fields is in the first place.

As a result of agrochemical research, it was established that from the researched nutritional regimes (nitrogen, phosphorus, potassium) of soils in the first minimum is nitrogen and phosphorus.

In order to regulate the nitrogen regime it is recommended to increase the content of organic matter in the soil by implementing scientifically justified crop rotations with a share of legumes of 20-25% (alfalfa, sparceta, peas, beans, vetch etc.), application of manure and secondary agricultural production (straw, stalks, etc.). In order to obtain high and stable harvests at the first stage, it is recommended that nitrogen fertilizers be applied in the doses indicated in Table 3 until the implementation of the measures indicated above.

On both demonstration fields is recommended to take radical measures to improve the phosphate regime in the soil by applying phosphorus fertilizers in the next 4-5 years at a dose of 100-120 kg/ha according to the scheme (Table 4).

In order to maintain the potassium regime on the demonstration fields, it is recommended that in a multiannual cycle the local fertilizers be used in optimal recommended doses: manure, composts, vegetable residues and secondary agricultural production, etc. In order to homogenize the nutrients in the soil on the field with the mini-till of the soil is recommended once every 3-4 years of ploughing to a depth of 27-30 cm.

Rezumat

Parametrii agrochimici ai solurilor au fost analizați pe câmpuri cu agricultură conservativă: no-till și mini-till în 10 școli pentru fermieri. Parametrii indicilor agrochimici definesc nivelul fertilităţii efective a solurilor. care la rândul lor sunt foarte diferiţi şi depind de geneza şi forma lor de degradare. În Republica Moldova conţinutul de humus în stratul arabil (0-30 cm) de sol variază de la 0.8-1.2% (sol foarte degradat) până la 4.2-5.0% (sol cu profil deplin), fosfor mobil – de la 0.6-0.8 mg până la 6-8 mg/100g de sol şi potasiu schimbabil – de la 14-16 mg până la 50-60 mg/100g de sol. Conform clasificării solurilor pentru cernoziomuri cu conţinutul de humus de 3.1-4.0%, fosfor mobil (P_2O_5) de 3.1-5.0 mg/100g şi potasiu (K_2O) de **20.1-30.0** mg/100g de sol în stratul arabil (0-30 cm) este optim asigurat. Solurile cu conţinut mai mic de 2% de humus, mai puţin de 1.5-2.0 mg/100 g fosfor mobil şi potasiu mai puţin de 10 mg/100g de sol au o fertilitate efectivă slabă. Solurile terenurilor cu conţinut ridicat şi foarte ridicat de humus, fosfor mobil şi potasiu schimbabil au un potenţial mare al fertilităţii efective, pe aceste soluri se pot obţine recolte înalte.

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GEOCHEMICAL REGULARITIES OF HEAVY METALS DISTRIBUTION IN THE IRRIGATED ALLUVIAL SOILS OF THE MIDDLE DNIESTER MEADOW

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ABSTRACT

The alluvial soils weakly or moderately evolved, irrigated from the middle Dniester meadow are characterized by stratified, loamy, weak or moderately humiferous profile, moderately carbonate. One of the significant characteristics of the distribution of heavy metals in the profile of these soils is the relatively high concentrations of most total and mobile forms in the depth horizons, due to their leached from the upper horizon, an additional supply of ground water, and a high content of organic matter. The fallow alluvial soils differ from the arable by a higher content of elements in profile, especially in the humus horizon, which is related to the specific conditions of their formation, geomorphological characteristics, hydrological regime, etc. Thus, in alluvial soils, approximately 50% of the total reserve of heavy metals are concentrated in the upper part of the profile. The distribution and accumulation of Zn, Co, Fe, Mn, Pb, Cu is associated with the biogenic accumulation in the soil layer of 0-23 cm. Accumulation at the geochemical barrier (57-80 cm) is evident - the beginning of the gleyic horizon. Maximum accumulations of Fe (47.7 mg kg^{-1}), Mn (52.4 mg kg^{-1}) and Zn (2.9 mg kg^{-1}) are detected in the horizon (160-200 cm). Irrigated alluvial soils are not polluted with heavy metals: their concentration in the soil does not exceed the maximum permissible limits.

Key words: heavy metals, soil properties, river meadow, alluvial soil

Introduction

In conditions of soil degradation and climate change, food security in the Republic of Moldova can be ensured by using alluvial soils near the Dniester River and expanding areas with irrigated soils in these areas. The most suitable areas for the development of irrigated agriculture are the lands in the river meadows with typical and strongly evolved alluvial soils. On the territory of the Republic of Moldova, within the lands with agricultural destination, the alluvial (meadow) soils occupy the surface of about 117 thousand ha (26). A major interest in expanding agriculture and irrigation is the evaluation of heavy metals in the alluvial soils of the Middle Dniester meadow.

In the middle course of the Dniester (from Nijnee to Dubasari) (8), there are six terraces, mostly under arable land, but also ocuped by orchards, gardens, vineyards, field crops. In the middle course of the river the riverbed is more strongly meandered than in the upper one, the length of the meanders reaching 12-15 km, and the radius of the arches 2-10 km.

The external appearance and condition of the Medial Dniester ecosystems during the last decades have undergone cardinal changes. The instability of the hydrological regime was expressed by the redistribution of the annual flow of the river, the sudden fluctuations of the level and flow, contributed to the spread of aquatic plants in the riverbed. The long period of drought led to a considerable decrease in water flow speed and in the river part of the Middle Dniester. This in turn favored negative changes in terrestrial and aquatic ecosystems, intensified the processes of degradation of soil resources, intensified the processes of erosion on slopes, changed the vegetal composition of pastures, etc. The modified thermal regime of the middle sector of the Dniester also disrupted the natural process of self-purification of the basin (5).

On the territory of the Dniester district, typical alluvial soils are quite widespread in river meadows, occupying 10.2% of the country's territory, over 55% of them are salinized. The high degree of agricultural use of land in the Dniester district has a significant impact on the environment quality, affecting the ecological balance of ecosystems, causing soil degradation and desertification processes (23).

The soils on the Dniester district, due to the predominantly fragmented relief, especially in the central part, are intensely subjected to geodynamic processes, but also to significant anthropogenic impact caused by excessive deforestation, destruction of forest belts and riparian protection areas, irregular or poorly managed hydrotechnical works, excessive and uncompensated exploitation of mineral and organic reserves, etc. Even in the lower course of the Dniester, where the relief is quite smooth and soil erosion is not so pronounced, the loss of fertility of arable land due to erosion is estimated at 43.4% (29).

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Material and method

The typical arable alluvial soils from the Middle Dniester meadow (Jora de Mijloc village, Orhei district) were selected as objects. Soil profiles up to a depth of 200 cm were placed on the land selected for research, from which soil samples were collected on genetic horizons. Heavy metals were determined by the method of atomic absorption spectrophotometry.

The soil cover was formed, for the most part, on Quaternary sediments, represented by clays, clay-sandy soils and sandy-loamy soils (especially in the floodplain of the Dniester). There are two main types: floodplain soils and soils on the terraces of the Dniester, where chernozems with full profile predominate.

Alluvial (meadow) soils are representative in the soil cover of the area. Floodplain soils are new alluvial soil formations in the Dniester river basin. Alluvial processes include on the one hand the erosion of the riverbed, which causes the periodic "*rejuvenation*" of the riverbed and the adjacent sectors of the meadow, and on the other hand accumulations on the surface of the meadow of solid river runoff. In the Dniester meadow there is a periodic flooding of its meadow with water from the river; In such cases the soils and the whole layer of alluvial deposits are considerably moistened. The flood conditions a hydromorphic character of soil formation on the meadow territory. An important feature of meadow soils is their high biogenesis, conditioned by the acceleration of the circuit of substances and the process of soil formation.

Alluvial soils, as a result of different conditions of manifestation of solification, zonal climate, origin of river deposits, their texture and composition, depth and mineralization of ground-water, are characterized by a very large variation of physical, chemical and geochemical properties. Arable use and irrigation act differently on the quality status of alluvial soil varieties, geochemical composition, their production capacity. In order to assess the physico-chemical and geochemical quality (migration and accumulation of heavy metals) of alluvial soils, further research is needed for the correct use of these soils in sustainable agriculture. The research area is an area where two ecosystems intertwine: natural pasture and agricultural ecosystem, which is also called - ecoton (4, 10, 31).

Results and discussions

The high contents of heavy metals in the soil present a direct risk of soil pollution and therefore affect the plants that absorb them, the animals that consume those plants and implicitly humans. If not recognized and treated properly, heavy metal toxicity can lead to morbidity and mortality. The accumulation of heavy metals in agricultural soils is associated with the use in agriculture of mineral fertilizers, plant protection products, organic waste, etc. At the same time, heavy metals are also considered microelements, because they are used by plants in very small quantities. The microelements are Fe, Mn, Cu, Zn, Ba, Ti, Li, I, Br, Al, Ni, Mo, As, Pb, Va, Rb, and others (22, 30, 32). When a necessary chemical element is missing or insufficient in plant nutrition, physiological diseases appear, accompanied by the slowing down or stopping of the growth of the root, stem, leaves, or fruits (28).

Manganese (Mn) has a stimulating role in plant growth, flower formation, synthesis of vitamins and carbohydrates. In glycolysis as in other processes in which phosphorylation is present, an important role is played by the presence of manganese, Mn ions activate various enzymes (1, 9). Mn ions lead to a higher activity of peroxidase in wheat grains induced by additional nutrition with Mn, but also a more intense catalysis activity. Manganese is needed to reduce nitrates. Manganese promotes the multiplication of bacteria from nodules to legumes, as well as the accumulation of a larger amount of nitrogen, by activating the enzyme system that catalyzes the reaction between hydroxylamine and glutamine derivatives. Mn supplementation promotes vitamin C content in tomatoes and cucumbers (12, 13).

The total Mn content in the typical alluvial soils is within the limits of 383 and 901 mg kg^{-1}. The values of the total Mn fall within the limits determined for the soils of the Republic of Moldova (150-2250 mg kg^{-1}), the average content being 790 mg kg^{-1}. The upper horizon of the alluvial soil contains 830 mg/kg of Mn, and the lower ones (carbonate) - 383-510 mg $kg^{-1}$of total Mn.

The mobile Mn content in the upper soil horizon of the Republic of Moldova varies between 0.4-195 mg kg^{-1}. The values of Mn content accessible in the studied alluvial soils are between relatively average limits (43.6-89.4 mg kg^{-1}), with a distribution very close to that described by the normal distribution law. As a result, the upper part of the soils has higher contents of accessible Mn than the middle glazed part. The highest Mn content (89.4 mg kg^{-1}) was found in the glazed layer 81-110 cm, which shows the existence of a glycemic geochemical barrier. The mobile Mn content has three maximum accumulations in the studied soils: in the humic horizon of the profile (0-23 cm) - 74.6 mg kg^{-1} in the gleyic horizon (81-110 cm) - 89.4 and

in the lithological horizons (160- 180 cm) - 66.8 mg kg^{-1}. Therefore, the distribution of mobile Mn in the alluvial soil profile cannot be described as uniform (Fig.1).

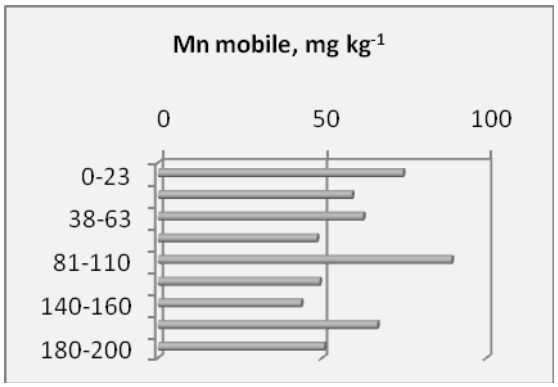

Fig. 1 - Mobile Mn content in typical alluvial soil

Copper (Cu) is part of the chemical composition of many substances used in agriculture. Copper is essential for all plants and has a role in chlorophyll formation, seed germination, increasing drought resistance and water supply. Controls respiration and protein synthesis. Cu is the component of phenoloxidase, lactase, ascorbic acid and oxidase. The copper content in plants varies from traces to 46 mg kg^{-1}.

Lack of Cu from the plant is manifested by wilting of young leaves on potatoes, bleaching of leaves on salad. In cereals, the tips of the plants turn white, the leaves turn and die, the growth of internodes is stopped. At an intense deficiency the spike does not form. It is also reported especially in trees and cereals. Thus, in trees, young shoots have leaves with burnt or chlorinated edges (15, 16), and flowering and fruiting are stopped. Cu deficiency occurs mainly on swampy or post-swampy soils (meadow alluvial soils), which is manifested by wilting and discoloration to a white shade of young leaves. The total Cu content in the soils of the Republic of Moldova is estimated at the limits of 2 - 400 mg kg^{-1}, with an average of 23 mg kg^{-1}. In the studied soils The total Cu is in the range of 24-72 mg kg^{-1}, which exceeds the average content for Moldovan soils.

The concentration of mobile Cu in soils varies in the range of 0.1-60.0 mg kg^{-1}, with an average of 1.6 mg kg^{-1}. The content values of Cu mobile in the researched soils oscillate between the limits (0.30-1.94 mg kg^{-1}). Distribution of Cu mobile demonstrates higher concentrations in the humifer horizon (0-38 cm) - 1.74-1.94 mg $kg^{-1}$and at the depth of the gleys horizon (38-81 cm). In the carbonate layer (110-180 cm) of the soil the content of mobile Cu is 0.30-0.45 mg kg^{-1} (Fig.2).

Zinc (Zn) is indispensable for plants. It is absorbed by them from the living environment in the form of ions. It is widespread in lower plants (algae and fungi) and in higher plants. Zinc enters the chemical structure of enzymes: carbohydrase, phosphatase and many dehydrogenases.

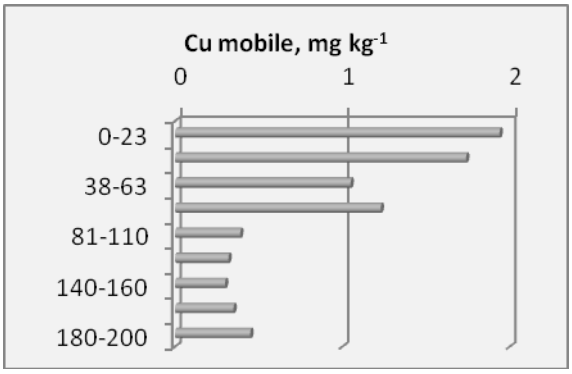

Fig. 2 - Mobile Cu content in typical alluvial soil

A good supply of Zn favors the increase of the content of tryptophan, a known precursor of auxin, and as a result the presence of auxin in the plant kg is favorably influenced (18). Zn increases the soluble sugar content, has an action on the viscosity of the protoplasm, due to the decrease in free water content (7). Zn has a role in chlorophyll synthesis, plant growth, increased resistance to drought and frost, in the fixation of nitrogen by legumes (14).

Zn deficiency in plants is manifested by the reduction of their growth, the arrangement in the rosette of the terminal branches and leaves, the yellow staining of the leaves, is manifested from the top of the plant to its base. In tobacco, vines, barley, sunflower appears the disease of *"small leaves",* in corn - bleaching of leaves. These plants are most sensitive to the lack of nutrition in zinc. Wheat, rye, oats and peas are less sensitive.

The maximum permissible limit for the total Zn content of the soil is 300 mg/kg (20). Anthropogenic sources of Zn are significant, coming mainly from industrial and agricultural activities, waste, etc. In the surface environment it has a moderately high mobility, limited by its tendency to be adsorbed on MnO_2 and by the insoluble organic matter in soils (32).

The total Zn content in Moldovan soils is estimated at the limits of 10-166 mg kg^{-1}, with an average of 71 mg/kg. In alluvial soils the total Zn content is in the range of 38 and 77 mg kg^{-1}. Accumulations of Zn are observed in the humic layers - 69 mg $kg^{-1}$and in the carbonate layers - 72 mg kg^{-1}, which does not exceed the average content for the soils of the Republic of Moldova. Lower

values of content are detected in the gleic horizons: 38-54 mg $kg^{-1}$of Zn.

The mobile Zn contents determined in typical alluvial soils vary in wide limits (0.47-2.78 mg kg^{-1}), with an important dominance of the contents in the deep layers (110-160 cm), in which 205-208 mg Zn/kg. These Zn concentrations are due to lithological genesis. In the soil profile the distribution is not uniform, it has two accumulations - in the humic and carbonate layer (Fig.3).

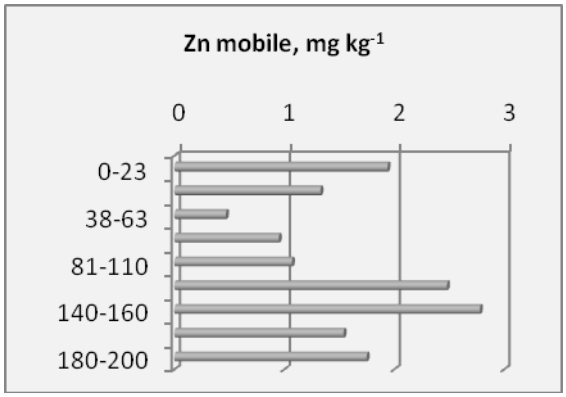

Fig. 3 - Mobile Zn content in typical alluvial soil

Zinc is an element with reduced mobility. The concentration of mobile forms Zn does not exceed the permissible limits for Moldovan soils - 4.9 mg kg^{-1}.

Cobalt (Co). The maximum permitted limit for the total Co content of the soil is 50 mg kg^{-1} (20). In soils, cobalt is found in various compounds in the form of ions (Co^{2+}), present in the soil solution, adsorbed on the surface of colloidal particles, bound to organic matter, sesquioxides or present in the crystal structure of clay minerals or other minerals in the soil. Geochemical mobility in soils is mainly controlled by Co adsorption and co-precipitation with Mn and Fe oxides. Anthropogenic sources of Co in soils include: pesticides and fertilizers. Co-pollution environment problems are generally less significant than those associated with other heavy metals (2, 27).

The total Co content in Moldovan soils is on average 13 mg kg^{-1}, and the limit values in the range of 4-18 mg kg^{-1}. In the studied soils the total Co is in the limits of 8-13 mg kg^{-1}. Higher amounts are detected in the second part of the profile: in the gleyic layers: 13 mg kg^{-1}.

The content of mobile Co in the upper horizon of alluvial soils is 0.64 mg kg^{-1}, with a visible increase in depth - 0.89 mg kg^{-1}in the soil layer 38-63 cm. Higher content was determined in the gleic layer (63-81 cm) - 1.59 mg kg^{-1}, with a significant decrease in depth - 0.35-0.45 mg kg^{-1} (Fig.4). In the investigated soils, the Co content in the surface layer demonstrates a weak association with the organic matter in the arable layer 0-23 cm.

Accessible Co concentrations recorded in the studied soils oscillate in a fairly wide range, determined by the limits of 0.31 and 1.59 mg kg^{-1}, which suggests a distribution belonging to the natural geochemical background.

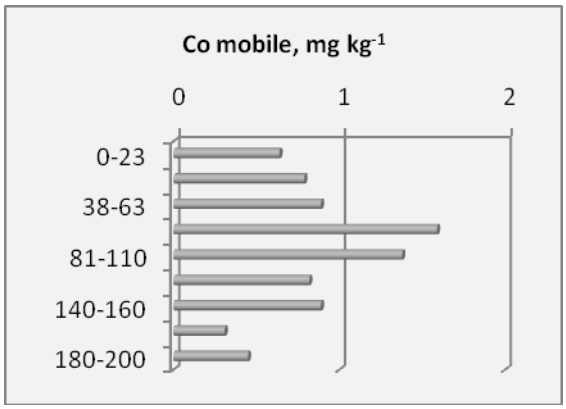

Fig. 4 - Mobile Co content in alluvial soil

Lead (Pb) has no known biological function, but is recognized as toxic to plant and animal life when present in ionic form. Because it behaves similarly to calcium, it is concentrated in the human and animal skeletal system. The total Pb content in Moldovan soils is in the range of 5-30 mg kg^{-1}, with an average of mg kg^{-1}. The values of the total Pb contents determined in the alluvial soils are within the average limits: 10-18 mg kg^{-1}, which suggests a distribution between the normal limits for this element. Typical alluvial soils are characterized by a Pb content that decreases in the depth of the profile. Two accumulations are outlined in the profile of the studied soils: one in the upper part and the second, more pronounced in the lower part of the profile, at a depth of 160-180 cm.

The mobile forms of Pb in alluvial soils are estimated in the wide limits: 0.65-1.37 mg kg^{-1}, which exceed the average for Moldovan soils are: 0.4 mg kg^{-1}. Higher concentrations are detected at the top of the profile, with significant decreases in depth (Fig.5).

Chromium (Cr) is considered one of the most harmful heavy metals for human health (17). The uses of Cr are: in stainless steels, numerous alloys, Cr plating, pigments, catalysts, dyes, tannins, wood impregnation, refractory bricks, magnetic strips (27).

The total Cr contents in alluvial soils were estimated at 177 and 236 mg kg^{-1}. The average values for Moldovan soils are equal to 91 mgCr/kg of soil, and the variation limits are 25-145 mg kg^{-1}. Thus alluvial soils contain total Cr above the

allowed limits, emphasizing a significant accumulation - 1.9-2.6 times more than the limits.

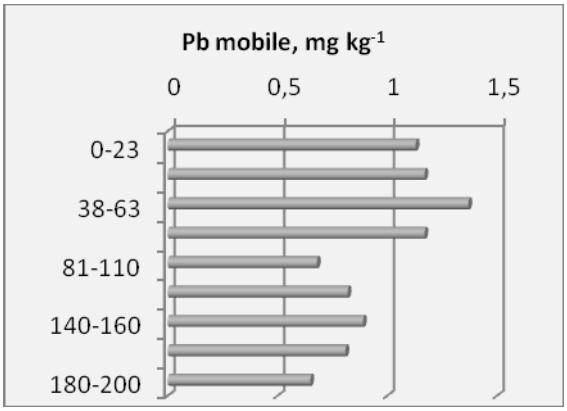

Fig. 5 - Mobile Pb content in typical alluvial soil

The content values determined for mobile Cr in the soils of the researched area range from 1.32-2.54 mg kg^{-1}. The mobile Cr distribution in the researched soils appears to be very close to a natural one, with higher concentrations in the humifer horizon (0-23 cm) - up to 2.54 mg kg^{-1}. In alluvial soils the biogenic accumulation takes place in the humic layers, with decreases in depths, proportional to the organic matter content (Fig. 6).

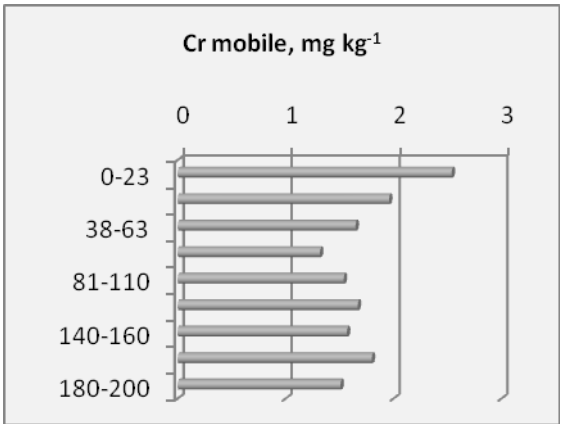

Fig. 6 - Mobile Cr content in typical alluvial soil

Cadmium (Cd) reaches the environment in three important ways: refining and using Cd, melting Cu and Ni ores and burning fossil fuels. The percentage level of Cd load in the sewage sludge is a problem in terms of its discharge and limiting or preventing the application of sludge on land as fertilizers. Increased use of Zn in fertilizers can lead to Cd contamination. Phosphate fertilizers contain between 5 and 100 mg kg^{-1}Cd, and up to 300 mg kg^{-1}Cd can be present in the sewage sludge.

This enrichment of Cd in the soil has several possible causes: anthropogenic pollution due to the chemical fertilizers used in agriculture; possible upward movement in soils due to repeated re-precipitation; and association with organic matter, which is more abundant in the surface of the soil.

The maximum permitted limit for the total Cd content of the soil is 3 mg kg^{-1} (20), equal to the value of the alert threshold for a sensitive use of the soil, and the value of the intervention threshold for the same type of use is 5 mg kg^{-1}. Cadmium belongs to the same group (II) as Zn of the periodic table and as a result has many properties in common. In the soil surface, it has a good correlation with Zn, Mn, Pb and a poor correlation with Co and Cu (19). The average concentration of total Cd in Moldovan soils is 0.41 mg kg^{-1}, and the permissible limits are 0.2-0.84 mg/kg. Higher Cd contents are detected in the upper part of the profile - up to a depth of 110 cm, constituting 1.09-1.26 mg kg^{-1}. These values can be considered high for alluvial soils compared to the average content for Moldovan soils. Taking into account the pedogenesis of these soils, these values are admissible.

The content of mobile Cd is in the range of 0.01-0.3 mg kg^{-1}, and the average is 0.04 mg/kg (6). Cd mobility in alluvial soils and their accumulation in the upper horizons is amplified by the low content of organic matter and their texture. In the upper part of the studied soil profile, the concentration of mobile Cd forms is higher (0.30 mg kg^{-1}), than in depth (in the parent rock) - 0.18 mg kg^{-1}. Cd accumulates at a depth of 81-140 cm (gleyic horizons) - 0.33 mg kg^{-1} (Fig.7).

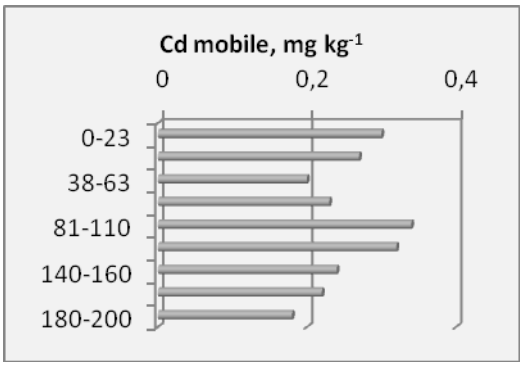

Fig. 7 - Mobile Cd content in typical alluvial soil

The studied alluvial arable soils are moderately evolved, therefore Cd accumulates depending on the organic matter and the texture of the layers, but the abundance of Cd predominates in the upper and middle part of the profiles.

Nichel (Ni). The maximum allowable limit for the total Ni content in the soil is 50 mg kg^{-1} (20, 24). No biological role is known for Ni. Anthropogenic sources of Ni in agricultural soils include fertilizers (30). The total Ni contents in the

alluvial soil profile are between 10 and 12 mg kg^{-1}, values that fall within the allowable limits (5-75 mg kg^{-1}) for Moldovan soils. The average total Ni content in the country's soils is estimated at 39 mg kg^{-1}. The total Ni content in alluvial soils is 4 times lower than the average content.

The mobile Ni contents determined in alluvial soils are between the limits: 0.46-1.67 mg/kg, values that exceed the limit of the normal ones (0.80 mg kg^{-1}) for Ni in the humic and gleyic layers (Fig.8).

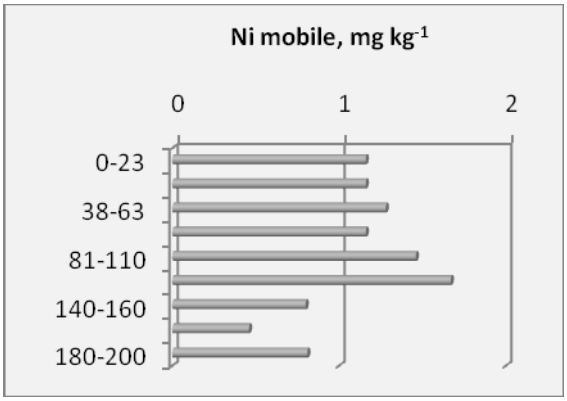

Fig. 8 - Mobile Ni content in typical alluvial soil

These concentrations suggest a natural distribution of Ni in the researched soils, disturbed only to a small extent by irrigation. From this it can be deduced that, on the thickness of the soil profiles, the Ni contents have an increased variation.

Iron (Fe) is found in the soil in the form of amphoteric oxides or hydroxides. In the soil surface horizons the most abundant are the hydrated happy oxides. In these horizons the total iron content oscillates, on average between 1.5 and 3.0% Fe in luvic soils, between 3.8 and 4.8% Fe in chernozems and between 5.7 and 12.5% Fe in soils of blond earth type. In soils rich in organic matter, iron is present in the soil solution as a bivalent ion or is retained by adsorption in the form of ferric hydroxide, insoluble and inaccessible to plants (40).

Iron is used by plants in the form of ferrous salts. It is absorbed by terrestrial plants through the root system, and by aquatic plants, submerged throughout their body in the form of ions. Iron is a microelement with a catalytic role and a dynamic role. It is present in large quantities in spinach, nettle and tea. Iron deficiency in plants causes the leaves to turn yellow and slow down their growth. In general, soils contain enough soluble iron necessary for plant nutrition. Insufficiency is caused by a number of factors, the most important of which are the alkaline reaction and the calcium carbonate content, most of which is active. Iron is needed for the enzymatic synthesis of chlorophyll in plants.

Alluvial soils contain enough total iron: 2.34-3.40%. The legitimacies of distribution are manifested by the increase of the content in depth, the gleic horizons with higher content of total Fe are highlighted. In the investigated soils, the distribution of mobile Fe content varies between high limits: 4.65-39.23 mg/kg of Fe (Fig.9).

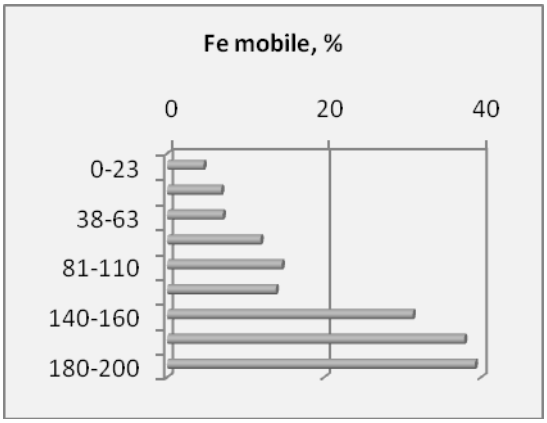

Fig. 9 - Mobile Fe content in typical alluvial soil

This distribution is apparently a consequence of the variability of the pedogenesis of alluvial soils in the investigated area, as well as of the various land uses. The lower Fe content is, with few exceptions, characteristic of the upper layers of alluvial soils. Soils with an Fe content higher than 12 mg kg^{-1}Fe are found in deep gleyic layers. The distribution of Fe in the investigated soils can be shown to be natural, only slightly affected by anthropogenic factors - arable use and irrigation. The content of Fe mobile forms in the deep of horizons varies between 31-39 mg kg^{-1}. The distribution of Fe in alluvial soils indicates its accumulation at 160-180 cm. In general, alluvial soils contain enough soluble Fe for plant nutrition.

The ecological situation in the researched area. Several problems contribute to the degradation of natural resources in the area. First, there is a lack of an area management body that could protect biodiversity and provide sustainable development in the region. Natural forest and grassland ecosystems have a relatively small area and are isolated, being surrounded by extensive arable land and artificial plantations. Agriculture has greatly contributed to the degradation of steppe vegetation. The system of forest curtains along the waters is poorly preserved and protected.

Irregular grazing is practiced, mainly on meadows and edges. Likewise, it is sewn unsystematically, the floristic composition being

modified, and the grassy carpet of the meadows becoming degraded and weeded. The steppe lands occupy, mainly, steep slopes impassable for agriculture, which are affected by landslides and grazing. At present, no measures are being taken for the care and reconstruction of pastures.

In terms of actions to improve the ecological situation in the region, local land development plans are currently lacking, including landscape development plans, anti-erosion measures and soil condition monitoring. One reason is that the legislation does not provide for a control mechanism and an obligation to take appropriate action. Another cause is the almost total lack of proper crop rotation, which is based on perennial forage crops. Some private agricultural sectors are located right on the riparian water protection strip, which is forbidden (23, 26, 30].

Agriculture is a very important source of pollution that makes a significant contribution to soils and especially to areas where intensive agriculture is practiced. The main sources with potential polluting character in this area are: - impurities from fertilizers containing: Cd, Cr, Mo, Pb, U, V, Zn; - sewage sludges containing: Cd, Ni, Cu, Pb; Zn and many other elements; - organic residues from animal husbandry, in particular pigs and poultry, containing: Cu, As, Zn; - pesticides containing: Cu, As, Hg, Pb, Mn, Zn; - compost wastes (not necessarily used in agriculture) containing: Cd, Cu, Ni, Pb.

Most agricultural and horticultural soils are regularly fertilized with chemical and organic fertilizers. The concentration of heavy metals in these materials used as chemical fertilizers, organic fertilizers, amendments and composts in agricultural waste can be important sources of heavy metals. Chemical phosphorus fertilizers are an important source of Cd in soils and can have an acidifying effect and therefore facilitate the mobilization and advanced absorption of Cd in plants. Organic fertilizers contain many metals in differentiated assortment and high concentrations. Organic pig and poultry fertilizers have high Cu and Zn contents in addition to as which is used in feed (22).

However, the beneficial properties of sludge are limited by their content in potentially hazardous substances such as heavy metals and organic micro-pollutants (pesticides). Although all sludge contains a wide variety of metals and other contaminants in different concentrations, those in industry have the highest metal content. Heavy metals are most likely the cause of problems for agricultural products obtained on soils fertilized with sludge and which have high contents of Cd, Cu, Ni and Zn.

Due to the high concentration of heavy metals in used sludge, they are an important source of pollution when used. Due to the relatively small percentage of agricultural land on which used sludge is applied, it remains a less important source for many heavy metals (3, 11).

Heavy metals are toxic when they reach concentrations close to the maximum allowable limit. The control and quality of plant foods is a major problem for the health of the population, due to the negative implications of heavy metals in the metabolism of the human body. Tracking the pollution of agri-food products with heavy metals is a current problem, the respective chemical species are complexed with organic or inorganic ligands, which influences their toxicity.

The overall effect of heavy metal pollution is to reduce soil fertility and worsen plant nutrition conditions, influencing their growth and development processes. Inorganic toxins influence the growth and development processes of plants, the process of photosynthesis and the water absorption regime (15, 25). Pollution of soils with heavy metals had the effect of acidifying them and debasifying the absorbed complex. At the same time, the quality of organic matter is degraded by increasing the content of fulvic acids that form with heavy metals compounds with an advanced degree of mobility and accessibility for vegetation (27).

As a result of pollution, there are imbalances in the mineral nutrition of plants. These nutritional imbalances are due both to the general unfavorable nutritional conditions (acid reaction, low content of phosphorus, calcium and magnesium) and to the passive absorption of air and soil pollutants, which have a toxic effect on plant tissues. The result of these imbalances is the reduction of growth, premature drying of vegetation, disappearance of fruiting and thus decreased production.

Among the major metallic pollutants, Pb and Cd occupy the first place being non-essential elements of living organisms. Cu and Zn are essential elements of organisms, they become toxic only beyond certain limits. Due to the interaction of heavy metal ions with proteins, a strong inhibitory action is exerted on the enzyme systems. The initiated reactions take place at the level of the cell membrane and are followed by the penetration of toxic substances into the cells, with changes in its normal physiology (15). Therefore, in nature there are no plant-friendly or unfavorable elements, it all depends on the amount available to the plants, the same element can exert favorable effects (in optimal doses) or unfavorable effects (in insufficiency or excess).

Conclusions

The main feature of the composition of heavy metals in the profile of arable alluvial soils is the relatively high content of total and mobile forms in the humiferous horizon (0-23cm), due to their biogenic accumulation. On the other hand, although a stratification of the profile of alluvial soils persists, in them there is a general pattern of distribution of heavy metals, reflected by a reduction of Mn, Cu, Pb, Ni and an increase of Zn, Co, Cr, Cd, Fe from top to bottom, with 3 accumulation maxima: biogenic, gleyic, carbonate.

Arable alluvial soils have a higher content of chemical elements in the profile, especially in the humus horizon, which is related to the specific conditions of their formation, geomorphological characteristics, hydrological regime, etc. Thus, in arable alluvial soils about 50% of the total reserve of total heavy metal forms are concentrated in the upper part of the profile.

In general, with regard to the biogenic accumulation capacity in the humus horizon of arable alluvial soils (0-23 cm), the mobile forms of microelements are located in a decreasing series: Mn> Cr> Zn> Cu> Ni> Pb> Co> Cd; total forms: Cr> Cu> Zn> Mn> Pb> Ni> Co> Cd.

The distribution and accumulation of Mn, Cu, Zn, Cr, Cd, Pb, is associated with the biogenic accumulation in the soil layer of 0-23 cm. The accumulation at the geochemical barrier (61 cm) is obvious - the beginning of the gleic profile. In the buried humic horizon (81-110 cm) the total and mobile forms of Mn (900 mg/kg) and Fe (3%) accumulated. In the carbonate layers (140-200 cm) the maximum accumulations of Zn, Co, Cr, Ni and Fe (38 mg/kg) are detected.

Typical arable alluvial soils are not polluted with heavy metals: their concentration in the soil does not exceed the maximum limits allowed for the soils of the Republic of Moldova. Under proper management, alluvial soils can be productive for a wide range of dryland crops, but due to the dry climate without irrigation, yields are small and very small. Barley, alfalfa and sunflower, and to a lesser extent winter wheat, are the most suitable crops. Under irrigation conditions, alluvial soils are widely used in vegetable growing.

In natural ecosystems, alluvial soils have a relatively low percentage of vegetation cover, consisting mainly of meso-xerophilous meadows on high ridges, or mesophilic meadows and willows on wet ridges. These soils, however, are very suitable for poplar forests, but also for sown meadows. The results on heavy metal content can be used to develop measures and recommendations on sustainable use, protection and quality improvement of alluvial soils in the Medial Dniester Meadow.

Rezumat

Solurile aluviale slab sau moderat evoluate irigate și neirigate din lunca Nistrului Inferior se caracterizează cu profil stratificat, sunt lutoase, negleizate, slab sau moderat humifere, cu profil humifer puternic profund, moderat carbonatice. Una dintre caracteristicile semnificative ale distribuției microelementelor în profilul acestor soluri sunt concentrațiile relativ ridicate a majorității formelor totale și mobile de elemente în orizonturile de adâncime, datorită levigării lor din orizont superior al profilului, o alimentare suplimentară cu apă freatică, și un conținut ridicat de substanțe organice implicate în fixarea elementelor. Solurile aluviale înțelenite diferă de cele arabile printr-un conținut mai ridicat de elemente în profil, mai ales în orizontul de humus, care este legat de condițiile specifice ale formării lor, caracteristicile geomorfologie, regimul hidrologic etc. Astfel, în soluri aluviale înțelenite și arabile aproximativ 50% din rezerva totală a formelor mobile de microelemente sunt concentrate în partea superioară a profilului. Distribuția și acumularea de Zn, Co, Fe, Mn, Pb, Cu este asociată cu acumularea biogenică în stratul de sol de 0-20 cm. Acumularea la bariera geochimică (57-80 cm) este evidentă - începutul profilului gleic. În orizontul humifer (80-95 cm) s-au acumulat formele mobile de Cd și Ni. În orizontul gleic (160-200 cm) sunt detectate acumulările maxime de Fe (47,7 mg/kg), Mn (52,4 mg/kg) și Zn (2,9 mg/kg). Conținutul de materie organică, pH-ul, oxizii, carbonații și conținutul de argilă au influențat concentrația de metale grele în solurile aluviale la barierele geochimice. Solurile aluviale irigate nu sunt poluate cu metale grele: concentrația lor în sol nu depășește limitele maxime admise.

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THE SUSTAINABLE MANAGEMENT OF THE PROCESSES OF SEQUESTRATION AND STABILIZATION OF THE ORGANIC CARBON IN CHERNOZEMS BY THEIR AGGREGATION-STRUCTURING

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ABSTRACT

The process of pedogenesis involves the development and synchronized and interdetermined evolution of the processes of formation-accumulation of humus and those of aggregation-structuring. Their interdetermined interaction materializes in the constitution of the system of organic substances, the humic profile and the aggregate system / aggregate profile of the soil. Within the pedogenetic profile, the humeral and the aggregate profile overlap quantitatively and qualitatively, being interdetermined.

Sequestration-stabilization of organic carbon in soils is the product of the concomitant realization of physico-chemical, chemical and biophysical mechanisms of structural organization of soil mass with the formation of pedogenetic formations characteristic only to soils whose basic function is sequestration-stabilization of organic carbon in soil.

Under agroecosystem conditions, the carbon-sequestrational potential of chernozems is reduced due to the quantitative and qualitative changes induced by agrogenesis. This involves only partially achieving the organic carbon sequestration function. In addition, agricultural works lead to the degradation of the structure, the intensification of humus mineralization processes and the increase of C-CO_2 emissions from the soil to the atmosphere.

Algalization contributes to the aggregation of soil mass structure even in the first year after administration. Newly formed aggregates have loose organization and reduced hydrostability.

In order to increase the degree of compaction-consolidation of the newly formed aggregates, it is recommended to cultivate multiannual grasses and administer once in 4-5 years 5 t / ha of amendments with calcium-waste from the sugar industry and the thermal energy branch.

Key words: management, processes, organic carbon, chernozems

Introduction

Inventory of sources, identification of leaks and quantitative release of carbon fluxes into the atmosphere is one of the basic conditions for the development of long-term strategies and tactics aimed at mitigating climate change.

The global balance of carbon dioxide in the atmosphere is determined by the volumes of its emissions from natural and anthropogenic sources.

Soils are the main *"warehouse"* of carbon in the biosphere. The global content of organic carbon in the soil 4 times exceeds the content of biotic carbon and about 3 times that of the atmosphere.

The humusosphere of soil resources accounts for 2/3 of the total organic carbon content in terrestrial ecosystems.

The average lifespan of carbon in the atmosphere is 5 years, in plant biomass 10 years, and in soils 35 years. Thus, soils not only store organic carbon but preserve it for a longer period of time. According to calculations, some fractions of humus have a lifespan expressed in thousands of years.

Soils also play a major role in the transfer of carbon from the atmosphere to the lithosphere through the process of photosynthesis. In this sense, one of the basic ecosystem functions of soils is the storage of both plant and animal organic residues, their biochemical decomposition-transformation with the formation of humus, a specific organic substance characteristic only of pedogenesis.

Carbon transfer from the atmosphere to plant biomass, decomposition, transformation and humification of organic dead soil, humus formation and conservation of organic carbon for a long time with minimal risk of return to the atmosphere is the global process of *"sequestration of carbon in the soil"*.

Quantitative carbon sequestration in soil is assessed based on sequestration potential and soil / ecosystem sequestration capacity.

The sequestration potential of soils / ecosystems characterizes the intensity of carbon flow in soils with organic residues and fertilizers. It is 0.4-1.2 G / year. (Lal R., 2004).

The ability to sequester carbon in the soil reflects its feature of stabilizing and conserving in

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the composition of humus the carbon contributed to the soil with organic matter (organic waste and fertilizers).

Z.S. Artemieva and N.P. Chirillova (2017) find that the ability to sequester organic carbon in the soil under optimal conditions of temperature and humidity in natural ecosystems is reduced in the following sequence: leached chernozem> molic brown soil> typical brown soil> typical gray soil> fallow soil – podzol > tundra soil.

At humidities higher or lower than optimal, the ability to sequester carbon in the soil is reduced by 1.2 times. The change in humidity affects the processes of mineralization of organic waste and to a lesser extent of humic substances.

In the absence of organic residues in soils, the intensity of humus mineralization processes intensifies. At the same time, the biogeochemical circuit of carbon in the soil-atmosphere-soil system is influenced by a series of other internal factors (granulometric distribution, total volume and structure of the porous space, degree of compaction, etc.) and external (geomorphological, hydrogeological, climatic etc.). In the agricultural regime it is influenced by the category of use, the structure of the crops, the system of work and fertilization. Therefore, unlike the industrial and anthropogenic circuits that are available for control and limitation, the anthropo-natural one is difficult to control. Moreover, the artificial limitation of the mineralization of organic substances in the soil leads to the reduction of the production process of the crop plants and the reduction of the amount of CO_2 fixed by photosynthesis.

As a result, an unbalanced carbon biogeochemical circuit was established in the chernozems of the Pridanubian space, caused by the reduction of the quantities of fresh humus produced annually in smaller quantities than those consumed in the production of crops (up to 1.6 t / ha / year). Under these conditions, the imperative of soil evolution, in arable and climate change regime, especially chernozems, implies the need to practice agricultural technologies based on the management of the priority role of humus formation and accumulation in the functioning of their bioroutine system. Achieving this goal involves the synchronized solution of problems related to ensuring the stability of agroecosystems, mitigating the effects of climate change and reducing the vulnerability of the agrosphere to climate change.

The main performance indicator of such agricultural technologies is the sequestration of organic carbon in the humus from which it is mobilized on the geological scale of time.

The sequestration of carbon in the composition of humus involves several important components:

- ✓ Pedovegetal - cultivation of plant species with intensive growth and subsequent incorporation of phytomass or part of it into the soil as a source of carbon and biophilic elements;
- ✓ Pedobiochemical - intensifying the production processes of microbial and algal biomass as a source of humus and its humidifying agent;
- ✓ Humus-genetical - intensification of humus formation and accumulation processes. This involves two intercalated mechanisms: humification and stabilization of newly formed humic substances in organo-mineral compounds.

In the context of sequestration of organic carbon in the soil, the aggregation-structuring process has a special role. According to calculations in the humic-cumulative molic horizon (Am) of chernozems, about 90% of the humus reserves are concentrated in the structural aggregates.

Through this prism of ideas, the purpose of this paper involves evaluating the place of humic substances in the aggregation-structuring of the agrogenic layer of typical moderately humiferous chernozems in the central area of the Republic of Moldova, the pedoecological micro-district periphery of the Central Forests.

Objects and methods of study

The research was carried out in production conditions during 2015-2018. The pilot land is characterized by a homogeneous soil cover represented by typical moderately humiferous, moderately thick chernozems with an Am-AmB-Bml-Bca2-BCca-Cca profile. The soils are characterized by a balanced particle size composition. In its composition the ratio of physical clay: physical sand (<0.01:> 0.01 mm) varies in the range 0.97-1.04 and denotes an increased structuring potential. The dispersion factor on the whole profile varies in a narrow range of values (9.3-11.6%) and indicates low contents (1-2%) of unassociated clay in aggregates (non-aggregate). Under these conditions, from 88.4 to 90.7% of the granulometric elements are associated in agronomically valuable microaggregates with dimensions> 0.01 mm. The granulometric index of IGS structuring in all cases has values of about 100%. The content of agronomically valuable aggregates (0.25-10 mm) has values> 70%. At the same time, however, the content of hydrostable aggregates> 0.25 mm has values <35%. The main factor limiting the realization of the structuring potential is the low humus content. The instability index of the structure (IES = humus content,%: fine clay content (<0.001

mm)), even in the horizon Am makes up only 0.16-0.14. In the BI horizon its values are reduced to 0.08. Under these conditions, the amount of humus is insufficient to ensure the physico-chemical processes of association of elementary particles and microaggregates into structural aggregates. The amount of humus formed annually does not cover the amount of mineralized annually. At the same time, the required content of mobile humic substances that are the main factor of aggregation-structuring of the soil substance is reduced to a minimum (0.18-0.2%). As a result, the soils attest to the uncompensated (regressive) reproduction of the structural-aggregate state. The reduction of the weight of the aggregates formed with the participation of humus leads to the decrease of the hydrostability of the structure. When moistened, the aggregates dissolve easily into microaggregates and elementary particles. As a result, intensive humus mineralization takes place.

The soil samples subjected to the analyzes were collected from the layer 0-50 cm over every 10 cm at the beginning and end of the vegetation period.

Granulometric analysis was determined by the pipetting method - soil preparation with sodium pyrophosphate. Microaggregate analysis was performed by the pipetting method. The aggregate composition was determined by the Savvinov method (dry fractionation). Aggregate stability was determined by the Savvinov method (wet fractionation). The soil humus content and structural aggregates were determined by the Tiurin method in the Simacov modification.

The scheme of the experimental field is presented in tab. 1.

Table 1 - Scheme of experiences

Culture: Sunflower	**Culture: Corn**
Control	
Nostoc linckia – 3 kg/ha	*Nostoc linckia* – 3 kg/ha
Calothrix gracilis - 3 kg/ha	*Calothrix gracilis* - 3 kg/ha
Nostoc gelatinosum - 3 kg/ha	*Nostoc gelatinosum* - 3 kg/ha
Combined lot (*Nostoc linckia*+ *Calothrix gracilis*+*N. gelatinosum*) – 3 kg/ha	Combined lot (*Nostoc linckia*+ *Calothrix gracilis*+*N. gelatinosum*) – 3 kg/ha

Material and discussions

I. Sequestration of organic carbon in the soil.

The process of sequestration-stabilization of organic carbon in the soil is interspersed with the process of humus formation and accumulation. In this context, V. Seminov and B. Kogut distinguish processes of humus formation (formation of organic substances and humus) and humification processes (formation of humic substances) (Seminov V., Kogut B., 2015).

In the opinion of the cited authors, the sequestration - stabilization of organic carbon in the soil represents the totality of processes and phenomena that contribute to increasing the stability of organic substances in relations with biophysical and abiotic factors of decomposition and ensuring a longer period of rotation in soil.

Sequestration-stabilization of the organic substance is performed within a wide range of physical and physico-chemical processes, these being part of the mechanisms of formation of micro- and macro-aggregates.

Z.S. Artemieva and N.P. Chirillova claim that the processes of humus formation in the soil and those of structuring are closely linked, moreover this connection being unidirectional (Artemieva, Kirillova, 2017). We can assume that the start of the humus formation process is synchronized with the start of the coarse microaggregate formation processes (> 0.01 mm). In this sense, the formation of humus implies its stabilization materialized in the formation of microaggregates, which in turn improve the pedofunctional environment for the process of humus formation. Therefore, the stabilization of organic carbon in microaggregates involves the integration of organic matter (biotic) with the mineral (abiotic) at the lower level (organo-mineral complex) to form the soil aggregate system.

In soils in which the aggregate stabilization is controlled by the organic substance, a directly proportional dependence is achieved between the decomposition of the organic matter and the dynamics of the degree of aggregation.

In the agricultural regime, the disaggregation processes are intensively developed in connection with what changes the microaggregatic composition of the soils.

The research of several authors finds a directly proportional dependence between the organization of microaggregates and the granulometric composition - the degree of microaggregation

increases as the content of physical (> 0.01 mm) and fine (> 0.001 mm) clay in the soil increases.

The mentioned legitimacies materialized in the typification of the organo-mineral complexes of the upper horizon of the zonal soils from the Center of the Russian Platform adapted to the humus state, the sense of the anthropo-natural evolution of the chernozems in the Pridanubian space.

Table 2 - Typification of organo-mineral complexes (Артемьева З.С., Семеновна В. И., Силёва Т. М., 2009)

Type. Fine clay content,%	**Subtype; Humus content,%**			
	1 (0-2)	**2 (2-4)**	**3 (4-6)**	**4 (>6)**
I (0-10)	Slightly clayey, low humiferous	Slightly clayey, moderately humiferous	Slightly clayey, strongly humiferous	Slightly clayey, very strongly humiferous
II (10-20)	Moderately clayey, low humiferous	Moderately clayey, moderately humiferous	Moderately clayey, strongly humiferous	Moderately clayey, very strongly humiferous
III (20-30)	Strongly clayey, low humiferous	Strongly clayey, moderately humiferous	Strongly clayey, strongly humiferous	Strongly clayey, very strongly humiferous
IV (30-40)	Hyper clayey, low humiferous	Hyper clayey, moderately humiferous	Hyper clayey, strongly humiferous	Hyper clayey, very strongly humiferous

The first type (I) is characterized by a high degree of dehumidification and disaggregation, moderate and high degree of destructuring and supercompaction. Soils with such a type of organization of the soil aggregate system are characterized by a maximum degree of agrogenic degradational changes. It has a very high degree of vulnerability to structural degradation and mineralization of humic substances.

Type two (II) is characterized by a moderate degree of dehumidification, a moderate and high degree of disaggregation and destructuring and a large range of variability of the degree of overcompaction. It is characterized by a moderate degree of vulnerability to agrogenic degradation.

Type three (III) is characterized by low and moderate degree of dehumidification and disaggregation, but with a wide range of degree of destructuring and low degree of overcompaction.

Type four (IV) is characterized by low and moderate degree of dehumidification, disaggregation and destructuring, low degree of overcompaction.

Biophysical and chemical processes of stabilization of organic substances and sequestration of carbon in the soil involve the following stages (cited after Seminov and Kogut, 2015).

1) Formation of nuclei from organo-mineral complexes: nuclei of microaggregates can be colonies of microorganisms, the polysaccharide secretions of which form capsules that attract clay particles to their surface. They cover the capsules and prevent the decomposition of microbial organic matter;

2) Binding of organo-mineral nuclei by means of binders (oxides, hydroxides, clay minerals, humic substances) in microaggregates.

3) Binding of microaggregates to macroaggregates by means of binders with low stability (polysaccharides of microbial and vegetable origin) whose content is dynamic. Their content is maximum during the period of maximum biological activity of soils: April-June (Jigău, 2009).

4) Compaction-consolidation of aggregates under the action of plant roots, fungal hyphae, algae and microorganisms.

In parallel with the processes of aggregate formation, the porous space of the soils is formed.

Its dynamics is synchronized with the dynamics of the aggregate composition of the structure.

The physical model of aggregation and sequestration-stabilization of organic carbon in the soil is performed in the same sequence and involves several steps (Fig. 1).

The process of stabilization-sequestration of carbon and soil aggregation starts from the adhesion of elementary particles / microaggregates through microorganisms / algae on the surface of fresh plant residues with the formation of macroaggregates (stage 1).

The processes of transformation-decomposition of organic matter in aggregate pores lead to the formation of physically stable organo-mineral nuclei, protected by the action of mineralization processes (stage 2). Over time, as the reserves of organic matter, slightly decomposed, slowly deplete, microbial activity is reduced, and as a result the amount of binders (stage 3).

Consequently, the processes of destabilization and disaggregation of macroaggregates start, and new microaggregates are formed from the organo-mineral nuclei inside them, which can be involved in creating new microaggregates in the conditions of fresh organic matter flows (Stage 4).

Through this prism of ideas, aggregation-structuring is the main process of physical stabilization of organic carbon in the soil, and structural aggregates represent pedogenetic formations that sequester and stabilize organic carbon in the soil. In this sense, the structural aggregates are organo-mineral complexes formed as a result of the interaction of organic and mineral elementary particles within the processes of structural organization of the soil aggregate system (Fig. 2 – 3).

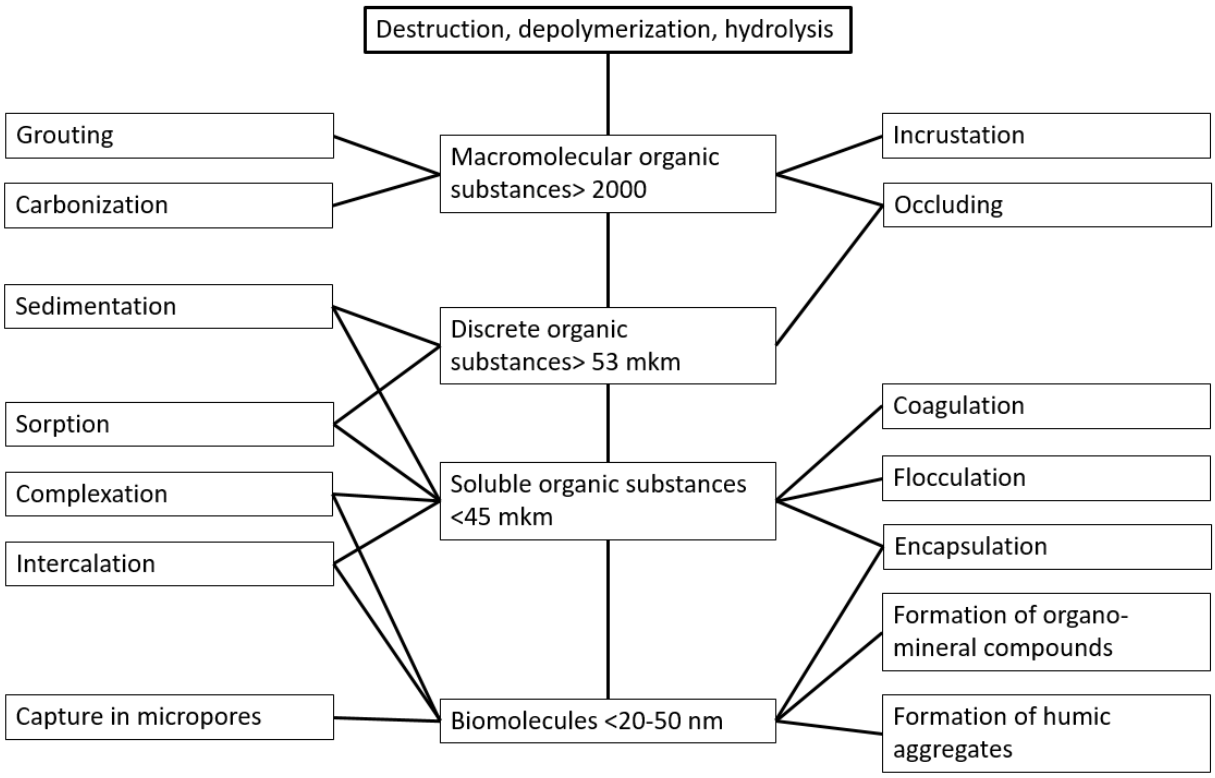

Fig. 1 - Physico-chemical and physical processes of stabilization-sequestration of organic substances in soils

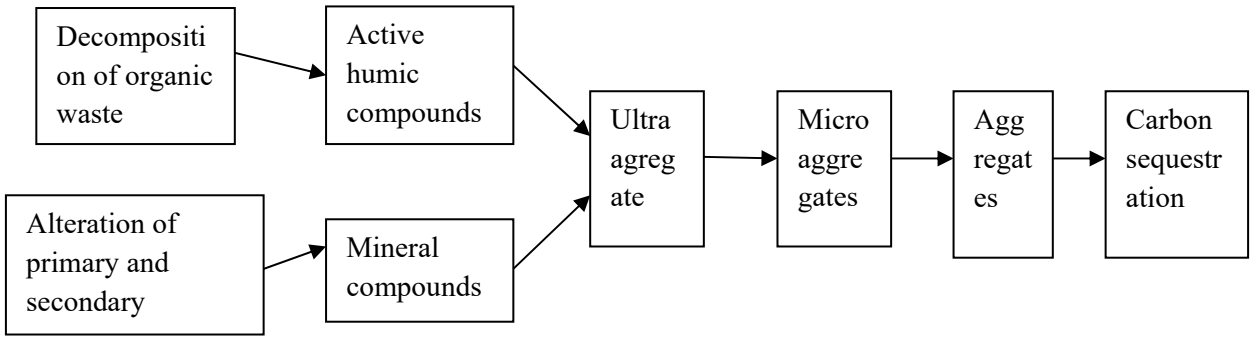

Fig. 2 - Mechanisms of sequestration of organic carbon in the soil within the aggregation-structuring processes

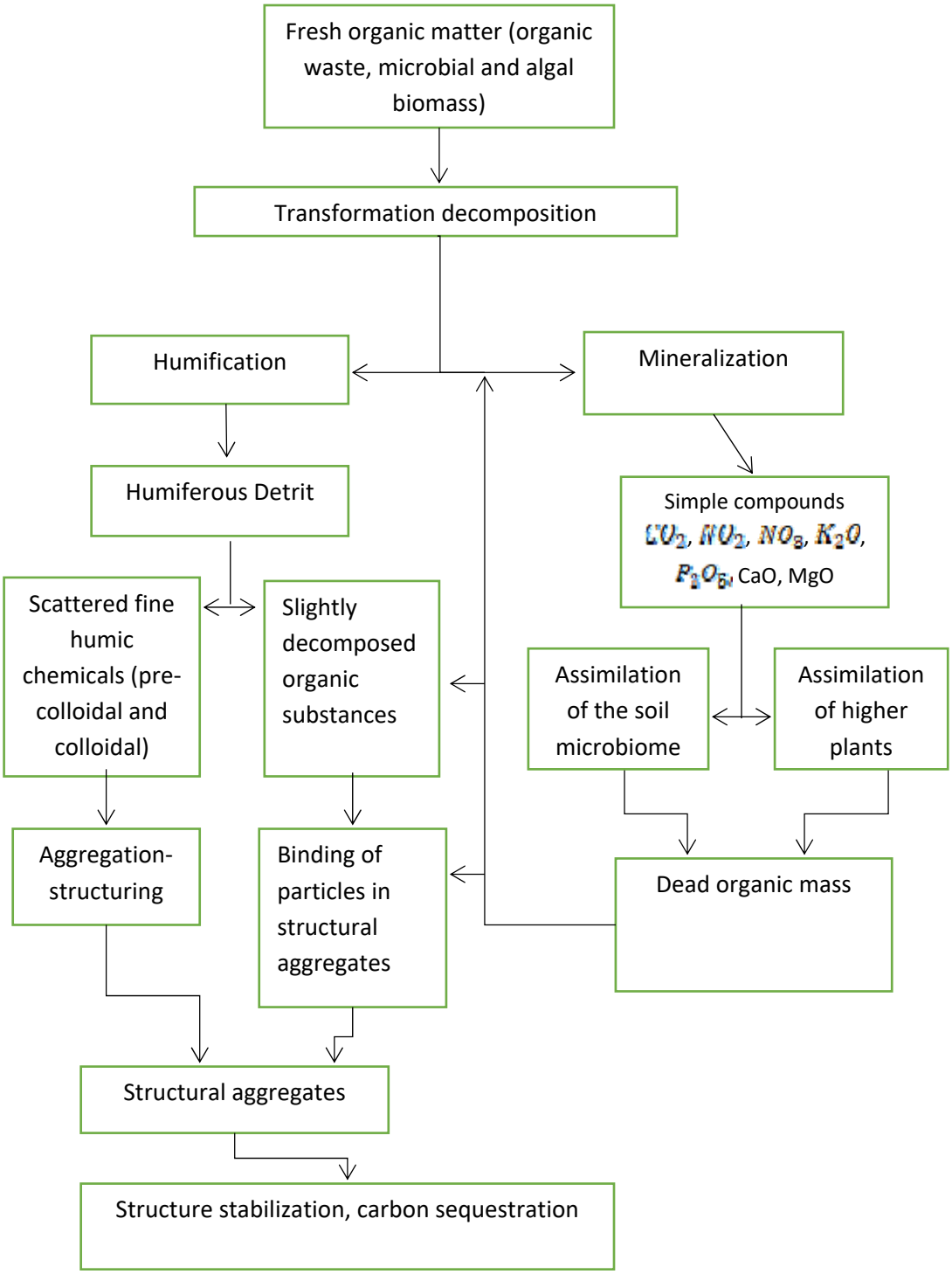

Fig. 3 - The pedofunctional chain of sequestration of organic carbon in the soil

The structural aggregates differ from each other by the mechanisms of the dominant aggregation processes, shape, dimensions and are divided into: organo-mineral colloids (<20 mKm), microaggregates (20-250 mKm), macroaggregates (250-2000 mKm) and fragments (> 2000 mKm).

Organic substances present in microaggregates are older, have a more advanced degree of decomposition and are more protected than those contained in macroaggregates, caused by the spatial division of the substrate and microorganisms: the maximum density of microorganism populations is on the surface of aggregates and the maximum weight of organic matter is concentrated in the aggregate pores / inside the aggregates. The duration of the rotation period of the organic substances contained in macroaggregates is 15-50 years, and of the one contained in microaggregates is 100-300 years.

The processes of aggregation and sequestration-stabilization of organic carbon are controlled primarily by the flow of fresh organic matter in the soil, which determines the activity of meso-microfauna and microorganisms. At the same time, it is shown that organic matter, in the decomposition stage, is a more efficient aggregating agent, compared to humic substances, whose role is to support aggregate stability.

In this sense, for the formation and conservation of the aggregate structure is important not so much the amount of organic matter in the soil as much as the amount of its biologically and chemically modified forms.

This implies the permanent presence of decomposing organic matter. In agroecosystem conditions, this objective is practically unattainable during the vegetation period, or the organic residues are incorporated in the soil only at the end of the vegetation period. Instead, organic residues of microbial and algal origin are permanently present in the soil. Their sustainability during the vegetation period ensures the permanent supply of organic matter capable of ensuring the reproduction of the structural-aggregate condition of the soils. These processes are supported by the increased nitrogen content in the composition of algal and microbial biomass.

II. Case Study. Sequences of sequestration-stabilization of organic carbon in the processes of aggregation-structuring with the participation of algae.

In accordance with the concept of aggregation-structuring mechanisms described above, we consider that aggregation-structuring with the participation of nitrogen-fixing cyanophyte algae includes several evolutionary-hierarchical stages:

1. Elementary particle $\frac{\text{algae}}{\text{microbiota}}$ microaggregate (<0.25mm);
2. Microaggregates $\frac{\text{algae}}{\text{microbiota, humic substances}}$ elementary particle → aggregates (1-0.25 mm);
3. Aggregates (1-0.25 mm) - humic substances - aggregates (1-0.25 mm) → aggregates (7-1 mm).

The aggregation-structuring process of chernozems with the participation of algae is accompanied by the formation of three groups of aggregates:

a) With low stability - 7-5 mm;
b) With moderate stability - 5-1 mm;
c) With increased stability - 1-0.25 mm.

In the development of this concept we consider that a more important role in the formation of structural aggregates belongs to their interaction within the complex matter (substance) organic-microorganisms.

Within them, there are permanent processes of formation of fresh humic substances that ensure the in situ aggregation. As a basic component (nucleus) of microbial cenoses, nitrogen-fixing cyanophyte algae lead to the formation of associations of organisms responsible for the decomposition of different groups of organic substances (geno-metabolic networks) that decompose organic residues, thus ensuring a circuit closed of substances and energy with the development of the aggregate level of structural-functional organization of the organo-mineral matter of the soil.

Our research has shown that the biomass of all species of nitrogen-fixing algae experienced contributes to the aggregation - structuring of soil pedomatics. At the same time, the aggregation-structuring effects differ from one species to another (tab. 2)

Tab. 2 - Aggregate composition of the typical moderately humiferous chernozem under algalization conditions (non-irrigated regime; average values for layer 0-30 cm)

Variant	Diameter of aggregates, mm. Content of % aggregates					
	>10	**10-0,25**	**5-1**	**3-0,5**	**<0,25**	K_s
Corn culture						
Witness	17,91	77,57	42,42	30,36	4,37	3,46
Nostoc linckia	10,70	84,39	46,25	32,96	4,59	5,58
Nostoc gelatinosum	9,80	86,95	49,50	33,78	4,27	7,09
Calothrix gracilis	15,42	81,67	44,58	33,53	4,16	4,58
Cylindrospermum licheniforme	13,09	82,81	46,57	32,29	5,50	4,83
Combined lot	11,92	84,97	48,05	33,06	3,47	6,29
Sunflower culture						
Witness	10,38	78,82	40,69	33,25	10,83	4,17
Nostoc linckia	14,52	77,84	41,67	36,16	7,74	3,51
Nostoc gelatinosum	9,23	87,70	56,12	34,84	4,01	7,27
Calothrix gracilis	12,64	81,21	54,16	32,51	6,15	4,41
Cylindrospermum licheniforme	13,09	83,01	43,04	32,55	6,08	5,58
Combined lot	10,62	86,06	47,74	33,45	3,39	6,42

K_s - structuring coefficient.

The most intensive aggregation-structuring processes take place with the participation of the species Nostoc gelatinosum on the entire thickness of the layer 0-50 cm with the formation of aggregates 5-1 and 3-0.5 mm. This is due to the agglutination process with the participation of newly formed humic substances with the increase of the degree of protection and sequestration of carbon in the structural aggregates. At the same time, however, the newly formed aggregates have reduced hydrostability, as a result of a refined composition (Table 3).

Table 3 - Aggregate stability of the structure of the typical humiferous moderate chernozem in algalization conditions (non-irrigated regime) average values for the start 0-30 cm

Variant	Diameter of aggregates, mm. Content of aggregates%.				
	>5	**5-1**	**3-0,5**	**1-0,5**	K_e
Corn culture					
Witness	-	23.67	24.03	8.83	232
Nostoc linckia	-	22.13	27.87	11.80	220
Nostoc gelatinosum	-	28.29	32.67	15.17	516
Calothrix gracilis	-	23.62	28.36	13.70	517
Cylindrospermum licheniforme	-	29.43	37.94	15.32	457
Combined lot	-	26.12	33.12	14.20	501
Sunflower culture					
Witness	-	17.84	21.95	9.35	230
Nostoc linckia	4.30	34.80	34.66	16.41	216
Nostoc gelatinosum	6.46	34.60	37.71	18.07	442
Calothrix gracilis	5.18	26.15	33.70	16.32	460
Cylindrospermum licheniforme	4.80	43.04	33.00	16.70	305
Combined lot	4.88	49.41	38.18	17.50	537

K_e - hydrostability index.

Within natural ecosystems, the aggregation-structuring process also takes place with the formation of loose aggregates. Subsequently, however, they are subjected to compaction-consolidation under the action of forces exerted by the root system of herbaceous plants. The influence of plants is achieved both by the mechanical actions of the root system (particle displacement, compaction, etc.) and of various substances (metabolites) formed as a result of their vital activity.

The culture plants provide to a small extent the described processes and have a different action on the aggregation-structuring processes of the biopedoplasm with the participation of nitrogen-fixing cyanophyte algae.

In general, the intensity of the process of sequestration-stabilization of organic carbon in the soil can be reproduced with the following pedofunctional rows in the sense of decreasing it:
Corn: *Nostoc gelatinosum> Calothrix gracilis> Combined lot> Cylindrospermum licheniforme> Nostoc linckia;*
Sunflower: *Nostoc gelatinosum> Combined lot> Cylindrospermum licheniforme> Calothrix gracilis> Nostoc linckia*.

Conclusions

1. The processes of aggregation-structuring of the biopedoplasm of chernozems lead to the formation of pedogenetic formations (structural aggregates), in which organic substances are protected from mineralization.
2. The physico-chemical, chemical and biophysical mechanisms of the carbon circuit depend on the intensity of the humus formation and accumulation processes. The process of organizing the aggregate system of chernozems represents a hierarchically evolutionary row: organo-mineral complex (ultramicroaggregate) - microaggregate - aggregates 1-0.25 mm - aggregates 7-1 mm. Aggregates> 7 mm represent fragments of mechanical origin.
3. The destructuring-disaggregation processes proceed in the opposite direction with the intensification of the humus mineralization processes.
4. The algalization process contributes to the aggregation-structuring of the sequestration-stabilization processes of organic carbon in the soil. The aggregates formed in algalization conditions have a refined organization and reduced hydrostability.
5. Crop plants to a small extent contribute to the compaction-consolidation of newly formed aggregates. In order to increase the degree of compaction-consolidation of the newly formed structural aggregates, it is recommended to include multiannual grasses in the crop structure and to administer in the soil once in 4 years 5 t / ha of calcium amendments -waste from the sugar industry and the thermal energy branch.

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THE INCREASE OF LIVING ORGANISMS RESISTANCE THROUGH APPLICATION OF BIOLOGICAL ACTIVE SUBSTANCES

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ABSTRACT

At present, people need to face with thousands of toxic substances, pollutants and sickly products. Because of the big sensitivity level for diseases appearance, application of biological active substances could may represent the best solution. Bee products can be a major wellhead for obtaining of some essential bio-products, which are sources of pharmaceutical, aromatic and industrial compounds. A long time ago, herbal plants and bee products were used by people in metabolism regulation, immune system improvement and increase of mental skills.

Key words: impact, resistance, immunity, health, diseases.

Introduction

Recently, World Health Organization estimates that about 80% of people around the world are interested by pharmaceutical drugs with natural origin, which utilization increased in the last 30 years for medical purposes. Biological active substances are one of the most popular categories of nutritive products that are consumed by people at present. They contain essential substances, which are necessary for maintaining a good health state. Biological active substances can regulate the metabolism of organism, can increase the metal skills and improve the immune system. They act as antioxidants for free radicals eliminating, grow the level of energy, low the answer on stress and prevent diseases caused by vitamin or mineral deficiency.

The biological active substances are used for:

- Fast supplement in biological active substances deficiency, that are not arrive in organism in sufficient quantities;
- Increase the organism resistance;
- Preventive maintenance of metabolic processes;
- Immune system regeneration;
- Prevention of chronic diseases;
- Reduction of toxins level in organism.

In the last time, a series of natural products were increasingly studied by chemical and biological point of view for their stimulation effects of some organism functions. A particular category of such extracts is created by those which have immunomodulation, anti-inflammatory, antioxidant qualities, and those that represent in traditional medicine of some countries, the basic concepts in therapeutic techniques and methodologies for some diseases.

The Republic of Moldova disposes by a considerable potential of local stock, necessary for elaboration and implementation of new apitherapeutical drugs. These are confirmed through research results based on local stock usage – extract from beeproducts, realized by “Human and Animal Ecophysiology” Laboratory inside of Scientific Researches Center “Life of Sciences” at Moldova State University.

Propolis is presented as a product with an extraordinary therapeutic value, being appreciated as one of the most efficient natural compounds with effect of regulation, maintenance and health’s body improvement.

The main particularities of this compound are bacteriostatic and bactericidal actions. Propolis inhibits the activity, and also kills a quite wide spectrum of different microorganisms, including hepatitis viruses, trichomonas, tuberculous bacilli, candidiasis. It is worth to notice that intestinal microflora does not suffer, so it can’t be a dysbiosis. This property has both liquids: alcohol and aqueous propolis.

In the XXI century, scientists revealed that propolis sterilizes almost complet beehive, inhibits the virus growth and prevents the recurrence of viral infection. The simultaneous reception of propolis with antibiotics improves their action.

Propolis affected not only bad microorganisms, but also phagocytosis, improving this process that consists in unknown material elimination by body with special cells – phagocytes. This fact low the organism toxicity. In this way,

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propolis increases immunity and the gamma globules level.

This natural compound is considered an excellent local anesthetic, especially in liquid alcohol, being widely used:

- in the treatment of gums, mouth ant teeth affections;
- in otitis;
- in case of eye burns or injuries;
- in the cure of injuries, burns or frostbites.

Anesthesia begins at 5-10 minutes right after propolis application and can hold out from 45 minutes to 2 hours.

It was demonstrated that propolis helps to establish blood coagulation process. This fact has a special significance for compilations treatment and prevention after strokes and heart attack, because in such conditions the blood coagulation level increases very much. The coagulation process growth with age, this natural compound is also useful for people after 50 years old.

Propolis fortifies capillary walls damaged by injuries, cuts, bruises, nose or gums bleeding. It has also the ability to increase the skin permeability, healing abscesses and suppurations with a rapid resorption. Propolis helps to reduce pruritus in psoriasis, after bites, burns and fungal diseases. It plays a dermatoplastic role, restoring the mucous membranes that cover up the body organs, and also prevents scar evolution.

Propolis is known as well for antitumor and antioxidant properties. It limits the tumor process, normalizes respiration process at cell level and establishes the cell reproduction in our body.

Specialists in herbal medicine are resolute convinced of the fact that the most effective method for propolis administration remains the tincture. The propolis tincture represents the alcoholic extract of propolis, which was obtained after his preparation at cold temperature. Among herbal and bee products that are administrated in the oral form, alcoholic and hydro-alcoholic liquids are very easy assimilated by organism in a short period of time.

One from the multiple benefits of the propolis tincture is the antihyperglycemic action. The studies show that propolis tincture administration on the background of diabetes mellitus can stabilize the blood sugar level. This property takes place due to some elements from chemical composition of propolis as: vitamin PP, vitamin C, flavones. Vitamin PP interferes in carbohydrates and lipid metabolism as prostetic group; vitamin C contributes on growth of defense body capacity through leucocytes activation and immune response stimulation; flavones with a very wide spectrum, have an antihistamine, antihyaluronidase and anti-inflammatory effect.

The researchers [3] were demonstrated that ability to manage the blood glucose level and to control the exact process of glucose and lipids metabolism, ultimately inducing more poor results about lipids peroxidation and free radicals at rats with experimental diabetes. According to scientific researches, propolis represents a real food stimulant.

The effects on immune system include activation of macrophages, modulation of lymphocytes and antibodies proliferation, cytokines production, as well as inhibition of transcription factors. In this way propolis constitutes one of the bee products, that has an essential role in treatment and prevention of some human diseases, due to the context with amino acids, proteins, hydrocarbons, enzymes, flavones, microelements etc. The above examples suggest the possibility of propolis tincture usage for management of carbohydrates metabolism, amelioration of inflammatory problems to diabetic people, and also beneficial role on immune system.

The propolis tincture shows positive effects in body detoxification and revitalization due to his content. Also, plays a role in prevention of some complications, which appear at diabetic patients as cardiovascular affections. There is an interrelation between the phenomenon of leukocytosis and diabetes mellitus, the increase of leukocytes number in blood being the important cause of subsequent complications by this pathology.

At diabetic patients lows in distinctive way the capacity of granulocytes non-specific and specific defense. Also declines the lymphocytes number caused by apoptosis. This phenomenon has a rate twice more increased than the health subjects. The lymphocytes apoptosis provokes the deficiency of immune response and induces a lot of pathologies. In case of insulin administration at patients with type 1 diabetes was noticed an increase of leukocytes number. In case of ketosis and diabetic coma, the leukocytosis is usually raised, being accompanied by lymphopenia and eosinopenia.

In an initiated study that took place in the period: march 2015-2016, were emphasized the following effects on leukocytes at diabetic patients with type 2, between 40-60 years old of both sexes: in case of untreated diabetes the leukocytes execute an aberrant chemotaxis, an increased susceptibility at bacterial infections and releases lysosomal enzymes [1]. Researchers support that diabetic persons have an increased risk to catch much more severe and frequent infections than healthy people. This predisposition on infections is determined by hyperglycemia and faulty immune system.

According to a study [2], in case of experimental diabetes on rats was studied the frequency of DNA fragmentation at lymphocytes. After analysis of lymph nodes was found that DNA fragmentation at rats was twice increased, aught suggests that diabetes induces the lymphocytes apoptosis. Modifications of cellular immunity can be in relation with some metabolic changes – the base for research of leukocyte status in organism.

Recent were execute investigations (November 2016) on diabetes type 1, which demonstrated inflammatory effects and progresses in disease evolution, the results being published in American Journal of Pathology. It was noticed that diabetes type 1 changes the innervation and the immune function of bone marrow. This causes the increase of monocytes level, involving inflammatory signals in sympathetic centers at rats. The scientists were demonstrated that use of minocycline, an antibiotic which crosses blood brain barrier, reduces inflammatory responses by animal brain in diabetes type 1. This fact can prevent the diabetes complications at humans [4].

According to American researchers [2], in diabetes type 1 and 2 induced by alloxan on rats with a rich caloric diet, the leukocytes are strong recruited, having a reduce function in inflammation. Also, it was observed that phagocyte activity of rat leukocytes after inoculation with *Staphylococcus aureus*, being reduced towards the control group.

In case of investigations at "Human and Animal Ecophysiology" Laboratory, a special attention attracts the leukocytes changes in experimental diabetes. Comparing the Martor group with Propolis group is observed the fact that propolis tincture has the same effects on organism as physiological solution with small differences (Table 1).

Table 1 - The propolis tincture influence on number of leukocytes on the alloxanic diabetes background

Indices	Martor	Alloxan	Propolis	Alloxan +Propolis
Number	30	30	30	30
Leukocytes ($\times 10^9$ l/l)	8,35± 0,03	12,04± 0,21	8,01± 0,15	10,15± 0,17

Analyzing the experimental groups it can be observed that number of leukocytes increases in Alloxan group at 12,04±0,21×10^9 l/l towards Martor group. This growth have place due to metabolic changes which are occurred in organism after experimental diabetes installation.

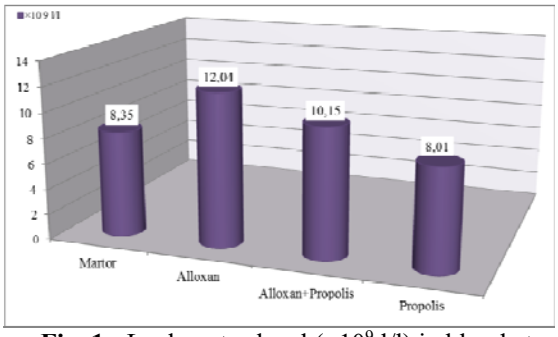

Fig. 1 - Leukocytes level ($\times 10^9$ l/l) in blood at propolis tincture administration on the experimental diabetes background

The big number of leukocytes at initialstages of diabetes demonstrates the body fight for homeostasis maintenance in several pathology. So results were obtained and by other scientists that can not to contradict us, because in late stages of diabetes evolution takes place an immunity discount followed by decrease of leukocytes number.

Table 2 - The propolis tincture influence on white blood cell indices on the alloxanic diabetes background

Indices	Martor	Alloxan	Propolis	Alloxan +Propolis
Number	30	30	30	30
Lymphocytes ($\times 10^9$ly/l)	4,13± 0,11	5,99± 0,20	4,21± 0,39	5,01± 0,87
Monocytes ($\times 10^9$mo/l)	1,33± 0,08	2,01± 0,07	1,41± 0,02	1,73± 0,42
Granulocytes ($\times 10^9$gr/l)	1,60± 0,80	2,17± 0,11	1,71± 0,51	1,88± 0,12

The white blood cells stick to endothelial cell via classic molecules of adherence: ICAM-1 (intercellular adhesion molecule-1) for blood vessels. Leukocytes accumulation is making in time, predominantly being monocytes and neutrophils. The level of these adhesion molecules increases with diabetes mellitus induction and is correlated with growth of white blood cells number.

The debut of diabetes vascular dysfunctions agrees with the growth of leukocytes number. At beginning, the dysfunction is subclinical or undetectable through clinical and paraclinical methods because of low sensitivity of diagnostic methods. When diabetic rats are treated with propolis tincture, the leukocyte adherence is suppressed, hematoretinian barrier is restored and endothelial damage is prevented.

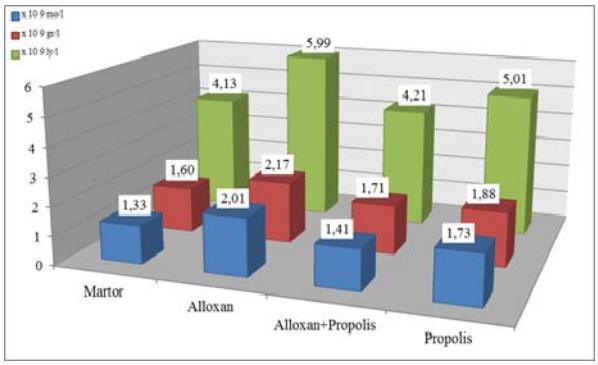

Fig. 2 - The level of white blood cell indices at propolis tincture administration on the experimental diabetes background

A big part of lymphocytes gets in blood through lymphatic vessels. A small part is lost in intestinal lumen and in lungs, others are phagocytosed, but the most lymphocytes deeper proliferates after the contact with specific antigens, and some of them are converted in producing antibodies cells, being dispersed in the body tissues.

After research investigations were identified the results about the number variation of lymphocytes in induced alloxanic diabetes on the background of propolis tincture administration. So, it was observed a number increase of lymphocytes in Alloxan group (5,99±0,20 $\times 10^9$ ly/l) with 15% more than control group (4,13±0,11$\times 10^9$ ly/l). Administration of propolis tincture on the alloxanic diabetes background leads to a relative balance of this parameter until 5,01±0,87 ly/l. The modifications that appear during progression of alloxanic diabetes is the base reason for thoroughgoing investigations study, emphasizing the need of methods and processes elaboration in directed maintenance for suffering organism by diabetes. The increase of circulating lymphocytes takes place in some acute and chronic infections, but in our research case it's also about in experimental diabetes.

Monocytes are big blood cells with very fine grains, which are produced in bone marrow and in lymphopoietic organs. They stay in the circulation only about 24 hours, after that migrate in tissues where transformed in macrophages and kill the bacteria. The number of monocytes varies from control group: 1,33±0,08$\times 10^9$ mo/l, to alloxanic group: 2,01±0,07$\times 10^9$ mo/l. In alloxanic diabetes on the background of the propolis tincture administration is attested a relative monocytes amelioration up to 1,73±0,42$\times 10^9$ mo/l. Similar results were obtained and from other researchers. This is a proof about stimulation role of propolis tincture on the background of experimental diabetes.

Granulocytes plays a big role in initial anti-infectious organism defense through phagocytose and microorganism digestion, but their inappropriate activation can lead to destruction of normal tissues through enzymes and pathogens liberation. With infection appearance are produced chemotactic agents that determine neutrophils migration to the infection focus and activation of their defensive functions with phagocytose of respectively agent, followed by granules liberation in phagocytose vesicle and destruction of the infectious agent. This effect is frequently associated with the increase of neutrophils production and release from bone marrow.

On the background of experimental diabetes we noticed an increase of granulocytes number – process that is called granulopoiesis. It takes place at the bone marrow level. It's considered that neutrophil, eosinophil and basophil granulocytes follow the same model of proliferation, differentiation, maturation and in blood liberation. In addition to bone marrow, the neutrophil granulocytes can be found in tissues, where some of them circulating in the blood vessels and others adhere at the vascular endothelium. The growth of circulating neutrophils is due to their liberation from bone marrow or mobilization of neutrophils from the border.

In our investigation is attested an increase of granulocytes number from 1,60±0,80$\times 10^9$ gr/l at control group to 2,17±0,11$\times 10^9$ gr/l at alloxanic group. The administration of propolis tincture on the experimental diabetes background led to a normalization of this parameter till 1,88±0,12$\times 10^9$ gr/l.

The changes about white blood cells in diabetes mellitus represent a big problem, the reason being illustrated in multiple investigations at this field. It was demonstrated the beneficial effect of propolis tincture on this indices not only in our investigations but also in other studies. Comparing the obtained results from different experimental groups we can see that the number of leukocyte indices in alloxanic diabetes has a significant increase, but administration of propolis tincture on the experimental diabetes background attested a relative equilibration of them.

The use of natural remedies based on apitherapeutical drugs became nowadays a highly requested branch. In this way, apitherapy stimulates the body defensive system, such that organism fights alone against the malady, this thing representing a holistic approach. Herbal medicine can be estimated as insufficiently strong in some of affections and can't be set to all persons, depending on disease

severity and complications. However, on the base of obtained results we can mention that propolis tincture used a long period of time in an adequate dosage can improve the situation at diabetic persons.

Rezumat

În prezent, oamenii sunt nevoiți să se confrunte cu o mulțime de substanțe toxice, poluanți și produse dăunătoare sănătății. Din cauza sensibilității crescute de apariție a maladiilor, aplicarea substanțelor biologic active poate reprezenta una din cele mai bune soluții. Produsele apicole pot fi o sursă promițătoare de obținere a unor bio-produse esențiale, care conțin compuși farmaceutici, aromatici și industriali. Cu mult timp în urmă, plantele medicinale și produsele apicole erau utilizate pentru reglarea metabolismului, fortificarea sistemului imun și creșterea abilităților cognitive

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THE USE OF RESVERATROL AS BIOLOGICAL ACTIVE SUBSTANCE IN STOPPAGE OF PANCREATIC β-CELLS DEGENERATION

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ABSTRACT

Nowadays is supported the idea that diabetes has a stage evolution where clinical manifest form is actually the last from those four expressivity stages of this disease. In the final stage, metabolic disorder stands at the most advanced degree, and destruction of β-cells rises above 80%. The fast growth of population morbidity affected by diabetes mellitus enforces identification of optimal solutions in creation and diversification of new pharmaceutical drugs with predetermined functional properties. In this way, achievements by modern biotechnologies lead the attention of today's researchers to use resveratrol as biological active substance from natural source due to high qualities that he owns.

Key words: modern biotechnologies, resveratrol, biological effects, degeneration.

Introduction

The modern biotechnologies, based on cellular and biomolecular processes, develop technologies and products that help improve our lives and the health of our planet. Recent developments in biotechnology include genetically modified plants and animals, nanotechnology and cell therapies. These include applications in various fields: from agricultural practice to the medical sector.

Diabetes mellitus (DM) is a complex metabolic disease characterized by high concentration of blood glucose level and increased insulin resistance (3). It is considered a state of free radicals overproduction due to metabolic stress, as a result of alterations in energy metabolism, elevated non-enzymatic and auto-oxidative glycosylation, inflammatory mediators levels and the status of antioxidant defense (5).

Pancreatic β-cells represent up to 70% of cells in islets of Langerhans, and play a major role in controlling glucose homeostasis by secreting the hormone insulin (8). Nowadays is supported the idea that diabetes has a stage evolution where clinical manifest form is actually the last from those four expressivity stages of this disease. In the final stage, metabolic disorder stands at the most advanced degree, and destruction of β-cells rises above 80%.

Type 1 DM results from damage of pancreatic insulin producing β-cells by autoimmune system through the action of proinflammatory cytokines, while type 2 DM (non-immunogenic type) results from insulin resistance with chronically elevated blood glucose levels that lead to pancreatic β-cell dysfunction and chronic complications, such as: retinopathy, nephropathy and neuropathy (1, 5, 8).

At present, numerous studies are focusing on pharmaceutical drugs production to find more efficient ways of combating different diseases. In this way, a great attention has been attracted to natural compounds due to their many biological effects.

Resveratrol, as a natural compound, performs different therapeutic functions, such as: antioxidant, antitumor, antidiabetic, antiviral and also cardioprotective, neuroprotective, radioprotective activities. It's considered by many researchers as the potential candidate of maintaining human health with non-toxic and well-tolerable properties (9).

Resveratrol (3,4',5 – trihydroxystilbene) is a naturally occurring phytoalexin found in a variety of fruits, such as: grapes, peanuts, cranberries, blackberries, pomegranates etc. For plants, this phenolic compound shows a protective role against microbial and fungal infections, injuries, heavy metals and UV radiations (6).

Being a potential candidate with different pharmacological activities, this natural compound has been extensively studied in diabetes therapy. It is reported that resveratrol eliminates free radicals, minimizing possible radical damage in different types of human tissues (11). This biological active substance protects pancreatic tissue by reducing the expression of inflammatory factors which regulates numerous genes in β-cells (8). Furthermore, it decreases blood glucose levels due to the activation of AMPK – a master regulator of metabolism and

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the lowering expression on hepatic glucose production, as well as on oxidative stress (4).

The present study aims to evaluate the effects of resveratrol on blood glucose level and plasma insulin concentration, as a beginning step in stoppage of pancreatic β-cells degeneration in alloxan induced diabetic rats.

Materials and method

For this investigation were taken 40 Wistar albino rats, of both sexes with a body weight between 135-175g, which were randomly divided into the following four experimental groups (n=10):

Group I (control group): with physiological solution (0,9% NaCl) administration of 1 ml per animal in the intraperitoneal cavity.

Group II (alloxan group): with alloxan administration in the proportion of 200 mg/ 1 kg body weight, that is diluted in 1 ml of physiological solution per animal in the intraperitoneal cavity. Intraperitoneal injection with alloxan is a common used method in inducing of animal diabetic model.

Group III (resveratrol group): with oral administration of resveratrol extracted from *Vitis vinifera*, in the proportion of 0,015g diluted in 0,3ml distilled water per animal. Oral administration is a route of administration where this biological active substance was taken by investigated rats through the mouth.

Group IV (alloxan+resveratrol group): with intraperitoneally alloxan administration followed by oral administration of resveratrol extracted from *Vitis vinifera*.

Alloxan is a cyclic-urea derivative, which has a highly cytotoxic effect on pancreatic β-cells. It is a diabetogenic agent, being used in a lot of scientific studies as a tool to induce experimental diabetes on animals. In this investigation, alloxan was administered to the group II, for a total of 20 days (diabetic standard group, in which diabetic rats didn't receive any treatment), while to the group IV – for 10 days, followed by 14 days of resveratrol treatment (mixed group). After 3-4 days of alloxan administration appeared typical initial diabetes symptoms: polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger), the investigated animals being hyperglycemic, glycosuric and ketoacidotic.

Resveratrol powder, obtained from grapes skin and seeds, was orally administered to the group III and IV, at the same time for two weeks.

At the end of experimentation, the blood from investigated rats was collected into tubes containing heparin as anticoagulant, and was separated the plasma fraction by centrifugation (3000 rotations per minute). Insulin level was quantitative determined using ELISA method (Enzyme-Linked Immunosorbent Assay). ELISA is based on the direct sandwich technique in which two monoclonal antibodies are directed against separate antigenic determinants on the insulin molecule.

The significant differences between the two groups were analyzed with Student's t – Test, being considered statistically significant if $p<0,05$. Results are expressed as the mean ± standard deviation.

Results and discussion

It is known that intraperitoneal injection of a single alloxan dose (200 mg/ kg) is shown to produce a modest rise in blood glucose level in rodents due to the action of this diabetogenic agent on the pancreas that consists of: directly disruption of β-cell membrane permeability and irreversible β-cell damage within 12 hours (10). After injection is seen a triphasic blood-glucose response: an initial hyperglycemia (at 1-4 h), followed by a profound hypoglycemia (6-12 h) and finally a persistent hyperglycemia (after 24 h) with a reducing impact on the plasma insulin level (Cooperstein and Watkins, 1981).

In this way, alloxan has the ability to decrease glucose-mediated insulin secretion and to induce selective necrosis of β-cells, which therefore makes this cyclic-urea derivative useful to study the required effects in a diabetic condition (7).

At the end of experimentation, blood samples of each group were collected for detection and subsequent analysis of glucose and insulin levels.

It is evident from the tab.1, that blood glucose level in the alloxan group was markedly higher (9,64±0,27 mmol/l) compared with the control group (4,93±0,21 mmol/l). In organism takes place a deterioration of cells ability to assimilate glucose and to use it for physiological needs.

Table 1 – Blood glucose level (mmol/l) in alloxan induced diabetic rats with administration of resveratrol extracted from *Vitis vinifera* (*p<0,05; **p>0,05)

Blood glucose level (mmol/l)			
Group I n=10	**Group II** n=10	**Group III** n=10	**Group IV** n=10
Control	Alloxan	Resveratrol	Alloxan+ Resveratrol
4,93±0,21	9,64±0,27*	5,34±0,32**	6,21±0,18*

Resveratrol extracted from *Vitis vinifera* has been shown an relative improvement on glycemic index (6,21±0,18 mmol/l) in the mixed group (Fig.1).

The decreased expression of blood glucose level in diabetic rats treated with resveratrol can be argued through the antioxidant property of this biological active substance which results in stoppage of free radicals' eliberation by alloxan. This natural compound also proved a stimulatory effect on the glucose absorption by hepatocytes and adypocytes (3).

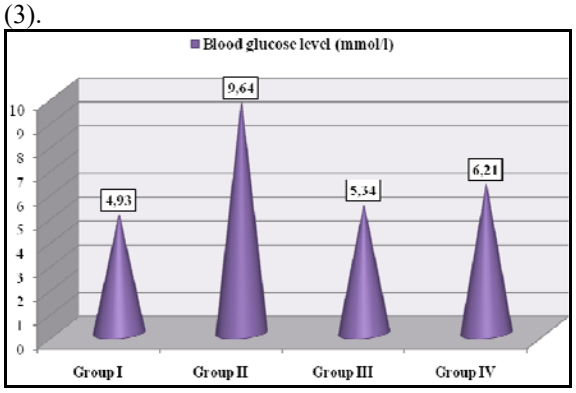

Fig. 1 – Influence of resveratrol on blood glucose level (mmol/l) in experimental diabetes

No statistically significant differences were identified between the resveratrol group and control group ($p>0,05$).

The present study also examined the levels of hormone insulin in alloxan-treated rats based on resveratrol administration (Tab.2). The results obtained by ELISA method, showed a decreased expression (0,68±0,11 pmol/l) of plasma insulin concentration in the group II. Insufficient insulin secretion has not only a negative metabolic consequence but also tends to ulterior pancreas β-cell exhaustion (2).

The interdependent relation between high glucose level and low insulin concentration in diabetes can be seen through the contribution of altered β-cell glucose metabolism to dysregulate insulin secretion (1).

Table 2 – Plasma insulin concentration (pmol/l) in alloxan induced diabetic rats with administration of resveratrol extracted from *Vitis vinifera* (*p<0,05; **p>0,05)

Plasma insulin concentration (pmol/l)			
Group I n=10	**Group II** n=10	**Group III** n=10	**Group IV** n=10
Control	Alloxan	Resveratrol	Alloxan+ Resveratrol
2,23±0,18	0,68±0,11*	1,95±0,17**	1,51±0,14*

Diabetic rats from the group IV, following the respective phytotherapy, demonstrated a partial recovery of pancreatic β-cells function by regulating the level of hormone insulin in plasma until 1,51±0,14 pmol/l compared with the control group ($p<0,05$).

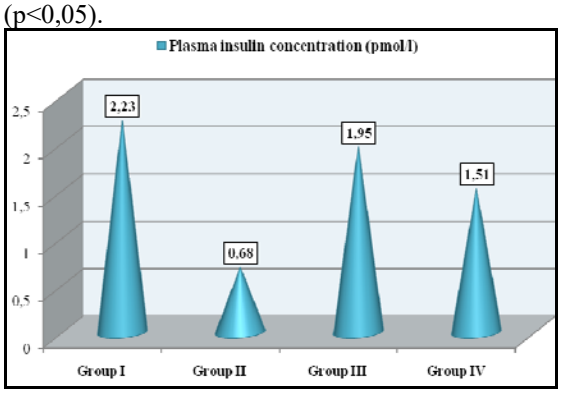

Fig. 2 – Influence of resveratrol on plasma insulin concentration (pmol/l) in experimental diabetes

These data suggested that resveratrol may significantly contribute in prevention of beta-cell apoptosis due to its antidiabetic activity and associated metabolic effects.

As illustrated in fig.2, the group III of investigated animals reached a normal plasma insulin concentration (1,95±0,17 pmol/l) due to the well-tolerable property of this natural compound.

Conclusions

The fast growth of population morbidity affected by diabetes mellitus enforces identification of optimal solutions in creation and diversification of new pharmaceutical drugs with predetermined functional properties. In this way, achievements by modern biotechnologies lead the attention of today's researchers to use resveratrol as biological active substance from natural source due to high qualities that he owns.

Based on the analysis of the obtained results in rat experimental model, can be concluded that resveratrol possesses protective effects against hyperglycemia and insulin resistance, which are the most interconnected processes with pancreatic β-cells degeneration. Respectively, this natural compound could be appreciated as a possible well-tolerable adjuvant in diabetes therapy.

Rezumat

Actualmente se consideră că diabetul cunoaște o evoluție stadială, în care forma clinică manifestată este de fapt ultima etapă din cele patru stadii de expresivitate a acestei boli. În etapa finală, tulburarea metabolică se află în gradul cel mai avansat, iar distrugerea celulelor β-pancreatice

depășește 80%. Creșterea rapidă a morbidității populației afectată de diabet zaharat impune identificarea unor soluții optime în crearea și diversificarea de noi preparate farmaceutice cu proprietăți funcționale predeterminate. În acest sens, realizările biotehnologiilor moderne îndreaptă atenția cercetătorilor din prezent spre utilizarea resveratrolului ca substanță biologic activă, de origine naturală, datorită calităților deosebite pe care acesta le posedă.

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APLICATIONS AND PERSPECTIVES OF USING BACULOVIRUSES FOR SUSTAINABLE PLANT PROTECTION

AURELIA STÎNGACI*

ABSTRACT

Păstrarea durabilă a culturilor de microorganisme reprezintă un factor important pentru utilizarea lor atât în calitate de obiecte ale cercetărilor științifice fundamentale, cât și în calitate de obiecte cu potențial biotehnologic. Articolul este dedicat control biologic al populațiilor de *Hyphantria cunea* Drury cu un produs baculoviral Virin ABB-3. Aplicarea baculovirusurilor în protecția culturilor deține o promisiune semnificativă în gestionarea insectelor prin livrarea controlată și orientată a produselor biologice. Baculovirusurile au avantaje față de metodele chimice convenționale care sunt asociate cu toxicitatea ecologică. Această revizuire este axată pe aplicarea ecologică ale baculovirusurilor în protecția culturilor agricule, decorative și forestiere.

Key words: *Hyphantria cunea* Drury, Virin ABB-3, baculoviruses, VG, VPN.

Introduction

Biopesticides have attracted attention in pest management in recent decades, and have long been promoted as prospective alternatives to synthetic pesticides. Biopesticides have also attracted great interest in the international research community, with a significant increase in the number of publications devoted to the subject. Chemical use in the parks from Republic of Moldova leads to environmental condition worsening. But due to the large-scale application of broad-spectrum insecticides, *H.cunea* has already developed some level of resistance in Republic of Moldova. Furthermore, frequent applications of pyrethroids and neonicotinoids may cause severe negative effects on organisms that provide ecosystem services including pollination and natural pest control [4].

The legal basis for plant protection in Republic of Moldova and Europe focuses on an Integrated Pest Management (IPM) strategy, that should limit the application of chemical plant protection products to a necessary extent by using a combination of procedures which are under the primary consideration of plant breeding and cultivation measures as well as biotechnical and biological methods (PflSchG 2012). Biopesticides are natural materials derived from animals, plants, and bacteria, as well as certain minerals, that are used for pest control [5]. Currently, biopesticides comprise a small share of the total crop protection market globally, with a value of about $3 billion worldwide, accounting for just 5% of the total crop protection market [6, 7]. In the United States (US) market, more than 200 products are available, compared to 60 analogous products in the European Union (EU) market [6]. Because of this pest characterisation, efficient pest management is required. Preparations based on baculoviruses are eco-friendly and specifically effective against lepidopteran larvae [1].

The collapse of insect outbreaks in some species is associated with epizootics of baculovirus disease suggesting that these pathogens can regulate insect populations In several cases these viruses have been developed for use as biological insecticides for thecontrol of pests of forests and agricultural crops, or as expression vectors in biotechnological applications [2,3]. In the present review we examine the evidence for covert infection of insects by baculoviruses, the similarities between baculoviruses and persistent virus infections in vertebrates, the relationship between virulence and transmission strategy, and the role of covert infection in the ecology of baculoviruses and their hosts-insect pathogenic viruses are a fruitful source of microbial control agents, particularly for the control of lepidopteran pests. Most research is focused on the baculoviruses, important pathogens of some globally important pests for which control has become difficult due to either pesticide resistance or pressure to reduce pesticide residues. Baculoviruses are accepted as safe, readily mass produced, highly pathogenic and easily formulated and applied control agents. New baculovirus products are appearing in many countries and gaining n increased market share.

Mass production of baculoviruses at a cost most potential users can bear remains a significant issue. Production of commercial baculoviruses insecticides is still dependent on in vivo systems utilizing specially reared or wild collected insects

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[7]. In vivo systems for production of baculoviruses in live larvae remain the normal production method for commercial companies and for public sector programs but the relatively high cost of producing baculoviruses in living insects compared to their chemical insecticide counterparts remains a constraint as farm prices are difficult to reduce below $20 per ha and scaling up in vivo baculoviruses production with its demands for high quality disease-free insects is also a challenge [2]. The use of automation and mechanization in inoculation, rearing, and harvesting has facilitated mass production and made baculoviruses a viable commercial option for the current range and usage scale.

However, the absence of a practical in vivo mass production system, generally higher production costs, limited post application persistence, slow rate of kill and high host specificity currently contributes to restricted use in pest control. Overcoming these limitations are key research areas for which progress could open up use of insect viruses to much larger markets.

The objective of the study was aimed to highlight new agents for biological control of insects with baculoviruses. This study investigated the potential of baculoviruses isolates obtained in IGFPP in Republic of Moldova for the control of *Hyphantria cunea* Dr., a dangerous invasion pest which has quickly settled in the territory of the Republic of Moldova during the last three years. This study aimed to highlight new agents for biological control of invasive pest on local baculoviruses strains. The results of the present study revealed the larvicidal potential of baculoviruses isolates found in the larvae of *H.cunea*, local production of biopesticides, which will reduce the final cost of the product and will more accessible to farmer. This study was addressed to find an environmentally and user friendly, effective control method, which is commercially available and do not require permitting or testing for introduction.

Material and method

The researches have been realised on the caterpillars of 2-3 ages of the *H. cunea.* In the study, we used the Nuclear Polyhedrosis Virus, selected and identified in the laboratory of the insect viruses. For the contamination of the laboratory insects, we used the dosed feeding, which contains 10 polyhedrons for each caterpillar. The monitoring of the insects lot and the estimation of the dead caterpillars has been carried out daily, beginning with the 3rd day of the contamination. The caterpillars *H. cunea* were kept under laboratory conditions at 27˚C.

For infection of larvae there was necessary a preliminary preparation of viral suspensions, using for that purpose pure or initial suspensions and applying dosed infection of insects according to the Vago C. procedure (1972) and its different modifications.

During the process of identification and determination of biological activity of baculoviruses there was necessary its purification. At initial phases purification of VPN and VG does not differ substantially. Dead larvae were soaked with the help of a mixer, and the biological mass was mixed with sterile filtered bidistilate through an apron screen. For purification of VPN were used several methods, for which we have used the modifications of our institute, consisting of the following phases. Filtered viral suspension is centrifuged within 30 min at 1000 rpm in ȚLN-2 centrifuge. The obtained deposition is washed three times with water. The obtained suspension is centrifuged in the gradient of sucrose concentration (70-20%) and is centrifuged at 5000 rpm within 10 min. Zones with concentration of 40-50% were put together and layered in the gradient of 50-60% and after 15 min of centrifugation there was obtained the fraction of SPVC.

For determination of concentration of baculoviral suspensions there were used different methods, especially electronic microscope [3, 8].Titration of baculoviruses with the help of quantum microscopy depends on the kind of virus. Thus, if VPN may be examined with all kinds of optical microscopes, because they have relatively big size (0, 5-10 mcm), then VG having much smaller size (0, 01-0,5 mcm), is at the edge of optical microscope resolution, that's why they were mostly treated with the help of electronic microscopes.

For the determination of baculoviral concentration, there are used different methods, especially of electronic and optical microscopy [3].Titration is carried out with the help of Goreaiev chamber or in the fixed and coloured preparations. There were elaborated different methods of determination of biological activity of baculoviruses. At the initial phase, viral suspension is titrated, determining its concentration. Then there is prepared a series of successive dilutions with the help of which are infected larvae of the second age (it is rational to use 40 larvae of the same physiological state). After the third day there is determined the morality of larvae by options, and is being prepared the diagram of "dose-effect" relation. For that reason

there is applied the method of sample analysis. Then are made some additional calculations, which allow transformation of axis for obtaining of the "dose-effect" relation in the form of straight line, and not in the form of asymmetrical curve. Construction of diagram allows us to determine the logarithm of the viral suspension dose, which ensures the death of 50% of the experimental larvae. Knowing the virus concentration and volume of viral suspension it is easy to determine lethal concentration (CL_{50}).The mathematical treatment was registered on the 15th day after contamination; the statistical treatment was made according to [6, 7].

Results and discussions

Reproduction of baculoviruses on the basis of plant feeder insects remains the main way of insect production. That was confirmed by the researches carried out in different scientific and production centres. Baculoviruses adopt mixed-mode transmission strategies that depend on the relative fitness gains that accrue through vertical and horizontal transmission (Figura1).

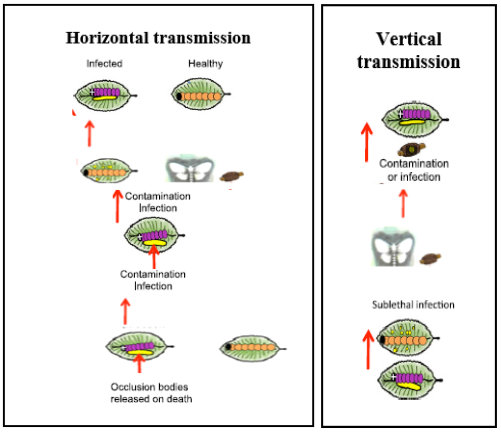

Fig. 1 - Vertical and horizontal transmission of Fall webworm (*Hyphantria cunea* Drury)

These pathogens adopt a mixed-mode transmission strategy involving both horizontal and vertical transmission that is common across a broad range of viruses, parasites, symbionts, and microbiota. Horizontal transmission is usually risky if susceptible hosts are rare, while vertical transmission is safer, but is constrained by host survival and reproductive success. As a result, horizontal transmission is selectively advantageous at high host densities, whereas vertical transmission is favoured in low density host populations. In the case of baculoviruses, these transmission strategies generally exclude one another because the production of massive numbers of OBs for horizontal transmission results in host death prior to the adult stage.

Results placed in the above table show the difference between the parameters of biological activity of biological mass obtained on the different years from the infection with baculoviruses. There are not noticed any substantial differences of biological activity in the case of viral suspension with the same concentration (10^7 polyhedral /ml). Analysing the biological effectiveness of the baculoviruses we obtained a value of 87-92%.

Table 1-Biological activity Virin-ABB-3 for control of the Fall webworm moth (*Hyphantria cunea* Drury)

N	Year testing Virin-ABB-3	Virus preparation and biological standard	Treatments, Kg/ha	Biologic efficacy of treatments, %
1	2012	Virin-ABB-3	0,1	92,0
2		Lepidocid	1,0	-
3	2013	Virin-ABB-3	0,1	84,86
4		Lepidocid	1,0	87,26
5	2014	Virin-ABB-3	0,1	87,1
6		Lepidocid	1,0	87,21
7	Media	Virin–ABB-3		87,0

In the terms of that aspect, biological mass obtained from dead larvae after these days is characterized by parameters specific to wild strains obtained from natural conditions, that aspect induces the difference of biological activity of biological mass obtained from dead larvae on different years of infection and denotes the possibility of application baculoviral preparation and will be very useful for the baculovirus treatments managment.

Results having been analyzed, we may observe, that reduction of attack in comparison with witness in the chemical variant Actara 25WG at the 9 day was 93,9%., but the degree of attack in the biological variant with Virin-ABB-3 at a rate of consume 0,15 kg/ha constituted 89,9%.

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Conclusions

The insect virus pesticide is only one method to construct and restore the stable ecosystem, other methods can also be applied as the effective methods as long as they are useful to the control of target pest insects and do not cause destruction of the environment.

From the results it can be concluded that this method of fighting, in addition doses viral preparation, special importance has and choosing the most favorable treatment times, about larval development and overgrowth of foliage trees. Treatments should be applied only during the period when larval are the first two age and leafy trees. The method put forward in this paper is the preliminary result of the experiments we have been trying to control the foliage feeding insects for many years. And this method taking the virus as the main measure to restore and construct the stable ecosystem were the pest insects had occurred.The researches point out *H. cunea* critical stage and will be very useful for the baculovirus treatments management. Climatic conditions have influenced negatively development of the culture and the same time the fast development of the pest *Hyphantria cunea*. The preparation Virin-ABB-3 does not negatively act on physiology development of the culture and on formation of plants. Testing of the preparation Virin-ABB-3 at a rate of 0,15 kg/ha for control development, II generation, on plants has demonstrated a significant biological efficacy of 89,9% in comparison with that of chemical etalon Actara of 92,6%.

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THE BIOTECHNOLOGY FOR SOLVING OF PLANT PROTECTION PROBLEMS IN ORGANIC FARMING

LEONID VOLOSCIUC*

ABSTRACT

Application traditional technologies demonstrate indispensable contradiction between the plant protection requirements condition and the need to preserve environment. The systemic approach of relations between crop and pests opens new possibilities in researching biocenotic relationships within ecosystems and halting spending growth trends directed to plant protection. For solving of plant protection problems were developed biotechnological processes of production and application of an impressive range of biological means, which is used for conventional and organic agriculture. The main legislative documents (Low No 115 from 2005 concerning the ecological agriculture, Government decision No 149 from 2006 concerning its implementation, a series of regulations) have been adopted. Given the experience in the production of biological agents and the need to combat harmful organisms that cannot be countered by other biological means, our scientists were developed a lot of biological active substances, entomophages and biological preparations with a special role in pests control. With their competition have been implemented and approved a lot of biological means, which is a powerful tool to combat harmful organisms and improving environmental conditions.

Key words: Biotechnology, conventional agriculture, organic farming, ecology, biological preparations

Introduction

The pesticide, as a chemical compound, used to control weeds, plant diseases or insects. Since pesticides may be harmful to humans, animals, or the environment, it is important to understand the fate of pesticides after application. In connection with the adverse impacts of pesticides people throughout the world are interested in organic or "naturally produced" foods. However, although similar in principle, growing crops or producing animal food or without use of pesticides is different from “organic” farm production. Legally, there are steps that growers must follow before the word “organic” can appear on the label.

Overestimation of productivity of crops during the period of "green revolution" has led to the underestimation of soil fertility. Higher level of yields could be maintained with higher rates of inputs and higher yield potential of the new varieties and hybrids of crops, but in the same time with decreasing level of soil fertility. The humanity became in the face of dilemma - how to increase the production in order to cover the increased demand of people in food products and in the same time how to avoid the increased degradation and pollution of the environment. This led to the Rio world summit in 1992, where for the first time at the international level it was declared that new ways of intensification, including in agriculture have to be found in order to provide sustainable development (Altieri M., 2000; Briney A., 2010; FAO, 2010; Maria R. Finckh, Ariena H. C., van Bruggen, and Lucius Tamm, 2015). Typically, the health of the soil is of secondary importance compared to gaining strong short-term crop yields. Conventional farmers can also use manure without restrictions and are not required to keep records of their production practices (CIBA, 2008; Volosciuc L.T., 2009a; Harry Brook and Mark Cutts., 2016).

Organic farming (ecological agriculture) is a completely different system from conventional farming. Over the years, organic farming has become defined very simply as a practice that does not use synthetic pesticides or conventional chemical fertilizers, but organic farming involves much more than this (Cory Jenny S., Myers Judith H., 2000; Badgley C., et al., 2007).

Now, organic farming is more popularly known for what it is not. Conventional agriculture is far more widespread, so let’s first take a look at the conventional process in order to better understand the differences that distinguish organic farming from other agricultural systems (Allan S. Felsot, Kenneth D. Racke., 2007; Connor, D.J., 2008; Голдштайн В., Боинчан Б., 2000).

Ecological agriculture is a system which avoids or largely excludes the use of synthetic inputs (pesticides, fertilizers, hormones, feed additives etc.) and to the maximum extent feasible relies upon biological protection, crop rotations, animal manures, mineral grade rock additives and biological system of nutrient mobilization. Organic farming is a method of crop and livestock production that

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involves much more than choosing not to use pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones (Sundararaman S. R.., 2009; Treadwell D., et al., 2010; Organic farming, 2014; Maria R. Finckh et al., 2015).

Taking into account the negative phenomena of conventional agriculture and to ensure permanent progress and lengthy agriculture, which must remain in harmony with nature, the world has consolidated the International Federation of Organic Agriculture Movement (IFOAM). Over the past few years have been crystallized and the main requirements for organic products, which are currently classified in EU Regulation no. 2092/91 of 24.06.1991 (Volosciuc L., 2009b; Голдштайн В., Боинчан Б., 2000). To improve process improvement activities in organic agriculture since 1 January 2009 new regulations were approved (no. 834/2007 and no. 889/2008), which references to Directive 2092/91 were automatically taken over by no. 834/2007 (Volosciuc L., 2009b; Volosciuc L., Josu V., 2014).

Although serious premises are known to promote green technologies, however, the results have been modest, which requires further research to ensure scientific and technological strategy for implementing this kind of activity (Volosciuc L. et al., 2015). In this context, the paper presents an analysis of the situation and problems of plant protection in ecological agriculture.

Materials and methods

Isolation, identification and determination of biological strains of baculovirus, bacteria, fungi, and actinomicetes were performed by applying optical and electronic microscopy, production and application of biological means of plant protection. The efficiency of biologic preparations was determined by Abbot formula, which provides natural insect mortality (Voloşciuc L., 2009a; Altman A., Hasegawa P.M., 2012.).

The establishment of biological protection systems applying bacterial preparations, baculoviral and fungal entomopathogens, biologically active substances, including sex pheromones has been carried out on the systems of pest forecasting development (Чернышов В., 2001; Bellon Stephane, Penvern Servane, 2014).

Testing in laboratory and experimental group means, methods and conventional and organic farming systems was conducted in four randomized repetitions in accordance with the general requirements of experiences of this kind (Volosciuc L., 2009b; Доспехов Б. 1989; Волощук Л.Ф., Войняк В.И., 2012).

Results and discussions

The plant protection and worsening environment

The losses of crop production caused by various species of pests, pathogens and weeds is 25-30%, and with the development epiphytotic disease and pest and weed invasion vertiginous, crop losses exceed 50-60% or compromise the overall majority crops (CIBA, 2008; Volosciuc L., 2009b; Хлопяников А.М., и др., 2012).

Conventional agriculture based on intensive application of various chemical means, especially pesticides, solved one of the global problems of humanity, that of ensuring food. But against the backdrop of the impressive achievements of traditional agriculture are obvious and negative phenomena of the medals (Allan S. Felsot, 2007; El-Hage Scialabba N., 2007; Voloşciuc L., 2009b). It attests increasing negative impact of plant protection measures and environmental protection requirements (Rundluf M., J. Bengtsson, H. Smith, 2008; Rex Dufour, 2011).

While reducing the ravages caused by harmful organisms, pesticides causes serious disturbances in the ecological balance, greatly reducing the number and role of flora and fauna useful and their application prolonged cause various genetic changes, including the emergence of resistance to pesticides that conditions need to increase the dosage and the number of treatments in controlling pests. The requirements for the organization of plant protection measures are in permanent conflict with the requirements of environmental protection and human health (Volosciuc L., 2009a; 2009b; Future IPM, 2013; Волощук Л., Войняк В., 2012).

Alternative directions in plant protection

The research of ecosystems have shown that the deepening impact of plant protection and the environment can be stopped only at the development of agriculture as a body as a living ecosystem, which has its model in nature, which is an alternative to intensification, specialization and dependence full to chemicals and pesticides. It is directed harmonious not cause any damage agricultural ecosystems environment in which they evolve in accordance with the national laws of development of the biosphere (Ferron Pierre, Beguine Jean-Philippe., 2005; El-Hage Scialabba N., 2007; Голдштайн В., Боинчан Б., 2000).

Integrated plant protection measures is a technological block in technological maps and crop

farm, which lies in the dedication of plant protection based on the biocenotic principles. Operation integrated protection is not just mechanical joining methods and chemical protection is not just alternating different sources of protection is not a simple change of chemical means other, but deep restructuring includes the concept of plant protection (Neil Helyer, Nigel Cattlin, Kevin Brown., 2014).

Wide systemic research approach involves the integration of knowledge from different sciences such as phytopathology, entomology, microbiology, ecology, virology, biotechnology, etc., which are largely related to plant protection. Apart from direct relationships, indirect links integrated plant protection is particularly huge and include knowledge related to biology, cultivation, economy, healthcare. Namely systemic approach has enabled to realize that plant protection include a number of specific systems that interact and function as a whole, thus emphasizing the direction of solving practical problems by using process modelling methods, which take place in agrocenoses.

Organic farming as a flexible complex of measures called to ensure optimum protection of plants over a long period of time, meeting the requirements of sustainable development of society. On the basis of agro knowledge they stand as a functional unit of the biosphere and is not geared to combating a certain species of harmful organisms, but to control the entire complex of harmful organisms that once culture (Letourneau D., Van Bruggen A., 2006; Vinson S.B. et al., 2016).

The application range of knowledge about immunity and resistance of plants to pests and diseases, biotic and abiotic factors that act on harmful organisms, introduction and acclimatization beneficial organisms allow greatly reduce the population density of pests such an extent that damage to them does not exceed the economic damage. We support the use of different measures, called the constitutional, which provides adjustment of population density and establishing useful agents in agro ecosystems. In conditions when applying these measures do not provide the desired effect, propose corrective measures that reduce population density of pests to economically tolerable level. When applying corrective measures are taken into account not only the results close, but subsequent follow-up, more distant.

Organic farming involves more administrative costs than conventional farming. Being certified organic involves quite a bit of regular record keeping, detailing the strict records of their growing practices (Zadoks J.E., Waibeu H., 2000.).

The majority of studies claim no difference in the nutritional content of organic food from conventional food. Keep in mind that the methodology for all of these studies looks at the nutrients contained in the food - vitamins, minerals, proteins, etc. If you factor in the use of chemical fertilizers, pesticides, hormones and antibiotics as part of the equation, organically grown food will come out as more nutritious and more healthful every time (Shamim Md., et al 2013).

Organic farming promotes the use of crop rotations and cover crops, and encourages balanced host/predator relationships. Organic residues and nutrients produced on the farm are recycled back to the soil. Cover crops and composted manure are used to maintain soil organic matter and fertility. Preventative insect and disease control methods are practiced, including crop rotation, improved genetics and resistant varieties (IFOAM, 2015).

The Biological Protection - foundation and part of organic farming

Many different definitions of biological control have been proposed. According to Cook and Baker (1983) “Biological control is the reduction of the amount of inoculum or disease producing activity of a pathogen accomplished by or through one or more organisms other than man’’. Based on this broad definition of biological control, organisms and procedures involved include: avirulent or hypo-virulent individuals or populations within the pathogenic species, antagonistic microorganisms, and manipulation of the host plant to resist the pathogen more effectively.

Biological plant protection utilizes nature’s own methods in the prevention and combatting of plant diseases and pests. It is based on ecological balance, where each and every living thing has a place of its very own in nature, its own biological niche. In biological plant protection pathogens are controlled by their natural enemies – microbes isolated from nature. From new methods of pest control are the most effective biological that the current concept would be more correct to name as their density routing methods through biological agents and comprise a broad spectrum of processes.

These include the introduction and acclimatization of new areas of biological entities, mass production and launch seasonal agrocenosis protected (Volosciuc L., 2009a, 2009b). This is a system for regulating population density of pests, taking into account the specific environment and their dynamics, using natural mechanisms and entities useful adapted to maintain the populations of

pests and pathogens below the economic damage, ensuring economic efficiency and environmental .

Enhancing the efficiency of biological protection can be achieved in the phytosanitary situation of the protected-culture knowledge, biology capabilities pest and biological agent. Addressing Plant Protection and Development of the production of organic products can be achieved when applying main groups of biological agents: entomophages, biological products (viruses, fungi and bacteria) and biologically active substances, first sex pheromones (Volosciuc L., 2009b; Organic farming, 2014).

Given the fact that the mechanisms regulating natural ecosystem is determined by complex relationships between components lower levels of organization of living matter (the consortional systems and food chains), which can be searched in accordance with existing methods, it is obvious that investigations natural ecosystem in order to determine mechanisms of adjustment can be made only in the food web. It is necessary to research the relationships that are falling species enlightening plant and phytophagous specialized as species polyphagous and oligophagous pests do not determine the status circuits of substances, but only serve as elements of doubling the mechanisms of transformation of matter and energy. Therefore, in order to develop models and plant protection systems necessary to detect natural ecosystem regulation naturally mechanisms or less modified under the influence of anthropogenic factors.

As an indication main selection means of plant protection do not have to use the degree of destruction of the pest, but the elimination phytophagous during the whole ontogenetic and taking into account the phenomenon of post action over several years. The persistence of biological agents within agro ecosystems demonstrates that these is extracted from natural conditions, and then apply in order to protect plants become artificial analogues of natural compounds regulating density populations of harmful organisms (Voloșciuc Л.Т., 2019).

The aim of natural control is to restore a natural balance between pest and predator and to keep pests and diseases down to an acceptable level. The aim is not to eradicate them altogether. Here are three important reasons why natural control is preferable to pesticide use (FIBL, 2010).

Pesticides can quickly find their way into food chains and water courses. This can create health hazards for humans. Human health can also be harmed by people eating foods (especially fruit and vegetables) which still contain residues of pesticides that were sprayed on the crop. There are a number of harmful effects that chemical pesticides can have on the environment. Pesticides can kill useful insects which eat pests. Just one spray can upset the balance between pests and the useful predators which eat them. Artificial chemicals can stay in the environment and in the bodies of animals causing problems for many years. Insect pests can very quickly, over a few breeding cycles, become resistant to artificial products and are no longer controlled.

Development of Ecologic Agriculture in the World and Republic of Moldova

In response to environmental actions, in 1972, in Versailles was established IFOAM who managed to promote organic farming and currently meets approximately 1,000 members in 170 countries. The main results of the latest survey on certified organic agriculture world-wide show that 43,1 million hectares of agricultural land are managed organically by 2 million producers. The regions with the largest areas of organically managed agricultural land are Oceania (17,3 million hectares or 40 % of the global organic farmland), Europe (11,5 million hectares or 27 % of the global organic farmland) and Latin America (6.6 million hectares or 18 %).

On a global level, the organic agricultural land area increased by 6 percent or almost 6 million hectares compared with 2012; mainly due to a major increase of organic land in Australia. The countries with the most organic agricultural land are Australia (17,1 million hectares), Argentina (3,2 million hectares) and the United States (2,2 million hectares). The highest shares of organic agricultural land are in the Falkland Islands (36,3 percent), Liechtenstein (31,0 percent), and Austria (19,5 percent). The countries with the highest numbers of producers are India, Uganda and Mexico (Willer Helga, Lernoud Julia., 2015; Scialabba N., 2015).

As of the end of 2013, 11,5 million hectares in Europe were managed organically by more than 330000 farms. 2,4 % of the European agricultural area is organic. Twenty-seven percent of the world's organic land is in Europe. There are eight, countries in Europe with more than ten percent organic agricultural land: Liechtenstein, Austria, Sweden, Switzerland, Estonia, the Czech Republic, Latvia, and Italy. Compared to 2012, organic land increased by 0,4 million hectares and the European market size was 24,3 billion euros.

As organic moves beyond a niche, the organic movement needs to take stocks of what organic has become and what the future holds for us

all. The movement needs to be prepared to cope with future political developments, environmental challenges and market trends (IFOAM, 2015; Paull, John & Hennig, Benjamin, 2016).

In Republic of Moldova to achieve these goals were taken some measures sparse, which did not allow this movement to grow. It should be mentioned that it is known for some favorable conditions. Besides the achievements already made towards the development and application of biological methods of plant protection, the primary basis for obtaining organic products were taken a series of measures aimed at obtaining, processing and marketing of organic products (Raumjit Nokkoul, 2016).

It is worth mentioning that in terms of production achieved, organic agriculture and responding to the objects particularly important for Moldova, as for example:

- Meet the growing domestic and foreign natural products, which clearly demonstrated the contribution to maintaining and improving the health of humans and animals;
- Considerably diversified range of product categories in the market is in a state of overproduction and increasing the volume of crop production values appreciated at the moment we value;
- Facilitates the production activity of native farm out the lack of competition on the foreign market for some vegetables and fruits that have optimal conditions for the application of technologies for organic products;
- Material interests prices farmers through organic products exceeding 1.5-3 times the conventional prices, although there has been a 15-20 percent decrease in production volume;
- Enhances the quality of biological, biochemical and nutritional organic products. Given the fact that organic products are not a result of industrial processes, the consumer chooses the criteria morphometric but after their biological value;
- Strengthen opportunities for agricultural producers to enter the western market for agricultural products, which is highly conventional and competing products show particularly high requirements for organic products.

Namely in this way can we hope to stop the processes of ecological crisis and maintain the natural dynamic balance. Application technologies for organic farming are resulting in products with high biological value, healthy, pesticide-free and high-quality content.

The new paradigm of sustainable development in agriculture is based on respecting the following principles:

- minimization purchased artificial inputs from outside of the farm and avoiding them completely in organic agriculture,
- intensive use of renewable sources of energy mainly of local provenience, and a more complete energy and nutrient recycling,
- minimization of the negative impact on the environment, and utilization of local, more adapted varieties and hybrids of crops, a higher biodiversity of crops,
- restoration of soil fertility, which is determining the vitality and the health of soil, crops, animals and people,
- equity in relationships between producers, processors, distributors, sellers and buyers.

Republic of Moldova has the legislation in this aspect, harmonized with the European and international requirements which includes:

- the national concept on ecological agriculture and the action plan for the implementation of this concept, adopted by the Governmental Decision no 863 from 21.02.2000,
- the Law no 115-XVI from 09.06.2005 regarding the ecological production,
- the Governmental Decision no 149 from 10.02.2006 regarding the implementation of the low on ecological production.
- the Government Decision no. 1078 of 13.10.2008 "Technical regulations for the implementation of Regulation EC 834/2007 on organic food production, labelling and control."

In order to respect these principles, we should return to holistic (system) researches instead of reductionist ones. Improvement of technologies isn't enough for achieving a more sustainable development and especially for organic farming systems. We need to develop self-sufficient and self-regulating production systems, which are less dependent from artificial, industrial inputs, can use more efficiently local resources and are friendly to the environment (Jigau Gh., 2011).

Researches have to be undertaken for the whole food chain – from crop breeding, primary production by farmers, processing, marketing up to consumers. By saying this we mean to take in consideration not only the production sector, but also the environment and social sectors. In other words, the whole link should be in the attention of researches – from the fork up to the table of consumers.

Vigorous actions taken in Moldova have allowed the institutionalization of this field of

activity, increase activities within the agricultural producers interested in promoting organic agriculture, approval of the National Label "Organic-Moldova" and the recording of significant indicators.

The number of companies concerned with obtaining organic products has increased since 2003 from 11 to 387 operators.

During this period, the area occupied by organic crops increased considerably: from 168 to 51 thousand ha.

It also impresses the dynamics of the volume of the exported organic production: from 1373 tons in 2003 to 81 thousand tons in 2018.

Use of Pesticides in Ecologic Agriculture

Plant protection is one of the major issues in organic farming. Biologic crop protection strategies often rely on a limited number of methods that provide only partial control of pests and that induce lower yields and economic performances. As a result, farmers hesitate to adopt these strategies and doubts are cast on the ability of organic agriculture to feed the world. This chapter questions how agro ecological concepts may contribute to bio control, while taking the different alternative schemes already developed to manage, integrate and design crop protection strategies into account.

As demonstrated by a bibliographic analysis, integrated pest management (IPM) remains the leading paradigm in crop protection. It also provides its foundational basis, giving priority to ecological processes and alternative techniques to reduce pesticide use. Beyond IPM, agro ecology is characterized by a holistic approach and the importance given to the design of a "healthy" agro ecosystem. In practice, all these concepts are subject to various interpretations, and organic farming includes a variety of practices, ranging from intensive input-substitution to a comprehensive integrated approach (Biotech-Crops, 2012; Фокин А.В., 2010; Кирюшин В.И., 2012).

Organic farmers should be aware of the law relating to substances used to protect their crops from harmful organisms. In addition to checking that they are allowed to use the product with their organic certification bodies, they must also check that substances or products are permitted for use in this country before using them on their crops.

Even natural substances such as plant oils or ingredients used in the food industry such as pepper need to have an approval before they can be marketed or used as a plant protection product. Any retailers and growers will be the subject of enforcement action should it be discovered that they are marketing or using an unapproved pesticide.

IPM is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

The biotechnology of production of biologic preparations for organic farming

Plant biotechnology scientists working to maintain healthy plants, optimize crop yields, and minimize pesticide usage. Applying modern technologies of genetic and gene engineering, become more consistent achievements aimed at controlling pests and enhancing plant protection in the next directions: enhancing a plant's resistance with genes from the plant kingdom, genetic engineering, as a powerful tool to combat plant virus diseases, using antimicrobial proteins to enhance plant resistance (Volosciuc L., 2015).

Given the experience in the production of biological species and the need to combat harmful organisms that cannot be countered by other means biological, bio developed a special role of local scientists. With their competition they have been implemented and approved a lot of biological means, which is a powerful tool to combat harmful organisms and improving environmental conditions (Voloşciuc L., 2009a, 2012; Волощук Л., Войняк В., 2012). Among these are the following:

Trichodermin BL is constituted under the fungus *Trichoderma lignorum* and used to combat white rot, grey and root vegetable crops, ornamental, vegetable and tobacco seedlings and vegetable crops, reducing crop attack by pathogens 2-3 times stimulating growth, plant growth by 25-30%.

Trichodermin F7 - based preparation is the fungus *Trichoderma harzianum* granular and liquid. It is used to combat agricultural crops root rots, root rots reducing 1.5-2 times.

Nematofagin-BL is constituted under *Arthrobotrys oligospora* fungus and used for combat nematodes in protect technical and vegetable crops.

Verticilin - the base of preparation is the fungus *Verticillium lecanii* in the form of a wettable powder. It is recommended for the control greenhouse whitefly to the efficacy of 95%.

Rizoplan is constituted under the bacterium *Pseudomonas fluorescens* AP-33 and is used to combat the root rots of crops.

A lot of viral preparations were developed for pest that cannot be combatted by other biological means.

Virin-ABB-3 - to combat *Hyphantria cunea* in orchards, forests and parks. The preparation is based on nuclear polyhedrosis viruses and cumulative and synergistic action granulosis, showing of the epidemic and post-action effects.

Virin-MB - to combat Cabbage worm and is based on *Mamestra brassicae* nuclear polyhedrosis virus.

Virin-OS - to combat insects of genus *Agrotis* and is based on granulosis viruses and nuclear polyhedrosis synergistic action.

Virin-HS-2 - to combat rootworm by cotton and insects of genus *Heliothis* and is based on nuclear polyhedrosis virus.

Virin-CP is intended to combat codling moth and is based on *Carpocapsa pomonella* granulosis virus.

As more and more plant biotechnology products become available, studies to evaluate the ecologic and economic effectiveness, as well as risks associated with biotechnology must be researched. A successful program biological control requires comprehensive cultivation management and good cultivation hygiene, which contributed for effectively prevents of pests and plant diseases. The right plant management guarantee optimum conditions for effective activation of beneficial organisms.

Conclusions

Application traditional technologies demonstrate indispensable contradiction between the plant protection requirements condition and the need to preserve environment. The systemic approach of relations between crop and pests opens new possibilities in researching biocenotic relationships within ecosystems and halting spending growth trends directed to plant protection.

Integrated plant protection systems, as an element applied conventional and organic farming, is not only a mechanical alternation of chemical methods of pest combating, but a complex of actions aimed at using natural mechanisms regulating the density of populations of organisms harmful and only in critical conditions, implementation of minimum quantities of pesticides.

Ensure effective non-chemical plant protection systems is becoming reality in the deployment of integrated plant protection with predominant application of biological methods of protection.

Biological plant protection - as an efficient method of avoiding the conflict between environmental protection and quality of the plant is based on continuous use of information related to monitoring populations of harmful and useful organisms, and the use of compensation measures and combat application entomophages, bio preparations and biological active substances.

Republic of Moldova has prerequisites and conditions for the extension and deepening of activities sufficient to obtain organic products. Promoting organic agriculture requires improving the legal framework, developing national strategy on organic food production, monitoring compliance of normative acts, strengthening national body for evaluation, inspection and accreditation of operators, supporting farmers to shift conversion period.

Strengthening technology strategy and research functionality to meet needs for technological processes aimed at providing means for obtaining and processing of organic products is the key position in the intensification and extension of educational activities in the taking and processing of organic products.

Organic farming can be a viable alternative production method for farmers, but there are many challenges. One key to success is being open to alternative organic approaches to solving production problems. Determine the cause of the problem, and assess strategies to avoid or reduce the long term problem rather than a short term fix for it. As a result, the wish for better synergy between biotechnology, ecology and plant protection for the benefit of sustainable exploitation of the biosphere could thus be granted.

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PART II – *ANIMAL BIOLOGY*

THE CUCKOO-BEE *NOMADA PLEUROSTICTA* HERRICH–SCHÄFFER 1839 (HYMENOPTERA: APIDAE) A NEW RECORD FOR THE ROMANIAN FAUNA

BOGDAN TOMOZII*

ABSTRACT

Nomada pleurosticta H. Sch., a cleptoparasite in the nest of the mining bee *Andrena polita* Sm. is for the first time recorded in the Romanian fauna. With this species, the cuckoo-bee genus *Nomada* in Romania counts 77 species.

Key words: *Nomada pleurosticta*, cuckoo-bee, new record, Romania

Introduction

The bee genus *Nomada* comprises over 800 described species, being the most diversified group of cuckoo bees worldwide (Michez *et al.*, 2019). In Europe, the genus numbers 208 species (Smit, 2018).

The genus includes small and medium wasps-like bees (4-17 mm) with reduced hairs and variable colour patterns such as black, yellow, white and red (Michez *et al.,* 2019). Many species have large intraspecific colour variability and thus are problematic to identify.

This genus is largely distributed almost all over the globe, being more diversified in the Holartic region, Mediterranean basin being particular rich in species (Smit, 2018; Michez *et al.,* 2019).

The bees of this genus never build their own nests, but are brood parasites of the ground nesting solitary bees mainly from genus *Andrena (*Andrenidae), but also from bee genera *Lasioglossum* (Halictidae), *Panurgus* (Andrenidae), *Melitta* (Melittidae) and *Eucera* (Apidae) (Michez *et al.,* 2019).

In Romania, the genus *Nomada* counts 76 species (Ban-Calefariu, 2009; Smit, 2018; Tomozii, 2020).

Nomada pleurosticta H. Sch. is a cleptoparasite in the nest of the mining bee *Andrena polita* (Westrich, 1989). The species prefers habitats such as xero-thermophilous grasslands, ruderal sites, woodland edge, quarries, sandy and clay pits. *Nomada pleurosticta* has one generation, flying from June to August (Scheuchl & Willner, 2016). The species is distributed from North Africa (Tunis), Iberian Peninsula (Spain), Central, South and Southeast Europe to Caucasus, in the north Asia (Siberia), in south to Middle East (Iran, Turkey) (Scheuchl & Willner, 2016; Smit, 2018; Ascher & Pickering, 2020).

In this note, the cuckoo-bee *Nomada pleurosticta* H. Sch. is presented as the 77th species of the genus *Nomada* recorded in Romania, along with a description of the captured specimen and distribution data of its host, *Andrena polita* Sm.

Material and methods

The examined specimen belongs to the personal collection of the author. The keys used for identification of the species belong to Osytshnjuk (1978) and Smit (2018). The photos of the habitus and structures were made using an Olympus C-5060 Wide Zoom camera adapted to an Olympus SZ61 stereomicroscope. The quality of several images was improved using Helicon Focus software.

Terminology used to describe the external morphology of the male specimen follows Michener (2000) and Smit (2018).

Abbreviations: T- tergum; St. – sternum

Results and discussions

Examined material:
Fâneţele Seculare Ponoare - Bosanci Nature Reserve [N47º34'22", E26º15'28"], Suceava County, 10.07.2020, 1 ♂, on *Senecio erucifolius*, leg. B. Tomozii.

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Diagnosis of the male

Size: 9,5 mm

Head black, with yellow coloration on the apical part of the clypeus (like a narrow stripe), on malar areas, and basal half of the mandibles (3).

Labrum black with a very narrow, impunctate area at base. In the middle with a visible, pointed tooth. A small, red, narrow spot is found between the tooth and the base of labrum; the apical part of labrum also reddish (4).

Mandibles simple, with a small tooth on the outer surface (5).

Scape and pedicel black (last one deepened into the top of the first one), flagellum segments reddish with dorsal surface black, which is fading gradually to the last segments. First flagellar segment is shorter than the second one (6). The inferior part of flagellar segments 3-4 roundly prominent, segments 5-8 with small pointed tubercles (7).

Mesoscutum and scutellum with strong and close punctation, the interspaces narrow and shiny. Scutellum gibbous. Thorax black, pronotal lobes and tegulae reddish. Axillae narrow reddish. Thorax with silvery hairs, longer on scutellum, mesepisternum and propodeum.

Terga with dense punctation, excepting the basal half and lateral apical part of T1, which almost lack of puncture and the marginal zones of T1-T6. On the middle of the apical half of T1 the punctures are superficial and less dense comparing with the rest of terga. Abdomen red, with black coloration as follows: T1 basally half, T2 basally with 2 lateral spots, T4-6 with black basal stripes (1,2). The sternites red, with black coloration basally.

Legs red, all femora, middle and hind tibiae partially with black coloration. Inferior part of hind femora covered with dense, white hairs (9).

T7 broad, visible punctate, notched apically (8).

Gonostylus is narrowing to the apex, where is visible pointed, slightly curved inwards (10, 11). St. 7 and St. 8 as in Figs. 12, 13.

The cuckoo-bee *Nomada pleurosticta* has never been mentioned in the main papers published with regard to this genus in Romania (Móczár & Schwarz, 1968; Ban-Calefariu, 2006, 2009), nor in the recently published paper of Smit (2018) regarding the European *Nomada*.

A male specimen of *Nomada pleurosticta* was collected from the Ponoare-Bosanci Nature Reserve in July 2020. Two males of *Andrena polita* (Fig. 14-15), the host of *Nomada pleurosticta*, were also collected in June 2019 on *Inula britannica*. The mining bee *Andrena polita* lives in various habitats, both in dry and wet regions, although it seems to prefer relatively moist areas (Osytshnjuk, 2005; Radchenko, 2015). The collection locality, Ponoare - Bosanci Nature Reserve, is characterized by a dry climate, specific to Ponto Sarmatic steppes, with a vegetation mosaic due to a divers landscape, mainly with xero–thermophilous vegetation, but also with xero–mesophilous and mesophilous vegetation and in less extent with hygrophilous one (Morariu, 1965).

The distribution data of *Andrena polita* in Romania shows that this species occurs in all regions of the country. In comparison with its host, *Nomada pleurosticta* might have a more localized presence (Fig.16).

Nomada pleurosticta is a Near Threatened (NT) species in IUCN Red List (2014). The finding of this species in Ponoare - Bosanci Nature Reserve might be evidence of its still well preserved habitats that serve as a refuge for a diverse wild bee fauna, which require further research.

Acknowledgements

I would like to express my gratitude to Jan Smit (Netherlands), who confirmed the species. In addition, I would like to thank to my colleague Otilia Pavel, who helped me during the collecting trips.

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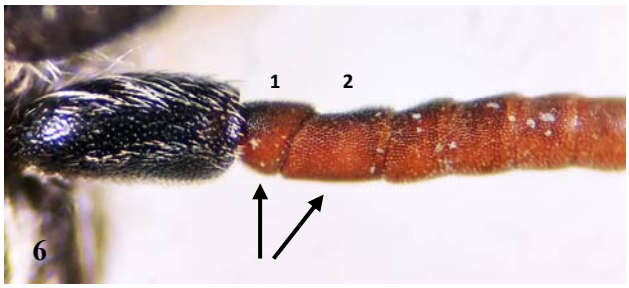

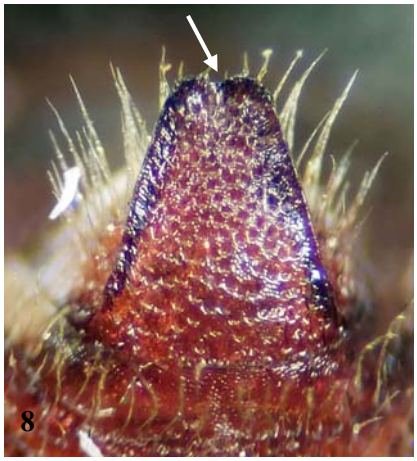

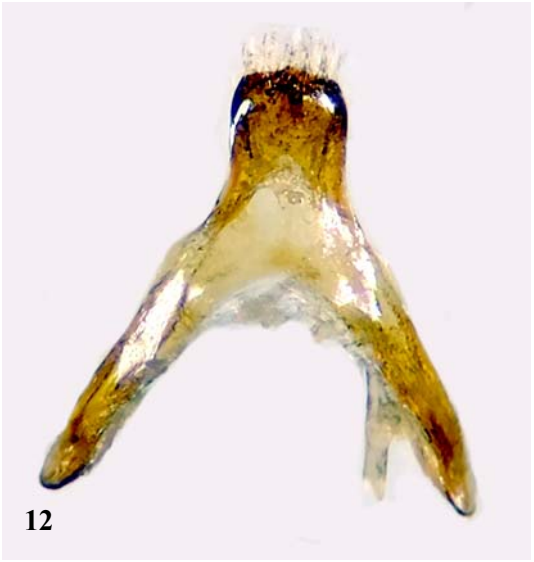

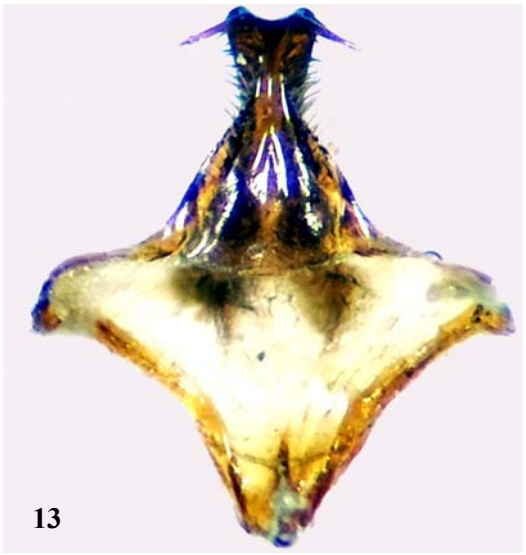

Figs. 1-2: ***Nomada pleurosticta*** **H. Sch. male habitus**: 1.dorsal view; 2. lateral view
Figs. 3–13: Diagnostic characters: 3. Head (frontal view); 4. Labrul (dorso-lateral view); 5. Left mandible (dorsal view); 6. First flagellar segments (lateral view); 7. Antennal flagellum (lateral view); 8. Tergum 7 (dorsal view); 9. Hind femora (ventral view); 10. Genitalia (dorsal view); 11. Genitalia (ventral view); 12. Sternum 7; 13. Sternum 8.

Figs. 14-15: *Andrena polita* Sm. male habitus
14.dorsal view; 15. lateral view

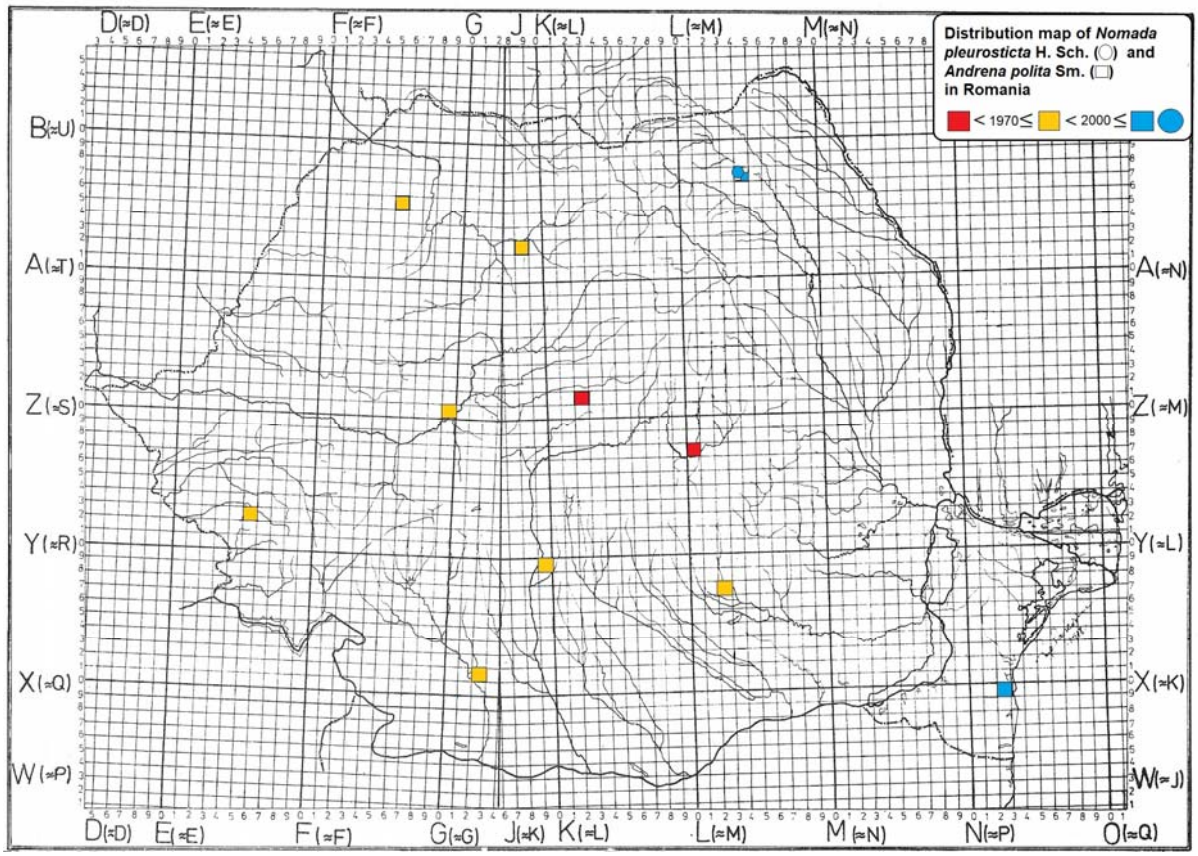

Fig. 16 - Distribution map of *Nomada pleurosticta* H. Sch. (circle symbol) and of its host, *Andrena polita* Sm. (square symbol) in Romania

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PART III – *MUSEOGRAPHY*

A „DELICIOUS” EXHIBITION: „SPICES, TASTEFUL STORIES”

ANCA TUDOR-ANDREI, FLORIN-CĂTĂLIN TOFAN,
LĂCRĂMIOARA-GABRIELA ZAHARIA, BOGDAN TOMOZII, BOGDAN BARABAȘ*

ABSTRACT

Spices have been cherished and used by people since ancient times. Throughout history they played an important role in the development of human civilization. They were used in economic exchanges being the main cause of the explorations that led to the discovery of the New World. The active substances they contain are recommended in the treatment of various diseases, a fact studied and reconsidered by modern scientific medicine. The reinvention of traditional cuisine brings spices back to the public's attention.

The book with the same title was the basis for the exhibition „Spices, tasteful stories”, opened in the spring of 2019. It includes a number of 28 spices and their varieties, a series of three-dimensional exhibits and an interactive panel where the visitors can identify by smell 9 types of volatile oils. Also during this exhibition, for the first time at the Museum of Natural Sciences in Bacău, an interactive chatbot application was made, using proprietary and open source software.

Key words: spices, museum, exhibition, storytelling, chatbot

Introduction

The idea of a museum exhibition about spices appeared after the writing and publication, in 2014, at its own publishing house „Ion Borcea”, of the book „Spices, tasteful stories” (ISBN: 978-606-92577-0-8). In the 206 pages of the A5 book, the authors Anca Tudor-Andrei and Florin-Cătălin Tofan tried to capture snippets from the adventurous history of spices, their use in traditional kitchens but also the results of modern research that reconfirms spices as valuable tools in maintaining good health or valuable adjuvants in the treatment of certain diseases such as diabetes, cardiovascular or infectious diseases.

The exhibition was opened on 11.04.2019 and presents 28 spices and their varieties and two tools used in their crushing (the grinder and the grinding mortar), as well as a series of three-dimensional decorative elements, cinnamon rolls and star anise, made of polystyrene covered with plaster and painted. As aromatherapy is back in vogue, an interactive olfactory panel offers to the visitors the opportunity to test their ability to recognize 9 types of spices by their flavor. The role of museums in society has changed in recent years, becoming an institution that actively promotes culture and education, curators must face the challenge of communicating with visitors of different ages but also with different levels of education and culture, to find the better ways to spatially arrange objects, signs, images and labels in an exhibition. The museum exhibition thus becomes a narrative space, in which different elements participate: cinema screenings, theater, workshops, interactive kiosks or, more recently, augmented or virtual reality. But when the information contained is too crowded they tend to absorb much of the visitors' time and thus divert their attention from the exhibits presented at the exhibition.

For the exhibition „Spices, tasteful stories” was made, for the first time at the Museum of Natural Sciences in Bacau, a chatbot application, installed on the two touch screens on the multimedia wall located right next to the exhibition. Thus, the touch screens were actively integrated in the exhibition structure, offering continuity to the documentary material and a good integration of the information in the narrative space. The chatbot or conversational interface as it is also called, is designed to convincingly simulate a conversation partner, being used in many practical applications such as: customer service, providing information in marketing or education. In the exhibition it provides information about the history of spices, curiosities about spices, the top 3 most expensive spices in the world and the game „recognize spice”. The chatbot is also used as a cultural marketing agent, which recommends, as an additional source of information, the book „Spices, tasteful stories”, which can be purchased, for a fee, from the museum shop.

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Material and method

Through the diversity and novelty of the information offered, the exhibition „Spices, tasteful stories" addresses all categories of visitors, from preschoolers to the elderly.

The classic approach is complemented by the interactive part, through which the visitor is challenged to learn new things or to check their knowledge about the spices presented in the exhibition, using not only the visual sense – through the game recognizes the spice, but also olfactory perception - where they can recognize the spice after its aroma.

Curiosities about spices are also presented to the public, such as the most expensive spices or their antibiotic, antiviral and anti-fungal properties.

The aesthetic aspect of the exhibition was pursued by creating a background containing a model based on hexagonal elements that frame various vintage images: fragments of old navigation maps, ships, spices, various objects and inscriptions, etc. The labels were made in A5 format, using a 36 pt Impress font for the title and an 18 pt Arial font for the content. The exhibits were placed in 5 hexagonal glass showcases. The exhibits spices were placed in glass bowls and were presented both whole and ground - depending on their use.

A poster and a banner were made for the publicity of the exhibition, data about it being posted on the museum website and on its Facebook account. The chatbot was created by own means, based on open source code taken from GitHub and proprietary code.

Interactive exhibits are excellent tools that provide large and complex amounts of information in a visitor-friendly, easy to understand and enjoyable way. They leave it to the visitor to choose how the information can be obtained and give the visitor control over it, resulting in greater satisfaction and a more rewarding experience after visiting the exhibition. On the occasion of the cultural event „Night of Museums", which took place on May 18, visitors of different ages showed a special interest in the miraculous world of spices.

Fig. 1 – Aspect from the exhibition

Fig. 2 – Aspect from the exhibition

Fig. 3 – Aspect from the exhibition

However, interactive exhibitions do not represent a replacement of traditional exhibition methods, but a complementary side of them, helping to better place the exhibitors in the historical, scientific and cultural context. The exhibition „Spices, tasteful stories" was a good example of this.

Proposed objectives

The authors set out to achieve the following objectives:

- making a complete exhibition about spices; achieving sensory interactivity, both visual and olfactory;
- active involvement of learners in discovering information;
- dynamizing experience of visiting the museum;
- transmission of new information to the public through classical and modern methods;
- exercising the capacity of analysis, selection, debate and discovery;
- achieving a more efficient cultural marketing.

Results and discussions

The authors managed to design and create a museum exhibition about spices, based on prior documentation. Using financial resources allocated

by the main authorizing officer within the project, but also resources in open source and proprietary code, it was possible to create a modern exhibition, which addresses a wide range of visitors. Beyond the informative aspect, it also has a practical aspect, with the reinvention of traditional kitchens that appeal to spices and combinations of spices, thus rediscovering the flavors of old dishes.

The use of a chatbot to initiate an open dialogue with the public was a first step for the implementation of a modern cultural strategy based on modern technologies, in order to attract young audiences to the museum and its activities.

Conclusions

The realization of the exhibition „Spices, tasteful stories" was a good experience in creating interactive exhibitions as attractive as possible for the general public.

The museum had the opportunity to exercise its cultural-educational function, the institution also gaining popularity.

Rezumat

The exhibition „Spices, tasteful stories" was conceived, made and opened based on the documentation for the book with the same name published at the publishing house „Ion Borcea" Bacău.

This paper presents the way in which this exhibition was made and the preliminary observations on the impact on the visiting public.

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A LOST WORLD – TEMPORARY EXHIBITION

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ABSTRACT

The temporary exhibition ”A lost world” organized at the Natural Science Museum subunit of the Natural Science Museum Complex ”Ion Borcea”, Bacău, has opened for visitors since December 2018. The exhibition brings forth to the audience various aspects concerning the formation of the Earth and also the diversity of the species which populated it in the geological past. Thus, in the exhibition over 100 fossil samples are presented. The visitors can admire natural-sized reproductions of several prehistoric animals such as: *Kelenken guillermoi* - a gigantic bird which populated the Earth 15 million years ago, *Australovenator wintonensis* – a dinosaur which populated the Earth 95 million years ago or *Pterygotus anglicus* - a gigantic arthropod which lived 400 million years ago. Those interested can step on a geological time stairway, being able to identify representatives of various geological eras. The exhibition was organized in partnership with specialists from the Faculty of Geography and Geology, the Faculty of Biology in the ”Al. I. Cuza” University of Iași and from the Natural History Museum of Iași.

Key words: fossils, dinosaur, exhibition, museum

Introduction

The cultural and exhibitional project ”A lost world” began in 2016, aiming to call public attention on various aspects related to the formation of the Earth and on the diversity of the species which populated it in the geological past. The present living world means less than 1% of the total number of species that have ever appeared on our planet until now. Thus more than 99% of the species ever living on Earth have completely disappeared. Now over 19.000 plant species and 5.000 animal species on Earth are classified as being on the brink of extinction. Some other thousands of species reach this status every year, just before being identified by the biologists. Like the individuals, species evolve and then die. This process is part of the natural life cycle. Nevertheless, it seems that the rhythm of extinction brutally accelerated in the last centuries, respectively in the last decades. Our planet is on its way of beginning a phase of mass extinction, often called ”the sixth extinction”, which simultaneously takes the shape of a disorder and of a living world impoverishment (2,7,9). On one hand the exhibition warns against the species periclitation and on the other hand wants to spread the knowledge about the extinction of several important species in our planet’s geological past. The exhibition positively responds to the request of a large number of our visitors.

Objectives

- the capitalization of the museum patrimony;
- the offering of information to the public regarding the paleontological collection of the Museum Complex ”Ion Borcea”, Bacău
- the enrichment of our public’s knowledge regarding the existence of various species in our planet’s geological past;
- the presentation of various theories regarding the extinction of some species in the course of time.

Material and methods

The achievement of the temporary exhibition involved several specific activities which took place between 2016-2018:

- proposing / editing the theme project;
- achieving the technical project;
- listing the authentic exhibits and then selecting them from the paleontological collection of The Museum Complex of Natural Sciences”Ion Borcea” Bacău;
- coworking with experts from the Faculty of Geography and Geology, the Faculty of Biology of the ”Alexandru Ioan Cuza” University of Iași (Conf. Dr. Paul Țibuleac and Conf. Dr. Ion Cojocaru) in order to select and to take the necessary exhibits;
- restoring several exhibits;
- buying / assembling some representative exhibits;
- making the auxiliary and complementary exhibits: panels, labels, moulds, interactive applications etc.;
- assembling the exhibition according to the technical project;
- making the cultural marketing materials (flyers, banner, invitation);
- making the exhibition file.

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Results and discussions

The exhibitions has 5 compartments in which the evolution of life is shown:

1. Living in the distant past
2. Living in the Paleozoic
3. Living in the Mezozoic
4. Living in the Cenozoic
5. The origin and evolution of humans

Each part of the exhibition includes a 1000X2000 cm information panel, fossil samples illustrating each geological era, moulds and natural-sized replicas of some prehistorical animals (figure 1). Visitors can notice the phases of the fossilisation process through authentic exhibits and also can learn how coal and petroleum (figure 2).

Over 100 fossil samples are exhibited, of which: *Paradoxides bohemicus* – trilobites (sea arthropodes which are extinct 250 million years ago), *Choerolophodon anatolicus* (which is extinct 5,3 million years ago), *Ursus spaelaeus* – cave bear (which is extinct 27800 years ago), *Mammuthus primigenius* – the woolly mammoth (which is extinct approximatively 3000 years ago) etc. (figure 3).

Visitors can admire natural-sized replicas of some prehistorical animals such as *Kelenken guillermoi* – a giant bird which lived 15 million years ago or *Pterygotus anglicus* – a giant arthropode which lived 400 million years ago (figure 4). Also visitors can discover the fascinating dinosaur world, admiring some dinosaur species reconstruction - *Australovenator wintonensis* (which lived 95 million years ago) or *Tyrannosaurus rex* (which lived 65-68 million years ago) (figure 5).

Those interested are invited to step on a geological time scale of our planet, being thus given the chance to identify representatives of various geological eras (figure 6) (5,6,8,10,11).

Within this exhibition 3 interactive applications for touchscreen were developed (1,3,4):

1. Earth structure
2. Continent and ocean formation
3. Human evolution

→ Earth structure: within this application we explained the Earth's concentrical strata structure. The outer part presented the solid Earth crust making both the dry land and the sea and ocean bed, then the next thickest stratum i.e. the mantle extending down to 2.885 m depth and finally the centre of the Earth i.e. the core, which is made up of two parts: an outer layer, the so-called liquid outer core and a solid inner core (figure 7).

→ Continent and ocean formation: within this application we presented data regarding the dry soil masses through the movements of the tectonic plates along the geological eras in millions of years and also regarding the characteristics the relief and climate of each geological periods. The application also shows that this movement led to the separation and to the junction of the dry soil areas and to the present-day continent formation (figure 8).

→ Human evolution: within this application we presented data regarding the place of living, when he lived, but also information regarding the body structure, the physical appearance, the tools, the nutrition of each hominid species (accepted by the majority of scholars) (figure 9).

Conclusions

The theme of the exhibition aimed to show the visitors a world which disappeared millions years ago and also to show the audience little-known aspects in every geological era. Furthermore we seized the opportunity of exposing highly valuable pieces taken from the paleontological collection of The Museum Complex of Natural Sciences "Ion Borcea" Bacău.

Acknowledgements

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Fig. 1 - Info panels

Fig. 2 - Fossilisation /coal and petroleum formation

Fig. 3 - Fossil samples

Fig. 4 - Natural-sized replicas of prehistoric animals

TYRANNOSAURUS REX (OSBORN, 1905)
RECONSTITUIRE LA SCARA DE 1:4,5 DE ION COJOCARU ŞI ALEXANDRU BUZURIN,

AUSTRALOVENATOR (HOCKNULL ET AL., 2009)
RECONSTITUIRE ÎN MĂRIME NATURALĂ DE DIANA RĂU ŞI RADU FIRICEL,

Fig. 5 - Dinosaur species reconstructions

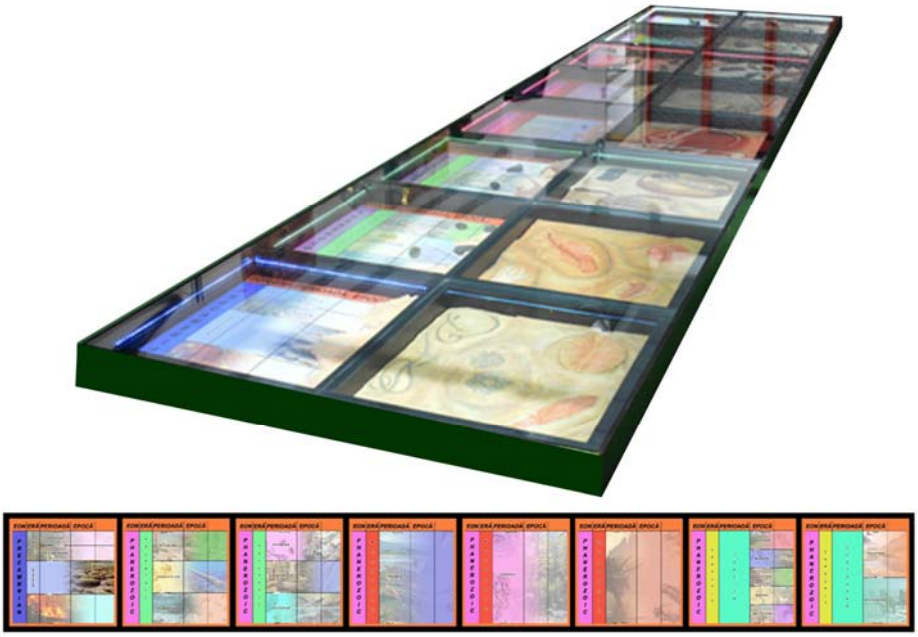

Fig. 6 - Geological evolution scale

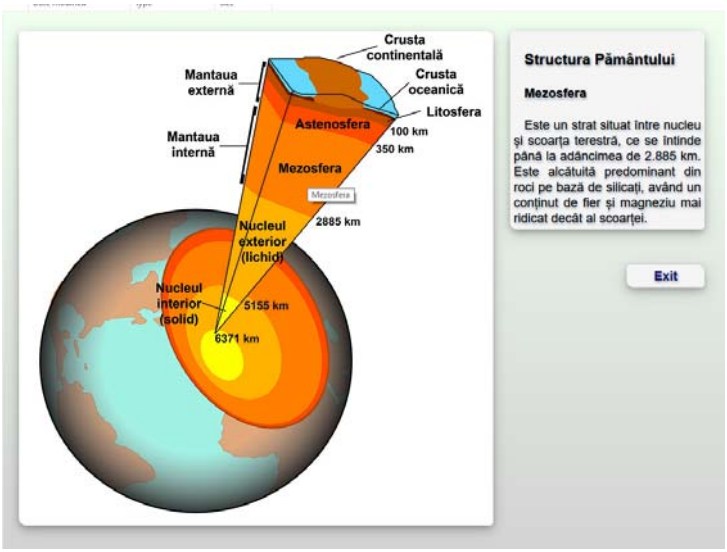

Fig. 7 - Interactive application – Earth structure

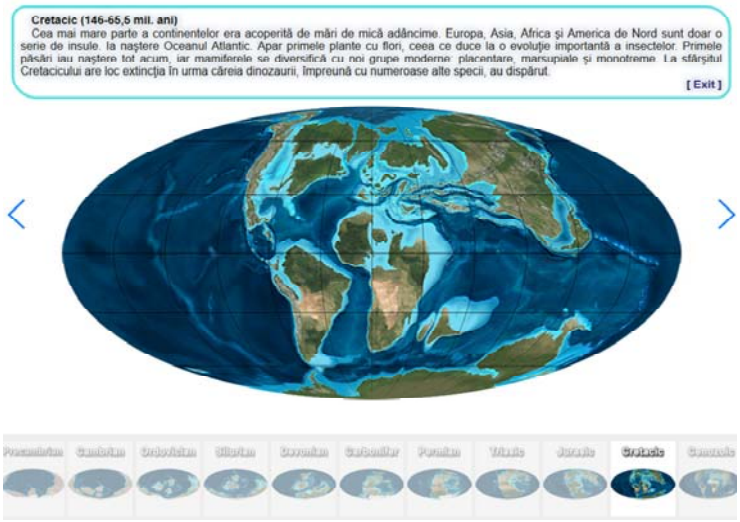

Fig. 8 - Interactive application - Continent and ocean formation

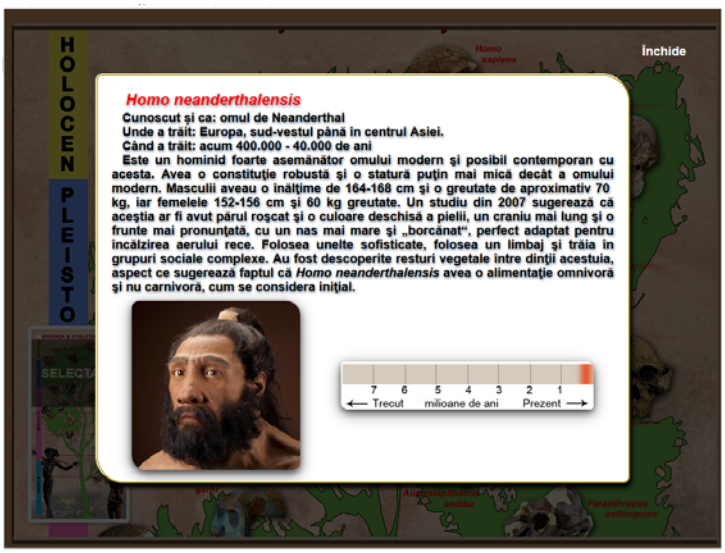

Fig. 9 - Interactive application – Human evolution

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INTERNATIONAL SPACE STATION BENEFITS FOR HUMANITY

ALEXANDRA CIUCHE*

ABSTRACT

The International Space Station (ISS) is a scientific station that affords researchers from all over the world to put their talents to work on innovative experiments. The ISS serves as a microgravity and space environment research laboratory in which crew members conduct experiments in biology, physics, astronomy, meteorology, and other fields. The station is suited for the testing of spacecraft systems and equipment required for missions to the Moon and Mars. In the areas of human health, innovative technology, education and observations of Earth from space, there are already demonstrated benefits to people back on Earth. Lives have been saved, station-generated images assist with disaster relief, new materials improve products, and education programs inspire future scientists, engineers and space explorers. Although each space station partner has distinct agency objectives for station research, each partner shares a collective goal to extend the resulting knowledge for the betterment of humanity.

Key words: International Space Station, benefits, space, astronauts.

Introduction

The International Space Station (ISS) is the largest artificial satellite in orbit on Earth, it is a unique scientific laboratory, several nations work for the construction and use the space station. The space station consists of pieces that have been assembled in space by astronauts, it orbits the Earth at an average altitude of 400 km, which means it orbits the Earth every 90 minutes. This space station is used to learn more about life in space, these researches will make it possible to send people further into space than ever before. The space station has made possible the continuous presence of astronaut in space, the astronauts live in space since the arrival of the first crew (2001).

Fig. 1 - Astronauts in extra-vehicular activities

The International realization illustrates the teamwork needed to create an international partnership that has continued to develop and serve as a model for international cooperation. Although each partner of the space station has a distinct research objective, the unified purpose is to expand the knowledge accumulated to benefit all humanity. The International Space Station is a laboratory for performing investigations that affect human health both in space and on Earth. During its period in orbit, of several aspects of human health, including aging, disease and environmental impact. Driven by the need to support astronaut health, several human biological and physiological investigations have yielded important results that can benefit us on Earth. The biologist has used ISS laboratory modules to study the response of the human body to extended periods of microgravity, and also development, life cycle and behavior of micro-organisms, plants and animals and how they are influenced by space radiation.

Space station laboratories allow crew members to do research that could not be done anywhere else, this scientific research benefits the people of Earth. Scientists study what happens with the body when people live in microgravity for a long time. All of these lessons will be important for the future on an exploration plan for other worlds.

Supporting water purification efforts worldwide

In space or in the life on Earth, clean water is essential for living organisms. The test methods developed to ensure water quality on the International Space Station has led to monitoring

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advancements here on Earth. Efficient wastewater recycling from ISS reduces the need to supply resources.

Without this ability, filtering water on board the space station would not support six crew members and supply is not an option for long-term space travel. The Space Station's Environmental Control and Life Support System (ECLSS) recovers wastewater from fuel cells of the station. Without such careful recycling, 40.000 liters of water per year from Earth would be required to resupply a minimum of four crewmembers for the life of the station. Unfortunately, many people around the world don't have access to clean water. Using the technology using for the space station the risk areas can access advanced water filtration, which makes a difference in saving lives in these communities. The collaborations between organizations and NASA show how efficiently space research can adapt to contribute the answer to this global problem. The Water Security Corporation, in collaboration with other organizations, has implemented a system that uses NASA's water processing technology. The first system using NASA technology was installed in northern Iraq in 2006.

Fig. 2 – ISS 19 Crew members drink water from the Water Recovery System

Preventing bone loss

In the early days of the space station, astronauts were losing about one and a half percent of their total bone mass density per month. Scientists have found that high-intensity exercise, dietary supplementation with vitamin D can remedy this. This research is also applicable to vulnerable populations on Earth. The common problem of bone loss in the elderly is also observed at astronauts when they are in space. Crew members engage in physical exercise for 2.5 hours a day, six times a week (15 hours a week). However, the risks of these problems occurring cannot be eliminated through physical exercise alone. Bisphosphonate is a therapeutic agent that has been used to treat osteoporosis patients for more than a decade, with proven efficacy to increase bone mass and decrease the occurrence of bone fracture. Through 90 day bed rest research on Earth, it was confirmed that this agent has a preventive effect on the loss of bone mass.

Protein crystals in Microgravity

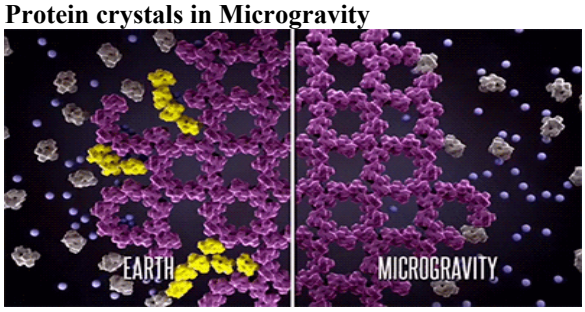

Fig. 3 - The difference between protein crystals grown on Earth versus in microgravity

The growth of protein crystals for medicine is an essential challenge in developing effective treatments and in knowing the shape of protein molecules in the human body. The unique microgravity environment of ISS allows the growth of higher quality protein crystals than those that can be grown on the ground. Proteins are responsible for several biological functions, including DNA multiplication but also digestion. Thus, protein crystallography is an essential tool for understanding these structures. The growth of crystals in a fluid on Earth is constrained by the convection movements caused by gravity and the precipitation of denser particles on the bottom of the fluid vessel. In microgravity, crystals can be larger than on Earth, allowing a simpler analysis of microstructure. Protein crystals developed on ISS are used in the development of new drugs for diseases such as cancer or muscular dystrophy, research that benefits from ISS are the growth of protein crystals. The unique microgravity environment of ISS allows the growth of higher quality protein crystals than those that can be grown on the ground. Studying the structure of proteins in the human body leads to the development of medical treatments.

Microgravity allows unique conditions for the growth of protein crystals where there is no gravity or convection to disrupt their growth. The protein expressed in certain muscle fibers of patients with Duchenne Muscular Dystrophy, which affects 1 in 3,500 boys, has been successfully crystallized in space revealing a new inhibitor several hundred times stronger than the prototype inhibitor.

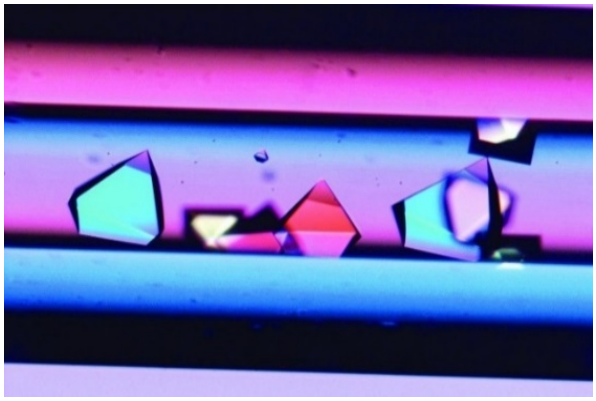

Fig. 4 - Protein crystals formed in microgravity

Monitoring natural disasters from space

The tool on the Space Station captured photos of Earth from space for fixation in countries during development affected by natural disasters. A wider collective experiment by NASA and the US Agency for International Development, known as SERVIR, worked with nations in the process of transforming the world to use satellites for decision making. Images from orbit made rapid response efforts to floods, fires, volcanic eruptions, deforestation, damaging blooms and other types of natural events. As a result of the plague, 90% of the areas populated on Earth every 24 hours, ISERV provided an availability to be able to imagine during devoting, collecting up to 1,000 images per day. For example, on March 13, 2011, the crew at the International Space Station responded in real-time to the crisis on the east coast of Japan, which was rocked by the magnitude 9.0 Tohoku earthquake, one of the strongest ever recorded, and which gave birth to a tsunami that flooded much of Honshu Island. The images provided by ISS illustrated two unique aspects of the earth monitoring and disaster response station. Using digital cameras, the crew can capture sunlight on water surfaces with greater frequency and control than most satellite systems, which means an improved ability to detect and map standing water and indicate areas of water interest in the contamination of the environment and health.

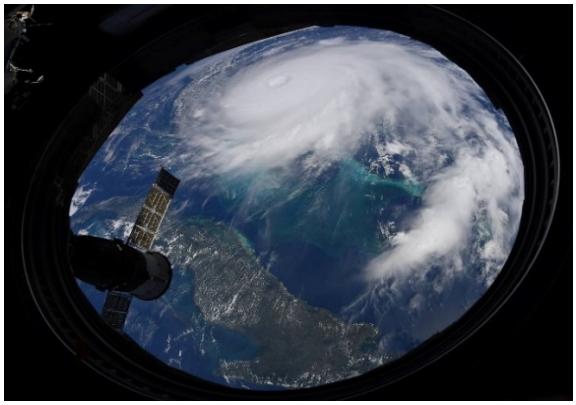

Fig. 5 - Hurricane Dorian saw from aboard the Space Station

Providing students opportunities to conduct their science in space

Since the launch of the first modules of the International Space Station (ISS) into orbit, students have been provided with a unique opportunity to get involved and participate in science and engineering projects. Many of these projects support inquiry-based learning, an approach to science education that allows students to ask questions, develop hypothesis-derived experiments, obtain supporting evidence, analyze data, and identify solutions or explanations. This approach to learning is well-published as one of the most effective ways in which to engage and influence students to pursue careers in science and technology fields. The International Space Station has a unique ability to capture the imaginations of both students and teachers worldwide. The presence of humans aboard the space station provides a foundation for numerous educational activities aimed at piquing interest and motivating children toward the study of science, technology, engineering and, mathematics. Projects such as the Amateur Radio on International Space Station, Asian Try Zero-G, and Synchronized Position Hold, Engage, Reorient Experimental Satellites Zero Robotics competition, among others, have allowed for the global student, teacher and public access to space through student image acquisition and radio contacts with crew members. Projects such as these and their accompanying educational materials are distributed to students around the world. Through the continued use of the space station, we will challenge and inspire the next generation of scientists, engineers, writers, artists and explorers.

Quickly Diagnose instruments for the Space Program

The ability to quickly diagnose an illness or injury and initiate treatment improves the outcome for the patient and reduces the consequences for the rest of the mission. For astronauts in orbit about 400 km above the Earth, on the International Space Station, this problem was addressed by the Advanced Diagnostic Ultrasound in Microgravity (ADUM) experiment. In partnership with the World Network, focused on ultrasound, ADUM's principal investigator, techniques originally developed for astronauts of the space station and adapting them to be used in the most distant corners of the Earth by developing protocols for performing complex procedures with remote guidance and training of experts. Health care has become more accessible in isolate regions through the use of small ultrasound units, and remote guidance techniques, like those used for people living onboard the space station.

Fig. 6 - Using the ADUM protocols, ISS Expedition Commander Leroy Chiao performs an ultrasound examination of the eye on Flight Engineer

Providing medical care for people in retired communities, such as Antarctic stations and on isolated crews, such as the International Space Station crew, is particularly challenging. Medical care at these isolate locations is usually performed by minimally trained medical personnel, and a physician is sometimes available only through phone. The ability to quickly diagnose an illness or injury and initiate treatment improves the outcome for the patient and reduces the consequences for the rest of the mission. The ability to make an accurate diagnosis in isolate areas reduces the impact of the incident and the chances of an expensive and potentially dangerous and unnecessary evacuation. Ultrasound imaging is among the fastest, safest and most universal diagnostic methods ever invented. It provides much of the information that can be obtained by expensive technologies, such as X-ray, computed tomography, or magnetic resonance imagery, and it is the only method to produce a real-time or live image that can be interpreted and transmitted at the same time.

Rezumat

Stația Spațială Internațională (ISS) este o platformă științifică care permite cercetătorilor din întreaga lume să lucreze la experimente inovatoare. ISS este un laborator de cercetare în care membrii echipajului efectuează experimente în biologie, fizică, astronomie, meteorologie și alte domenii. Stația spațială este folosită pentru testarea sistemelor și echipamentelor necesare pentru viitoarele misiuni pe Lună și pe Marte. În domeniile sănătății, tehnologiei, educației există deja beneficii demonstrate pentru oamenii de pe Pământ. Imaginile realizate de către instrumentele stației spațiale ajută la intervenția rapidă în cazul dezastrelor naturale, iar programele de educație inspiră viitorii oameni de știință, ingineri și exploratori spațiali. Deși fiecare partener al stației spațiale are obiective distincte pentru cercetare, fiecare partener are un scop unificat de a extinde rezultatele pentru binele umanității.

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2019 ACTIVITIES OF ”MATEI ALEXESCU” ASTRONOMY CLUB

MARIA VELEA*, ANA-MARIA BOTEZATU**

ABSTRACT

În lucrare este prezentată activitatea Clubului de astronomie „Matei Alexescu” din anul 2019, activitate ce include seminare pe teme de astronomie și astronautică, observații astronomice, concurs și expoziție de desene și machete pe teme de astronomie și astronautică, precum și o Școală de vară de astronomie. Tematica parcursă în timpul acestor activități a cuprins subiecte precum constelațiile, instrumente astronomice, Sistemul Solar, misiuni spațiale, viața în microgravitație, gruparea stelelor în Univers, clasificarea stelelor, producerea energiei stelare, evoluția stelară, planetele extrasolare, structura și evoluția Universului. Prin intermediul acestor activități s-a dorit ca membrii clubului să-și dezvolte competențele și abilitățile de documentare și cercetare în domeniul astronomiei.

Key words: constellations, planets, stars, nebulas, galaxies

Introduction

Curators Maria Velea and Ana Maria Botezatu within *Victor Anestin* Astronomical Observatory of Bacau founded “Matei Alexescu” Astronomy Club in 2017 which is a club meant for children.

The activities of “Matei Alexescu” Astronomy Club include astronomy and astronautics seminars, astronomical observations, contest and exhibition of space drawings and 3D models, as well as an astronomy summer school.

This paper presents the activities of the club in 2019, the educational project ”Matei Alexescu” Astronomy Club with the activities scheduled on the February – July period.

In 2019 the activity of the club started on the 16th of February with a seminar about the planets of the Solar System. The theoretical part of the seminar consisted in watching the planetarium show *Journey through the Solar System*, show that presents the structure of the Solar System, making the audience familiar with the main components of the System.

The central object is the Sun and it represents the light and heat source for all the other objects around it. The show explains the source of the solar energy (the nuclear fusion reactions), as well as the main phenomena that occur in the solar atmosphere: sunspots, solar flares, coronal mass ejections. The solar wind is also presented in the show as well as the way in which earth’s magnetosphere protects us from it and it reveals the ways in which the solar wind influences the formation of polar auroras. The Moon is then introduced, with its main physical characteristics, and its most widespread landforms. The 8 planets of the Solar System and their main characteristics are then showed. Small Mercury without an atmosphere has huge temperature variations from day to night. Its surface is full of impact craters, the biggest one being The Caloris Basin. A thick layer of sulphuric acid clouds and a dense atmosphere filled with carbon dioxide surround shining Venus, and, as such, the greenhouse effect make Venus the hottest planet in the Solar System. *Venera* Russian probes revealed the surface of the planet, showing that it has been transformed by an intense volcanic activity. *Magellan* American probe was the first space probe that managed to map the surface of planet Venus. *Venus Express* European probe studied in detail the atmosphere of planet Venus trying to find cues as to whether the surface of the planet is still experiencing volcanic activity or not. The rusty surface of Mars is arid and filled with sand dunes. At the poles of the planet ice caps can be observed. Sand storms roam the surface of the planet and its steep geographical landscape. The tallest volcano in the Solar System, Olympus Mons, can be found here. One of the largest canyons in the Solar System, Valles Marineris canyon can also be found here.

The giant Jupiter has an extended atmosphere with cloud strips that are moving in opposite directions thus creating huge hurricanes that last for hundreds of years. From the great number of Jupiter’s satellites the show presents Io where more active volcanos than on Earth were found and Europa, which contains an ocean of salty water under a thin layer of ice.

Saturn stands out through its rings, which are composed from billions of ice fragments remained from former satellites. From the great number of Saturn’s satellites, the biggest one is

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Titan, on which the *Cassini-Huygens* probe found methane lakes and seas.

Uranus stands out through its axis position, the planet being tilted at an angle of 98 degrees and thus tumbling on its orbit. Amongst its 27 satellites, Miranda has the most extreme topography with 20 kilometres tall ice faults.

The last of the planets, Neptune, has the most violent atmosphere in the Solar System. Its satellite, Triton, is geologically active and several nitrogen geysers have been identified on its surface.

The most well-known of the 5 dwarf planets is Pluto and the *New Horizon* probe discovered a very diverse topography on its surface.

There are millions of asteroids that orbit between Mars and Jupiter and beyond Neptune there are the Kuiper's Belt and the Oort's Cloud which represent the source of comets. But the Solar System is not alone in the Universe and until now thousands of extrasolar planets have been discovered in its close proximity. Who knows if some of them can sustain life or not.

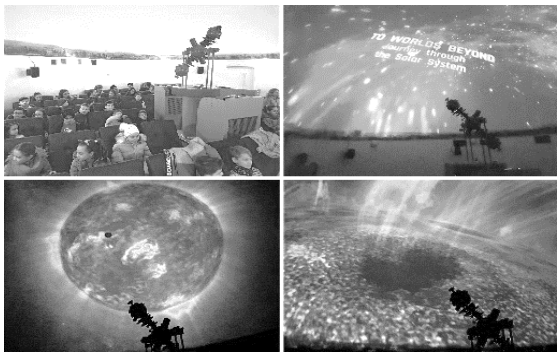

Fig. 1 – Watching the *Journey through the Solar System* planetarium show

The seminar included a practical activity as well within which each member of the club built their own 3D model of planet Earth.

Fig. 2 – Building the 3D model of planet Earth

During this activity, the club members had the opportunity to ask questions regarding the planets, and, at the same time, to test their practical abilities, and to improve their social skills by getting to interact with students from other schools in helping each other to create the 3D models.

Fig. 3 – 3D models of planet Earth done by the club members

The activity continued on the 16th of March with a seminar about the Universe. This started with the display of the sky and the constellations that are visible from the latitude of our country on a planisphere and it aimed to familiarize the club members with the notion of constellation and help them learn the most well-known and brightest constellations so that they can recognize them during the observing sessions. The theoretical part of this seminar continued with the multimedia presentation *The structure and the evolution of the Universe.*

The multimedia presentation *The structure and the evolution of the Universe* shows how the Universe was formed 13.8 billion years ago, presents all the stages of the Big Bang and describes how the early Universe looked like and how the first stars and galaxies formed. The star formation process from nebulas and how stars evolve according to their initial mass is shown. The source of stellar energy is also explained, and the stellar classification with examples for each category is presented. It is shown how stars are grouped within the Universe from double and multiple stars to star clusters, galaxies and galaxies clusters. The way in which galaxies interact within galaxies groups and clusters is also shown, as they often collide and merge which is a very important stage in their evolution. Finally, the structure of the Universe at the largest scale is

presented and the cosmic web is described as well as the way in which the Universe has evolved in the 13.8 billion years since its formation.

During this activity each of the club members has built a 3D model of the Kepler Space Telescope, the most important telescope dedicated to extrasolar planet discovery. During the activity, there have also been discussions about the most interesting exoplanets discovered in the proximity of the Solar System.

Fig. 4 – 3D models of the Kepler Space Telescope done by the club members

Cosmic Collisions within the Solar System seminar took place on the 13th of April and it started with a tour of the temporary exhibition *Astronautics in the 3rd millennium* which presents the most important space missions that are prepared by the largest space agencies, precisely missions with humans which are to be sent within the next two decades towards the Moon and Mars. The theoretical part of the seminar continued with the watching of *Cosmic Collisions within the Solar System* documentary.

Cosmic Collisions within the Solar System documentary speaks about the cosmic collisions that resulted in the formation of the celestial objects that compose the Solar System, as well as about the collisions that modelled the surfaces of these objects. It is shown how the Moon was formed as a result of planet Earth colliding with a planetoid the same size as Mars. The intense asteroid bombardment at the beginnings of the formation of the Solar System, which had a major contribution in modelling the surface of the Moon, is also shown. The way in which the atmosphere of a celestial object protects it against meteorite bombardments and the formation of impact craters are explained. It is shown how the numerous collisions that took place in the gas and dust disc remained around the Sun after its formation lead to the formation of the planets. Even though currently the probability for cosmic collisions inside the Solar System is very low, it is however possible that they take place. The possibility that they occur is real, and the documentary shows the collision between Shoemaker-Levy 9 comet and Jupiter that took place in 1994. It is explained that such collisions modified the planets' axis of rotation angle, and how a planet's tilted axis leads to the formation of seasons on that planet. It is also shown that there are cases of planets with an axial tilt higher than 90 degrees, which lead to them spinning around their own axis in the opposite direction compared to the other planets. The astronomers believe that the big altitude difference between the southern and northern hemisphere of planet Mars is the result of such a cosmic collision. Mars' northern hemisphere has a very low altitude and a relatively smooth surface while the southern hemisphere has mountains. It is possible that a gigantic impact between planet Mars and a planetoid produced this difference between the planet's two hemispheres, thus the low altitude area representing the largest impact crater in the Solar System. An impact at this scale occurred on planet Uranus that lead to the tilting of the planet to a 98-degree angle. Cosmic collisions between comets and Earth are what possibly represented the water source on our planet, this making life possible.

The practical part of the seminar consisted in the members of the club building their own 3D model of *Clementine* space probe which is one of the probes that orbits around the Moon to study its surface, which is littered with impact craters, the result of numerous cosmic collisions with meteorites, asteroids, and comets.

Fig. 5 – *The Universe seen through the children's eyes* drawings and 3D models exhibition

In May we organised for the members of the astronomy club a drawings and 3D models contest with astronomy and astronautics themes and with the best examples we created the *Universe seen through the children's eyes* exhibition which was displayed on the 3rd floor of *Victor Anestin* Astronomical Observatory, at the entrance of the planetarium dome. On the 18th of May we organised the exhibition opening as well as the awarding of the drawings and 3D models contest.

After the exhibition opening, at 11 o'clock, *The Polar Auroras and the Meteor Showers* seminar took place and it started with the planetarium show *Lucia – the Secret of the Shooting Stars.*

The planetarium show *Lucia – the Secret of the Shooting Stars* approaches the subject of polar auroras explaining their formation in detail. The show explains the way in which the solar wind interacts with Earth's magnetic field and with Earth's atmosphere thus creating the auroras. The characters of the show try to figure out the phenomenon behind the production of shooting stars. To see if there is a connection between the shooting stars that can be seen at night and the meteorites that hit the surface of Earth, the three characters start a space travel around the Solar System. They first visit the Moon and analyse its full of craters surface, arid and lifeless surface, with a black sky during day and night as a consequence of the lack of an atmosphere. After they witness the way in which a meteorite hits the surface of the Moon producing an impact crater they find out that this is the way in which the Moon's craters formed. To find out where meteorites come from the crew of the Polaris space ship leaves the Moon and heads towards the Asteroid Belt. Here they analize asteroids samples and the crew discovers that these have a similar composition with the meteorites found on Earth and Moon and conclude that meteorites come from the Asteroid Belt as a result of asteroids clashing against each other. The impact between an asteroid fragment and planet Jupiter is then presented. The impact leads to an explosion in the dense and extended atmosphere of this giant gas planet.

As the crew of the Polaris space ship continues its interplanetary travel, they meet the nucleus of a comet and they land on its surface where they observe that it is formed out of ice mixed together with dust and rock particles. On the face of the comet's nucleus that's lit by the Sun some of the ice starts to melt and boil off, along with particles of dust and they form the coma of the comet, the solar wind pushes the gas and the dust away from the coma forming the tail of the comet, which points away from the Sun. Polaris' crew then observes how planet Earth goes through the trail of dust and rock particles that was leftover from the comet and when the rock fragments enter Earth's atmosphere at high velocity they friction with the air and thus are set on fire, heating the air around them. This is how the phenomenon popularly called shooting star takes place. The same phenomenon is scientifically called meteor. The smaller fragments burn out in the atmosphere, while bigger fragments survive and hit the surface of the planet and are called meteorites. Thus the connection between meteorites and shooting stars that can at times be observed on Earth's night sky is revealed.

During the practical part of this seminar, the members of the astronomy club build the 3D model of the space probe SOHO, which is one of the most important space probes sent to study the Sun from its nucleus to the solar corona (the source of the solar wind, which produces the polar auroras).

On the 22nd of June we organized the *Road to Knowing the Universe* seminar which started with watching the planetarium show *The blind man with starry eyes.*

The planetarium show *The blind man with starry eyes* shows the story of a king that ruled its kingdom tyrannically. To find new ways to dominate the tyrant seeks advice from the wisest old man in his kingdom by asking him how to become more powerful. The old wise man advices the king to watch the sky and count the stars. The tyrant follows the advice of the old man hoping that he would find more ways to dominate and subjugate his people, but realises that this task overwhelms him so he orders his army to count the stars. The tyrant thus observes that the stars don't have a fixed position on the sky, but rising and setting to make space for other stars. The old wise man explains to the tyrant that this was because the Earth is spinning around its own axis. The tyrant then accuses the old wise man of challenging his authority and of wanting to convince the people that the king is not the ruler of Earth and imprisons the old man. But the tyrant keeps trying to find out whether what the old wise man had told him was true or not, and, in his search, slowly reaches the conclusion that the old wise man was right, that he wasn't the ruler of Earth, but belonged to Earth. And as the old wise man tells him that the Earth belongs to the Universe, the tyrant decides that he wants to own the entire Universe. The old wise man advices the tyrant to learn what the Universe is and then the Universe shall belong to him. In his attempt to follow the old man's advice the tyrant slowly discovers the secrets of the Universe: the explanation of the apparent movement of the night sky (the movement of the planet around its own axis), what the shooting stars are, what's the lifecycle of stars, what constellations are, etc. The contemplation of the sky and the discussions with the old man about the Universe slowly transformed the tyrant: he was thinking about war less and less and about studying the Universe more and more and the more he learnt the more he wanted to know more. Therefore, when the old wise man dies the

tyrant takes his clothes to take his place and studies the sky for the rest of his life.

After the planetarium show, the members of the astronomy club built the 3D model of a space rocket during a practical activity. They were told about the usefulness of space rockets: serving as vehicles that launch artificial satellites, automated space probes, or space ships with humans on board.

Fig. 6 – 3D models of a space rocket done by the club members

In between 25th and 27th of July, we organized *The Secrets of the Universe* Summer School for the members of the club. Each day started with a presentation of the constellations on the planisphere so that the members retain the shapes of the constellations to the best of their abilities and whenever they went to the planetarium they tried to recognize them on the planetarium dome.

Fig. 7 – presenting the constellations on the planisphere

On the 25th of July we continued with a tour of the *Solar System* exhibition and then with the watching of the planetarium show *Polaris.*

The planetarium show *Polaris* approaches the subject of polar nights and days and the two main characters of the show try to figure out which is the cause of the huge duration of 6 months of polar nights and days. The two characters wander if polar nights and days last as long on other planets and to find out the answer to this question they turn their telescope towards planets Mars and Saturn, but reach the conclusion that it isn't enough to just study the planets through the telescope to find out the answer. Instead, they need to travel with a space rocket and look at planet Earth from above and study it in as a whole and then to visit planets Mars and Saturn. Once they reach space, the two characters start orbiting around Earth and observe that the North Pole of the planet is in darkness so it's night. Regardless of the fact that the Earth is spinning around its own axis the North Pole remains in darkness as the polar night continues and this is because of the fact that Earth's axis of rotation is tilted and during the polar night the North Pole is tilted opposite to the Sun. The characters observe that the situation is reversed on the South Pole, which constantly has solar light and it's polar day time as because of the tilting of Earth's axis the South Pole is tilted towards the Sun. The characters realise that this situation changes throughout the year as the Earth orbits around the Sun according to Earth's position on the orbit and the position of the two hemispheres towards or against the Sun. Thus they decide to revisit Earth in a few months to analyse the situation and meanwhile go visit planets Mars and Saturn. On Mars' poles the characters observe ice caps and conclude that these must be formed as a result of long polar nights, the same way as on Earth. On Saturn's poles they notice there is no ice caps, but observe several thousand rings around the planet. They see that, unlike Mars, Saturn does not have a solid surface as it is made out of gas, and, as they approach the rings, they realised that they are made of billions of ice particles. As they return to Earth's orbit they observe that the situation is opposite compared to when they left: there's day on the North Pole and night on the South Pole. The axis of Earth preserves the direction of its tilt as it goes around the Sun, so the hemisphere that is at one point directed towards the Sun is going to be directed against the Sun in 6 months' time. If the North Pole is directed towards the Sun it means that here it's day and summer, while the South Pole is directed against the Sun in darkness experiencing winter and polar night. After 6 months the South Pole will be directed towards the Sun and the North Pole will be in darkness and the seasons will be reversed: 6 months of day and summer at the South Pole and night and winter at the North Pole. Thus, the cause of season formation on Earth is explained together with the explanation for the long polar nights and days. This leads to the conclusion that

any planet that has a tiled axis of rotation will experience seasons.

Fig. 8 – Solar observations

After the planetarium show we went to the Observatory's roof terrace to show the members of the astronomy club the ways in which the main optical instruments are used for astronomical purposes: the binocular, the refracting telescope and the reflecting telescope; and to make solar observations with the members.

The members of the club then built a 3D model of the Hayabusa 1 space probe, which is the first space probe that collected samples of an asteroid and brought them back to Earth.

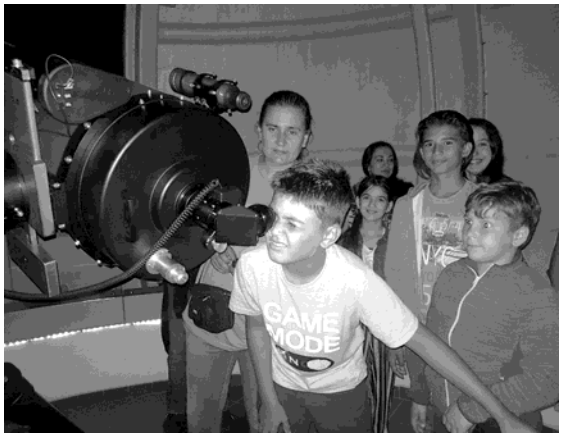

Fig. 9 – Astronomical observations through the reflecting telescope

The activities of the first day of the summer school ended in the night with astronomical observations of planets Jupiter and Saturn with a binocular, a refracting telescope and a reflecting telescope.

The second day of the summer school continued with a tour of *The grouping of stars* and *Stellar evolution* exhibitions and with watching the planetarium show *Constellations,* after the presentation of the constellations on the planisphere.

The planetarium show *Constellations* familiarises the students with the notion of constellation by presenting the constellations that can be seen on the sky in each astronomical season. The show presents both the mythology associated with the constellations and the celestial objects that are representative for each constellation, such as: star clusters, galaxies, or extrasolar planets.

It is explained how the astronomical seasons are delineated by equinoxes and solstices and how the duration of nights and days varies according to the astronomical season. The show presents the zodiacal constellations, and circumpolar constellations such as Small Dipper and Big Dipper, explaining how to use the latter to find the North Star, star which shows north and serving as a very good reference point. The brightest stars of each constellations are shown, and the different types of stars that exist in the Universe are presented and their characteristics are compared to those of the Sun.

The two categories of planets of the Solar System are showed: terrestrial planets and giant planets with an example from each category (the terrestrial planet Mars and the giant Saturn) and the main characteristics of each category of planets. Our galaxy, the Milky Way, is shown as it is seen from Earth and its full structure together with the types of celestial objects that comprise it. The show then presents the comets and how their remains form meteors. The strongest meteor showers are also presented.

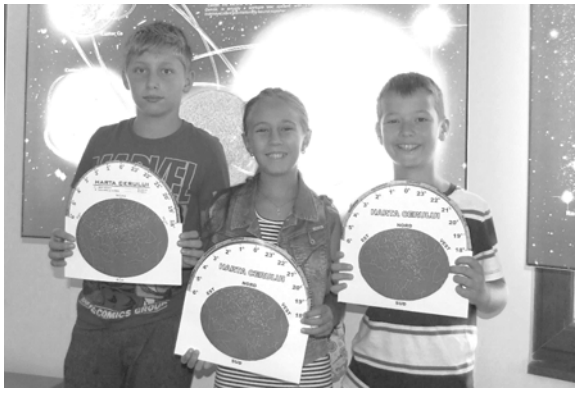

Fig. 10 – Planispheres built by the club members

During the practical part of the activity the members built a planisphere that would help them to orientate on the night sky.

The third day of the summer school was dedicated to the Apollo Program, as this year is the 50th anniversary since the first landing on Moon.

After the presentation of the constellations on the planisphere, the day continued with a tour through the astronautics exhibition and with the watching of the *Apollo 11* documentary.

The documentary presents the first space mission that brought humans to another celestial object, the Moon. The footage taken during all stages of the mission are presented: the launch of the spacecraft Apollo 11 with the rocket Saturn V, the activities of the astronauts during the Earth – Moon journey, the detachment of the lunar module from the Apollo 11 spacecraft, the landing on Moon, the activities of the astronauts on the surface of Moon, and their return to Earth.

The activities of the astronauts during their time outside of the Lunar Module are presented in detail: collecting Moon soil samples, planting the American flag on the Moon, installing of a set of scientific instruments on the surface of the Moon, photographing and filming the lunar landscape.

The documentary ends with the safe return of the three astrounauts on Earth, which marks the successful ending of the mission. The mission is considered to be the greatest achievement of the humankind regarding space exploration.

After watching the documentary, the day continued with a practical activity during witch the members of the club built a 3D model of the Apollo spacecraft. During this time it was shown to them on a 1/100 mock-up of the Saturn V rocket which are the stages of the rocket and how the rocket was launched into space.

Fig. 11 – Explaining how multistage rockets work

Fig. 12 – 3D models of the Apollo spacecratf done by the club members

In the end the members of the club were given participation certificates for taking part in the activities of *The Secrets of the Universe* Summer School. This also concluded the activity of ”Matei Alexescu” Astronomy Club in 2019. The activity is presented in the second edition of ”Matei Alexescu” Astronomy Club magazine.

Fig. 13 – Handing the participation certificates for the participation to the Astronomy Summer School.

Conclusions

Through all these activities ”Matei Alexescu” Astronomy Club aimed to increase the interest and motivation of the club members to study the Universe, to develop their ability to communicate using the scientific language specific to astronomy, and to offer the members the chance to discover the secrets of astronomy. During the activities the members of the club showed a real interest for astronomy, which, even though

represents one of the oldest sciences it is not taught in schools in Romania. As a result of the fact that astronomy is not being taught in schools the club members didn't know much about this subject when they first enrolled in the club. The non-formal education in this area of study done through astronomy clubs and astronomical associations is therefore extremely important as it replaces the formal education which is missing completely.

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