Scientific Papers. Series A. Agronomy, Vol. LXV, No. 2, 2022
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECTS OF FERTILIZATION WITH ALCOHOLIC BEVERAGE PRODUCTION WASTE ON HUMUS AND BIOPHILIC ELEMENT BALANCE IN CAMBIC CHERNOZOME

Andrei SIURIS, Maria GAMURAR

Institute of Pedology, Agrochemestry and Soil Protection "Nicolae Dimo", 100 Ialoveni Street, MD-2070, Chisinau, Republic of Moldova

Corresponding author email: siurisandrei@mail.ru

Abstract

As a result of any human activity an enormous amount of waste accumulates. Unused for various reasons (psychological, economic, legal, technological, etc.), they cause an ecological imbalance in nature, disrupting the normal functioning of the soil, the atmosphere and water resources. At the same time, they contain considerable quantities of elements necessary for plant nutrition and soil fertilization. In the current conditions when the application of industrial fertilizers has fallen to minimal levels, the widespread use of organic waste is of particular importance for Moldovan agriculture. An extensive study, recently carried out in the Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", shows that the use of waste from the production of alcoholic beverages (wine lees, vinasse, grains borage) applied to various crops, provides a specific income between 90-900 lei/ton. One euro invested in the use of these wastes is recouped with 1.3-3.7 lei. Expenditure is fully recouped, with yield increases in 1-2 years for field and vine crops. With all the benefits listed and the increasing needs during the growing season, waste from the production of alcoholic beverages is practically not used, but left unused, causing mess, dirt and health problems. The above-mentioned wastes were tested in two long-term field experiments at the technological-experimental station "Codru" located in Codru commune, Chisinau municipality.

Wine lees and vinasse are discharged from wine production units, and grain borage from enterprises producing ethyl alcohol. Research has confirmed that wine waste increases the content of humified organic matter by 0.16-0.41%, mobile phosphorus by 0.41-1.12 mg/100 g of soil and exchangeable potassium by 11-15 mg/100 g of soil. Yields per hectare when wine waste is applied are 11-13 t/ha. Grape yield increase is 1.0-3.2 t/ha (10-31%). Application of cereal borage increases soil organic matter by 0.12-0.21% (3000-6500 kg/ha), mobile phosphorus by 0.31-0.54 mg/100 g (6-11 kg/ha) and exchangeable potassium by 4-9 mg/100 g soil (80-180 kg/ha). The yield increase when using cereal borage is 40-60%. The beneficial influence of fertilization with waste from alcoholic beverage production on humus and biophilic elements (NPK) is also demonstrated by calculating the balance of these indicators.

Key words*: chernozem, wastes, wine lees, vinasse, grain mashes, humus, biophilic element, balance, cambic chernozem.*

INTRODUCTION

Carbon and nutrient cycling in the soil-fertilizer-plant-environment system is of paramount importance, since soil fertility, crop yields, agricultural production quality, environmental purity and population health depend on their quantity.

One of the main laws of agriculture is to restore the humus and nutrients extracted from the soil with the harvests obtained and to compensate for their non-productive losses in order to maintain soil fertility at a satisfactory level and with a balanced humus and nutrient balance.

At present, when the application of organic fertilizers has been reduced to a minimum in Moldovan agriculture, the unproductive loss of humus and nutrients from the soil continues, and urgent measures are needed to stop this phenomenon and increase the fertility of arable soil. This can be done on the basis of detailed research with the development of objective indices of all the values of input and consumption items in the humus and nutrient balance circuit in the soil.

Soil organic matter plays an extremely important role through its physico-chemical and biological functions, serving as an energy source for microbial flora and a factor on which the soil's fertility status largely depends. Humus is the most important store and at the same time the most important source of carbon and nutrients. It should be noted that the chernozems of Moldova have lost about 25 percent of their accumulated organic matter over 100 years (Crupenicov et al., 1989). This

phenomenon is also characteristic for other countries. For example, Canadian soils after 100 years of exploitation have lost 25 percent of their original carbon (Jausen et al., 1998).

In our country, waste from the production of alcoholic beverages (wine lees, vinasse and cereal borage) can partly serve as a source of carbon and nutrients in the soil. It should be noted that these wastes are a very important source for increasing carbon reserves, which serve as material for the formation of humus and huminic acids that improve the nutrient regime of agricultural crops and consequently soil fertility.

The aim of this work was to determine agrochemical indices and to assess their balance in the soil when applying waste from alcoholic beverage production as organic fertilizer. On the basis of the research carried out, technological models for the application of these wastes were developed (Material and method, Siuris, 2017; Siuris, 2019).

As study material served the organogenic wastes from the production of alcoholic beverages: wine lees, vinasse and grain borage. The research was carried out at the Technological-Experimental Station (STE) "Codru", located in Codru commune, Chisinau municipality in two field experiments during 2011-2019. The investigated soil is a luto-clay levigated chernozem with humus content - 4.31%; P_2O_5 - 3.42 mg/100 g soil; K_2O - 43 mg/100 g soil (Macighin method); pH 6.8 units; hydrolytic acidity 2.71 me/100 g soil. Wine wastes are applied to vine cultivation (Sauvignon variety) and those from ethyl alcohol production to field crop cultivation. In 2012 sunflower was grown in the experimental field, followed by autumn wheat, sunflower, grain maize, autumn wheat, grain soya and in 2019 autumn wheat.

The determination of humus balance and biophilic elements was carried out respectively according to the methodical guidelines (Banaru, 2002) and instructions (Donos, 2001) developed in the Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo".

RESULTS AND DISCUSSIONS

Characteristics of the waste investigated

Wine lees are formed, after dehydration by pressing of liquid lees. They are found to be concentrated fertilizers that can economically justify their transport over long distances, more than 10 km from the wineries. Compared to conventional manure, solid wine lees contain 2.7 times more nitrogen, 1.6 times more phosphorus, 2.4 times more potassium and 2.7 times more organic matter.

It is characterized by an acidic environment. The average pH value is 3.5 units. Moisture content ranges from 42% to 59%, averaging 48%. The chemical composition shows that solid wine lees are an important source of organic matter for the soil and primary elements for agricultural plants. Calculated from the mass with natural moisture the organic matter content averages 47%. Of the primary elements, total potassium predominates, averaging 2.5%, followed by total nitrogen 1.5% and total phosphorus 0.70%. On average 1 ton of solid wine yeast with natural moisture contains 47 kg NPK, with a ratio of these elements of 1:0.5:1.7 which corresponds approximately to the nutrient requirements of the main crops.

Vinasse (burnt wine) is the liquid remaining after distillation of the alcohol from the wine and is a residue of boiled wine without alcohol, golden-brown in color, with a specific smell of heat treatment and a sour taste. It contains organic and mineral compounds, proteins, coloring compounds, nitrogenous substances, phenolic substances, which can positively influence the biological qualities of alcoholic beverages or serve together with other compounds as a sterile nutrient medium in the process of fermentation of molasses and production of refined ethyl alcohol. In the Republic of Moldova there are no methods of complex processing of molasses. Thus, it goes into the sewage system, increasing the degree of wastewater pollution, polluting the environment. Vinasse is characterized by an acidic environment (pH = 3.0-3.7 units). It has an average content of 98% water and 2% dry matter. It contains on average 13.3% organic matter, 0.02% total nitrogen, 0.02% total phosphorus and 0.12% total potassium. The aqueous extract is dominated by monovalent potassium cations (580 mg/l) and sodium (170 mg/l). The concentration of bivalent calcium and magnesium cations averages 106 mg/l and 84 mg/l. Among the anions, sulphates

predominate with an average value of 155 mg/l. The chlorine content averages 90 mg/l.

Cereal borage is formed as a waste product in ethyl alcohol production plants. It is characterized by an acidic environment (pH = 3.4-4.2 units). They have an average content of 93% water and 7% dry matter. They contain a considerable amount of organic matter (1.6-6.2%) and a varied content of primary elements: total nitrogen 0.21-0.33%, total phosphorus 0.06-0.19% and total potassium 0.09-0.13%.

From the above we can see that the waste from the production of alcoholic beverages can be included in the agricultural circuit by using it as an organic fertilizer.

Influence of wastes on the main agrochemical indicators of levigated chernozem. The application of waste from the production of alcoholic beverages had a beneficial influence on the humus, nitrogen, phosphorus and potassium content of levigated chernozem (Table 1).

Table 1. Influence of waste from alcoholic beverage production on humus and nutrient content in the levigated chernozem layer averaged over the years 2011-2019 (STE "Codru")

Experience variant	Humus		Nitrogen		Phosphorus		Potassium	
	%		mg/100 g sol					
	Average	Increase	Average	Increase	Average	Increase	Average	Increase
Waste from wine factories								
1. Unfertilized control	3.99	-	0.74	-	2.16	-	28	-
2.Wine lees (N_{100}), 13 t/ha	4.22	0.23	0.92	0.18	2.75	0.59	36	8
3.Wine lees (N_{200}), 26 t/ha	4.36	0,37	1.07	0.33	3.14	0.98	40	12
4. Vinasse (K_{450}), 300 m^3/ha	4.17	0.18	1.22	0.48	2.43	0.27	38	10
5.Vinasse (K_{900}), 600 m^3/ha	4.26	0.27	1.35	0.61	2.48	0.32	41	13
DL 0.5%	0.11	0.11	0.40	0.40	0.11	0.11	6.70	6,.70
Sx, %	8.20	8.20	10.23	10.23	5.10	5.10	9.10	9.10
Waste from the production of ethyl alcohol								
1. Unfertilized control	2.91	-	1.17	-	2.08	-	26	-
2.Ceral borage (N_{120}), 47 m^3/ha	3.03	0.12	1.34	0.17	2.32	0.24	29	3
2.Cereal borage (N_{240}), 94 m^3/ha	3.13	0.22	1.38	0.21	2.58	0.50	32	6
DL 0.5%	0.10	0.10	0.60	0.60	0.19	0.19	2.80	2.80
Sx, %	7.80	7.80	7.40	7.40	12.20	12.20	10.70	10.70

Humus in soil. Average data showed that the administration of wine yeast doses (13 and 26 t/ha), equivalent to 100 and 200 kg N/ha per year, leads to a significant increase in humus content in the chernozem layer. The average increase over nine years (2011-2019) was 0.18 and 0.37% respectively. The application of vinasse at 300 and 600 m^3/ha, equivalent to 450 and 900 K/ha per year, leads to statistically significant increases in the humus content values, where the increase compared to the baseline averaged over nine years was 0.18-0.27%. Cereal borage applied at rates equivalent to 120 and 240 kg N/ha led to significant increases in soil humus content. The values of humus content increase in eight years of experimentation (2012-2019) averaged 0.12-0.22%, respectively.

Mineral nitrogen. The administration of waste from alcoholic beverage production into the aerial layer of levigated chernozem positively acted on the mineral nitrogen content. Fertilization with wine yeast at doses containing 100 and 200 kg N/ha per year led to a significant increase in mineral nitrogen content. Over eight years the average value of mineral nitrogen content compared to the control increased by 0.18-0.33 mg/ 100 g soil. Fertilization with vinasse at 300 and 600 m^3/ha increased this index by 0.48-0.61 mg/100 g soil compared to unfertilized soil. The application of cereal borage at the earlier mentioned rates

led to statistically significant increases in the mineral nitrogen content during the eight years of experimentation, where compared to the control it averaged 0.17-0.21 mg/100 g soil.

Accessible phosphorus and potassium. Fertilization with wine yeast at rates of 13 and 26 t/ha led to statistically significant increases in accessible phosphorus content. Over nine years the mean value of accessible phosphorus content compared to the control increased by 0.59-0.98 mg/100 g soil. The application of vinasse at rates of 300 and 600 m^3/ ha led to statistically significant increases in accessible phosphorus content values in all nine years of experimentation (2011-2019). The average phosphorus gain compared to the reference variety was 0.27-0.32 mg/100 g soil. As for the potassium content when applying wine waste statistically assured increases over the control were recorded throughout the years. The value of the increase in exchangeable potassium content was respectively 8-12 mg/100 g soil and 10-13 mg/100 g soil compared to the control.

Statistically significant values of accessible phosphorus content were also found when cereal borage was applied at 47 and 94 m3/ha (equivalent to N120 and N240 kg N/ha). The difference of the eight-year mean value from the control was 0.24 and 0.50 mg/100 g soil. As regards the value of exchangeable potassium content when applying cereal borage, the statistically assured increase was 3-6 mg/100 g soil.

According to the methodical instructions (Andrieș et. al., 2007) due to the application of waste from the production of alcoholic beverages the levigated chernozem investigated by humus content is classified as high, by moderate nitrogen content, by optimal phosphorus content and by high potassium content.

Humus and nutrient balance in the application of waste from alcoholic beverage production. The beneficial influence of organogenic waste fertilization has also been demonstrated by calculating the humus and nutrient balance in vine and field crop cultivation (Table 2-4).

Humus balance. Humus is the most important store and at the same time the most significant source of carbon and nutrients. It should be noted that in recent years zonal soils in the country are practically not respected. The share of perennial grasses in field soils has decreased considerably. At the same time, the area occupied by biological nitrogen-fixing leguminous crops has tripled and the share of grassland crops has increased to 65% (Andrieș, 2017). In the last 20 years, small amounts of organic fertilizers have been applied in agriculture (0.02-0.03 t/ha), the optimal dose being 10 t/ha (Monitoring bulletin, 2000). Secondary agricultural production is not applied everywhere as organic fertilizer. As a result, the humus balance in Moldovan agriculture is negative (-0.7 t/ha), and due to erosion losses we have an even greater reduction (-1.1 t/ha), (Andrieș et al., 2002; Andrieș, 2005). Organogenic wastes from the production of alcoholic beverages serve an important source for increasing carbon stocks.

The humus balance is negative in the reference scenario, with a deficit of 1203 kg/ha per year (Table 2).

Table 2. Annual humus and nutrient balance on levigated chernozem under vines, kg/ha.
STE "Codru", 2011-2019

Experience variant	Humus	Nitrogen	Phosphorus	Potassium
1. Unferitilezd control	-1203	-54	-18	-64
2. Wine lees (N_{100}), 13 t/ha	2514	126	70	273
3. Wine lees (N_{200}), 26 t/ha	4497	225	158	562
4. Vinasse (K_{450}), 300 m^3/ha	184	9	41	296
5. Vinasse (K_{900}), 600 m^3/ha	1153	56	101	645

For wine waste, the results of the balance were positive for the accumulation of humus content. When applying wine lees and vinasse the humus balance was respectively: 2514-4497 and 184-1153 kg/ha annually. It was determined that when applying cereal borage (Table 3), the humus balance in the unfertilized control variant was negative, with a deficit of 2136 kg/ha annually. In the variants fertilized with 47-94 m3/ha cereal borage the average

annual humus balance (2012-2019) is respectively 857 and 1676 kg/ha.

Research has shown that crops sown often in our case, autumn wheat are more favorable to the soil in terms of humus loss. The humus balance in the reference variety is negative (Table 4).

Table 3. Humus and nutrient balance in soil on levigated chernozem fertilized with cereal borage, kg/ha on average for the years 2012-2019. STE "Codru"

Experience variant	Humus	Nitrogen	Phosphorus	Potassium
1. Unferilized control	-2136	-107	-40	-103
2. Cereal borage (N_{120}), 47 m^3/ha	857	18	31	238
2. Cereal borage (N_{240}), 94 m^3/ha	1676	95	85	529

Table 4. Humus and nutrient balance in the soil per crop when fertilizing levigated chernozem with cereal borage, kg/ha. STE "Codru", 2012-2019

Experience variant	Crop			
	Autumn wheat	Sunflower	Grain maize	Soya beans
Humus				
1. Unferilized control	-1930	-1173	-1408	+78
2. Cereal borage (N_{120}), 47 m^3/ha	1211	625	456	308
2. Cereal borage (N_{240}), 94 m^3/ha	1625	2820	2700	2536
Nitrogen				
1. Unferilized control	-147	-59	-70	+20
2. Cereal borage (N_{120}), 47 m^3/ha	16	31	23	63
2. Cereal borage (N_{240}), 94 m^3/ha	31	141	135	127
Phosphorus				
1. Unferilized control	-53	-22	-25	+10
2. Cereal borage (N_{120}), 47 m^3/ha	23	23	40	54
2. Cereal borage (N_{240}), 94 m^3/ha	61	114	112	101
Potassium				
1. Unferilized control	-107	-120	-68	+16
2. Cereal borage (N_{120}), 47 m^3/ha	245	195	282	257
2. Cereal borage (N_{240}), 94 m^3/ha	529	486	587	560

A humus balance with positive values was found when applying cereal borage at rates of 47 and 94 m^3/ha, equivalent to N100 and N200 annually. Positive values were 625-2820 and 456-2700 kg/ha annually.

The highest soil humus losses through mineralization are brought by the arable crops, in our case grain maize and sunflower. During the investigation period in the experimental field grain maize was grown for one year. Negative values of soil humus balance or established in the control variant, which makes up 1408 kg/ha. The application of borage at rates equivalent to N120 and N240 kg/ha offsets a good part of the mineralized humus. The amount of humus deficiency compensation is directly proportional to the applied rate of cereal borage and amounts to 456-2700 kg/ha. In sunflower cultivation a negative deep balance was established only in the unfertilized variety. Humus losses were -1173 kg/ha. In the variants with cereal borage application the humus balance was positive, making up 625-2820 kg/ha.

The crops sown often are more favorable to the soil in terms of humus losses. The humus balance of the winter wheat crop in the control variant is negative. The four-year average value is - 930 kg/ha. When waste is applied, this index has positive values, averaging 1211-1625 kg/ha. So, more pronounced positive values was established when fertilizing with 94 m^3/ha of borage (1625 kg/ha).

When growing soybean plants for grain (one year only) the humus balance in the reference variety was positive, making up 78 kg/ha of humus accumulated in the soil. When using waste, the humus balance was profoundly positive. Humus content values were 308- 2536 kg/ha respectively.

Nitrogen balance. Nitrogen is the most active nutrient, which plays an important role in plant

life. It is part of protoplasmic structural proteins, nucleic acids, chlorophyll pigments, some vitamins and enzymes.

The main amount of nitrogen is found in soil organic matter. Plant-accessible nitrogen is formed and accumulates in the soil due to the decomposition of humus by micro-organisms. It has been established over time that every 1% of humus in the ploughed layer provides plants with 24 kg/ha of accessible nitrogen.

It should be noted that the nitrogen balance in soils is negative. This phenomenon leads to a decrease in soil fertility and productivity of agricultural crops.

The investigated wastes had a beneficial influence on the nitrogen balance in levigated chernozem (Table 2). The nitrogen balance in the unfertilized version is negative, the deficit being -54 kg/ha (Table 2). When wine waste was applied in the named doses the nitrogen balance results were positive, making up respectively 126-225 and 9-56 kg/ha annually. The nitrogen balance in the reference variant was found to be negative, with a deficit of 107 kg/ha per year (Table 3). In the variants fertilized with 47-94 m^3/ha of cereal borage the average annual humus balance was 18 and 95 kg/ha respectively.

It has been shown that the nitrogen balance at crop level in the control variant is characterized by positive values in grain soybean cultivation, making up 20 kg/ha (Table 4). More pronounced positive values of 63-127 kg/ha were established when applying cereal borage doses equivalent to N120 - N240 kg/ha. The nitrogen balance in autumn wheat cultivation in the control variety is deeply negative. The four-year average value is 147 kg/ha. The application of waste at rates of 47-94 m^3/ha maintains a positive nitrogen balance with values between 16 and 31 kg/ha. Losses of nitrogen from the soil through mineralization are brought by the arable crops (grain maize, sunflower). In the control variant the nitrogen balance values are negative and amount to 59 and 70 kg/ha respectively. When borage was applied the nitrogen balance was 23-135 kg/ha for maize and 31-141 kg/ha for sunflower.

Phosphorus balance. The phosphorus problem is very acute for contemporary agriculture because it is required by crop plants in high quantities and in low concentrations in the soil. It should be noted that phosphorus deposits in the country are few, with limited reserves. The soil contains on average 1.3 times more nitrogen and 17.0 times more potassium than phosphorus (Zarin et al., 1963). At the same time, the soluble salts of phosphorus have the property of reacting with soil consistencies, forming insoluble compounds that are difficult for plants to access. Of the total amount (3000-5000 kg P2O5/ha) contained in the unfertilized plough layer, only 24-36 kg/ha is maintained in a form accessible to plants - 1.0% of the total (Lixandru, 1990; Andrieș, 2000). To improve plants with phosphorus it is necessary to apply fertilizers, especially organic ones.

Fertilization with organogenic wastes from alcoholic beverage production had a positive influence on the accessible phosphorus balance. When wine waste was applied, the phosphorus balance was 70-158 and 41-101 kg/ha per year, respectively, with a deficit of 18 kg/ha. It was determined that the phosphorus balance was negative when applying cereal borage (Table 3), with a deficit of 40 kg/ha per year. When waste was incorporated this index made up 31-85 kg/ha annually.

The accessible phosphorus deficit in winter wheat, sunflower and grain maize was 53, 22 and 25 kg/ha per year respectively.

In the cultivation of soybean plants for grain the phosphorus balance in the non-fertilized variety has positive (balanced) values of +10 kg/ha.

Potassium balance. The exchangeable potassium in the soil is determined to optimize the plants with this element by applying fertilizers. Soils of Moldova formed on rocks with potassium-rich minerals are characterized by a relatively high potassium content. It has been established that the potassium content in the soils of our country depends to a large extent on the mineralogical and granulometric composition. Potassium adsorbed on the surface of the colloidal clay-humic complex readily passes into the soil solution by exchange reaction with another monovalent cation (NH4+, Na+). It should be noted that in clay-textured soils, the exchangeable potassium content is 20-22 mg/100 g soil, equivalent to 1.4-2.3% of the total. To keep the potassium content at an optimum level, fertilizer application is recommended. In our case we

used organogenic waste from the production of alcoholic beverages as organic fertilizer. By calculating the potassium balance in the soil, it was shown that this index in the unfertilized version was negative with annual values of 62 kg/ha. The application of wine waste favored the exchangeable potassium balance in the fertilized variants positively. The positive values of the accessible potassium balance were respectively 314-570 and 293-652 kg/ha annually. According to the calculations made when determining the potassium balance in crop rotation per crop when fertilizing levigated chernozem with cereal borage for the years 2012-2019 is shown in Table 4. It was determined that the potassium balance in unfertilized field crops was negative: 107 kg/ha in autumn wheat, 120 kg/ha in sunflower and 68 kg/ha in grain maize. Application of cereal borage compensated for the exchangeable potassium deficit by crop: 245-529; 195-486 and 282-587 kg/ha respectively. The exchangeable potash balance in grain soybean cultivation in the unfertilized variety was balanced, constituting 16 kg/ha. While in waste incorporation this index was deeply positive (257-560 kg/ha).

CONCLUSIONS

Research conducted during 2011-2019 confirmed that wine and ethyl alcohol production wastes increased the content of humified organic matter in soil by 0.12-0.37%. A significant increase of mineral nitrogen by 0.17-0.61 mg/100 g soil, mobile phosphorus by 0.19-0.98 mg/100 g soil and exchangeable potassium by 3-13 mg/100 g soil was found.

The results obtained from the determination of the humus balance and their nutrients in the soil showed that the unfertilized soil during nine years lost annually 1203-2136 kg/ha humus, 54-107 kg/ha nitrogen, 18-40 kg/ha phosphorus and 64-103 kg/ha potassium. Waste application compensated the losses of these indices respectively by 857-4497, 9-225, 31-158 and 296-645 kg/ha.

The results of the determination of the balance of humus, nitrogen, mobile phosphorus and exchangeable potassium at crop level showed that the application of the mentioned waste to autumn wheat, sunflower, grain maize and soya grain maintained a balanced and positive balance of these indices.

More pronounced positive values of agrochemical indices were established when fertilizing levigated chernozem with wine yeast at the rate of 26 t/ha, vinasse at the rate of 600 m3/ha and grain borage at the rate of 94 m3/ha.

ACKNOWLEDGEMENTS

This study was supported by the National Agency for Research and Development of the Republic of Moldova through the project 20.80009.5107.25 "Evaluation and optimization of nutrient and organic matter balance for the improvement of the fertilization system of agricultural crops by making fertilizer use more efficient and increasing soil fertility in sustainable agriculture".

REFERENCES

Крупеников, И. (1989). *Chernozems in nature and national farms*. Moscow. pp. 5-10.

Siuris, A. (2017). *Provisional technology for the use of solid wine lees as fertilizer in vineyards.* ln: Studia Universitatis. Agricultural and Natural Sciences, 1-1. 82–89.

Siuris, A. (2017). *Provisional technology for the use of vinasse as fertilizer in vineyards*. In: Papers of the University of Agricultural Sciences and Veterinary Medicine „Ion Ionescu de la Brad" Iasi. Ser. Agrochemicals, vol.60, p. 93–98.

Siuris, A. *Innovative technologies to recover waste from wineries*. In: Science in the North: Achievements, problems, perspectives. National conference with local practice, 21-22 June 2019, Balti, p. 216–220.

Donos, A. (2001). *Improved methodical instructions for determination and adjustment of biophilic element balance in Moldovan soils*. Chisinau, 24 p.

Banaru, A. (2002). *Improved methodical guidelines for the determination of humus balance in arable soils*. Chisinau, 24 p.

Andrieș, A., Țîganoc, V., Donos, A. et al. (2007). *Methodical guidelines on agrochemical soil mapping*. Chisinau, Pontos, p. 12–16.

Andrieș, S. (2017). Organic matter in Moldovan soils and measures to increase fertility. *Akademos, 2*(22), 71–77.

Andrieș, S., Zagorcea, C. (2002). *Soil fertility and agrochemical servicing of agriculture.* ASM Bulletin. Biological, Chemical and Agricultural Sciences, *2*. 42–44.

Andrieș, S. (2005). Humus content change in soils used in agriculture. Chisinau: INEI, p. 63-71.

Зырин и др. (1963). *Reference and calculation tables for physico-chemical methods of soil research*. Moscow, State University. pp. 94–95.

Lixandru, Gb. et al. (1990). *Agrochemicals*. Bucharest. Ed.: Didactica si Pedagogica, p. 132.