

RESEARCH ON AGRONOMIC AND ECONOMIC EFFECTIVENESS OF WASTES FROM THE WINE INDUSTRY USED AS FERTILIZER IN THE REPUBLIC OF MOLDOVA

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Abstract

Winemaking in Moldova is one of the main sectors of national economy, and this branch requires continuous implementation of new performance achieved in science and technology. In the last years, about 300-350 thousand tons of grapes are processed. From this amount, we get 60-75 thousand tons of byproducts: pomace, lees, vinasse, wastewater, etc. All these products represent a source of environmental pollution and create major environmental problems. At the same time these wastes contain a major amount of organic biofile elements (N, P₂O₅, K₂O), a number of micronutrients so necessary for plants.

Lees and vinasse were tested as an organic fertilizer in the vineyards at the Technological-experimental station "Codru", municipality Chisinau.

Fertilization of vineyards with vinasse and lees led to increase of humus content in the soil with 0.18-0.38%, mobile phosphorus with 0.37-0.72 mg/100 g soil and exchangeable potassium with 12-15 mg/100 g soil. Annual production of grapes increased with 1.5-2.0 t/ha, constituting profitability of 115%.

Thus, the rational use of agricultural waste wine will solve two major problems: first - ecological by reducing environment pollution and second - increase soil fertility and productivity of field crops.

Key words: vinasse, lees, organic fertilizer

Currently the wineries from the Republic of Moldova accumulate as waste about 25 thousand tons of wine lees and 50 thousand cubic meters of vinasse. The total amount of waste from the wine industry is impressive and is constantly growing. Mineral residue of this waste makes up 2.0-2.7 g/l, which characterizes them with a large mineralization, index sodium absorption ratio (SAR) being greater than 6.0, and the Stebler coefficient is 9-16. So, the risk of saline and alkaline contamination of soils is high during their abusive incorporation and uncontrolled discharges. The waste also contains primary elements very necessary for plant nutrition and soil fertility, which require recovered permanently. One hundred cubic meters of lees contains approximately 210 kg of nitrogen, 100 kg of phosphorus and 750 kg of potassium. Less concentrated in nutrients, but no less valuable is vinasse. The waste in question is not used in any way and there are no regulations in our country for its liquidation. It originates in agriculture, so all the containing elements were taken from the soil. So it will be fair as they return to soil through fertilization.

Accumulation and spilling without any legal norms of winery wastes causes a serious pollutant impact on the environment, but primarily on soil and surface water (Chiselița O., 2010). International research in terms of characteristics and use in agriculture of wastes from the production of alcoholic beverages are very few (Gemtos *et. al*, 1999; Ruggear L., Cadena E., Martinez J., 2009.; Tejada *et. al*, 2009). In the Republic of Moldova such researches are absent. In this context, we must solve the problem of waste through its application in agriculture as fertilizer. The purpose of this paper is to study agro-ameliorative indices of lees and vinasse and their testing under field conditions for assessing the productivity of grapevine and economic efficiency in the Republic of Moldova.

MATERIAL AND METHOD

The research was conducted during 2011-2015 years at technological-experimental station "Codru" mun. Chișinău. Object of the study were the lees and vinasse.

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Table 1

Chemical and physico-chemical indices of levigated chernozem (TES "Codru", 2011)

Horizon and depth, cm	pH (H ₂ O)	CaCO ₃	Humus content	total N	C:N	Mobile forms, mg/100 g sol		Exchangeable cations, me/100 g sol		
		%				P ₂ O ₅	K ₂ O	Ca ²⁺	Mg ²⁺	Suma
Ap1 0-16	6.8	0	4.64	0.22	12.2	3.42	43	25.2	3.2	28.4
Ap2 16-43	6.6	0	3.97	0.20	11.5	1.76	16	24.8	4.0	28.8
A 43-80	6.6	0	3.55	0.18	11.4	1.23	15	24.4	4.8	29.2
B1 80-97	6.8	0	1.92	0.11	10.1	0.72	14	23.6	2.8	26.4
B2 97-114	7.6	4.7	1.41	0.08	10.2	0.60	14	24.0	4.0	28.0
BC 114-150	8.0	16.1	0.85	0.06	8.2	0.36	12	20.0	4.0	24.0
Bck 150-195	8.1	14.3	0.56	0	0	0.20	12	18.8	5.2	24.0
Ck 195-205	8.2	13.2	0.36	0	0	0	11	18.0	5.2	23.2

Experience is located on silty clay leached chernozem. Agrochemical indices are shown in table 1.

Wastes were applied to a plantation of Sauvignon grapevines in bearing. Experience scheme is shown in table 4.

The surface evidence of the plot - 55 m². The number of repetitions - 3. For waste analysis were used the following methods: humidity - STAS 26713-85, organic matter - STAS 27980-88, pH - STAS 27979-88, ash - STAS 2671-85, total nitrogen - STAS 26715-75, total phosphorus - STAS 26717-85, total potassium - STAS 26718-85, N-NO₃ - after Grandval-Leaju, N-NH₄ - STAS 26716-85, the aqueous extract - STAS 26428-85. The statistical processing of the results obtained in the investigation was carried out by Dospehov method (Dospehov B.A., 1990).

RESULTS AND DISCUSSIONS

The lees of the wine industry are the waste that results of the fermentation of grape juice. The lees are characterized by an acidic environment. The average pH value is 3.5 (table 2).

Humidity ranges from 42.0 to 58.9% and constituted 48.0% on average. Chemical composition shows that solid lees are an important source of soil organic matter and nutrients for agricultural crops. Calculated from mass with natural moisture, organic matter content is on average 46.8%. The standard deviation of the mean (S) in absolute size is 9, and the coefficient of variation (V) 20.3%. Among the total primary elements potassium prevails with average content 2.5%, followed by total nitrogen and total phosphorus 1.5% and 0.70%. Compared with conventional manure, solid lees contain 2.7 times more nitrogen, 1.6 times more phosphorus, 2.4 times more potassium and 2.7 times more organic matter. On average 1 ton of solid lees with natural moisture contain 47 kg NPK. So, we can state that

solid lees are a concentrated fertilizer that can economically justify its transportation to long distances over 10 km from the wineries.

Vinasse presents the liquid remaining after the distillation of alcohol from wine. The amount of vinasse represents 75-85% of the wines subject to the distillation. Vinasse is a cloudy or slightly cloudy liquid, with a golden-reddish color, with a distinct odor of heat treatment and a sour taste. In Moldova there is no industrial method of vinasse use. It is directed into sewage system, increasing the degree of water pollution, greatly hindering their treatment. Vinasse is characterized by an acidic environment. The average pH value is 3.4 units (table 3).

Dry residue ranges from 7.5 to 24.7 g/l forming an average 15.2 g/l. The content of organic matter makes up an average of 13.3%, with a variance from 6.3% to 21.7%. Mineral compounds are an average of 1.9 g/l. From the primary elements in the composition of vinasse prevails total potassium with average of 0.12%. Total nitrogen and phosphorus content makes up 0.02% on average. Of the total nitrogen content, the ammonia constitutes about 34%. In the aqueous extract predominate potassium (579 mg/l) and sodium (172 mg/l) monovalent cations. The concentration of bivalent cations of calcium and magnesium constitutes on average 106 mg/l and 84 mg/l. Among the anions sulfate is predominant. The concentration is from 79 mg/l to 280 mg/l with an average of 155 mg/l. Chlorine content ranges from 69 to 122 mg/l, accounting for an average of 90 mg/l.

The results of research conducted over the reporting period showed that applying annually the studied wastes to grapevine had a beneficial effect on plant productivity (table 4).

Table 2

Chemical composition of solid lees from wine-making plants used during the experiment, by weight with natural moisture content (2010-2012), n=5

Index and measure unit	x	min	max	S	Vm, %	Sx	Sx%	$\Delta x (+, -)$
pH	3.5	3.2	3.7	0.12	3.5	0.07	2.0	0.2
Moisture content, %	48.0	42.0	58.9	9.6	20.0	5.5	11.6	18.0
Organic matter content, %	46.8	38.3	50.3	9.5	20.3	5.5	11.7	17.6
Ash, %	5.3	2.8	8.8	3.1	55.0	1.7	32.0	5.1
Carbon, %	23.4	19.2	25.5	1.2	5.2	0.6	2.6	2.0
Total nitrogen, %	1.50	0.77	1.81	0.6	40.0	0.35	23.0	1.1
N-NO ₃ , mg/100 g	1.60	0.71	2.80	0.68	42.5	0.30	0.002	0.99
N-NH ₄ , mg/100 g	32.9	26.9	51.7	2.41	7.32	1.08	3.28	3.55
Total phosphorus, %	0.70	0.60	0.79	0.12	18.5	0.07	10.6	0.2
Total potassium, %	2.6	2.3	2.7	0.26	10.2	0.15	5.8	0.5

Table 3

Chemical composition of vinasse from wineries (2010-2012), n=5

Index and measure unit	x	min	max	S	V, %	Sx	Sx, %	$\Delta x (+, -)$
pH	3.4	3.0	3.7	0.26	7.8	0.13	3.8	0.4
Dry residue, g/l	15.2	7.5	24.7	7.3	47.8	3.3	21.8	9.2
Fixed residue, g/l	1.9	1.2	2.9	1.2	65.0	0.5	28.7	1.3
Organic matter content, %	13.3	6.3	21.7	10.7	80.3	4.9	36.6	12.7
Total nitrogen, %	0.02	0.007	0.05	0.02	82.5	0.01	48	0.02
Total phosphorus, %	0.02	0.006	0.039	0.02	82.5	0.01	48	0.02
Total potassium, %	0.12	0.048	0.157	0.04	37.0	0.02	15	0.05
N-NH ₄ , mg/100 g	67	52	86	25.4	37.7	12.7	18.8	35.6
N-NO ₃ , mg/100 g	9.3	0.31	23.8	6.4	68.6	3.2	34.4	9.0
Ca ²⁺ , mg/l	106	72	120	20	19	9.0	8.0	23
Mg ²⁺ , mg/l	84	49	146	36	43	16	19	42
Na ⁺ , mg/l	172	125	210	44	25	20	12	51
K ⁺ , mg/l	579	335	1127	333	61	161	28	418
Cl ⁻ , mg/l	90	69	122	24	26	11	12	28
SO ₄ ²⁻ , mg/l	155	79	280	75	48	34	22	88

Table 4

Influence of wastes from the production of alcoholic beverages on grape harvest obtained on leached chernozem at TES "Codru" (Sauvignon variety)

Variant of the experiment	Grape harvest on the years					Average on 5 years		
	2011	2012	2013	2014	2015	Crop, t/ha	Crop increase	
							t	%
1. Witness	9.8	7.6	10.6	9.8	10.8	9.7	-	-
2. Lees (N100), 13 t/ha	10.8	8.7	11.9	12.0	11.9	11.1	1.4	15
3. Lees (N200), 26 t/ha	10.9	8.8	14.1	13.9	12.8	12.1	2.4	25
4. Vinasse (K450), 300 m ³ /ha	10.8	8.7	12.0	10.2	11.7	10.7	1.0	10
5. Vinasse (K900), 600 m ³ /ha	10.6	8.5	12.6	10.6	11.8	10.8	1.1	11
DL 0.5%	0.60	0.64	0.94	0.75	0.67	0.91	0.78	7.13

Application of lees at a dose of 13-26 t/ha annually provided a significant increase of the

grape harvest averaged from 1.2 to 2.2 t/ha, or by 12-22% more compared to unfertilized control

(9.7 t/ha). Significant impact on plant productivity of grapevines had vinasse incorporated in dose of 300 and 600 m³/ha annually. Crop growth rate averaged over five years was 0.9-1.0 t/ha or by 9-10% more compared to the unfertilized control.

According to the production increase formed at the experimental variants, were calculated cash value at the price level of 2015. Annual fertilization of grapevines with solid lees during five years at doses of 13-26 t/ha was paid 13130-24570 lei/ha (table 5). Sauvignon grape harvest value gain at the price of 4.5 lei/kg is estimated at 31500-54000 lei/ha. Total net income in five years has been 18370-29430 lei/ha. Specific income spent on 1 leu is 1.20-1.40 lei. Profitability is 120-140%.

Table 5
The economic efficiency of solid lees from the wine industry recovered as fertilizer (TES "Codru", 2011-2015)

Index	Wine yeast (N100), 13 t/ha	Wine yeast (N200), 26 t/ha
The five-year total increase of grape production, kg	7000	1200
The value of the total gain in five years, lei	31500	54000
Total expenses for five years, lei	13130	24570
Net income, lei	18370	29430
Specific income spent on 1 leu, lei	1.40	1.20
Profitability, %	140	120

Table 6
The economic efficiency of application of vinasse at the dose of 300 m³/ha through irrigation to grapevine-in bearing (TES "Codru", 2011-2015).

The four-year total increase grape production, kg	The value of the total gain in four years the production of grapes, kg	Total expenses for four years, lei	Net income, lei	Specific income spent on 1 leu, lei	Return expenses, lei
3900	15600	7200	8400	1.17	117

Table 6 reflects economic efficiency of application of vinasse through irrigation to grapevine in bearing (TES "Codru", 2011-2015). For vinasse application for annual fertilization of vine grape during five years at a rate of 300 m³/ha

was paid 7200 lei/ha. Sauvignon grape harvest value gain at the price of 4.5 lei/kg is estimated at 15600 lei/ha. Total net income in five years was 8400 lei/ha. The specific income for 1 leu spent is 1.17 lei. Profitability is 117%. The higher dose of 300 m³/ha is not profitable due to major transportation prices of vinasse.

CONCLUSIONS

At the wineries from Moldova are formed and accumulated annually on average about 25 thousand tons of lees and 50 thousand cubic meters of vinasse. They contain 5 thousand tons of organic matter, 60 tons of nitrogen, 30 tons of phosphorus, and 200 tons of potassium.

Wastes from the production of alcoholic beverages, with their varied content of nutrients and immense amount of organic matter, should be included in the agricultural cycle by using them as fertilizer.

Wine wastes incorporated into the soil as fertilizers contributed to increase of productivity of grape-bearing vines. Application of lees provided an average annual increase production of grapes 1.2-2.2 t/ha. The increase from incorporation of vinasse was on average five years of 0.9-1.0 tons of grapes. A cubic meter of vinasse provides a specific increase of 37.0 kg of grapes, and a ton of lees provides about 877 kg of grapes. Utilizing waste wine provided a return of 117-120%.

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