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RESEARCH ON EXPLOITATION OF WASTES FROM THE PRODUCTION OF ALCOHOLIC BEVERAGES AS FERTILIZER

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Abstract

Are examined several waste products, unexplored until now, that are discharged from the units producing alcoholic beverages: wine yeast, vinasse and grain mash. The last one has the origin from agriculture, so all the elements contained in it were taken from the soil. Equitable to the soil is that they would return to the soil through fertilization. Continuous accumulation and discharge without any norm cause environmental pollution, having main impact on soil and surface waters. Researches regarding their exploitation in agriculture are missing in the Republic of Moldova. In this context, we could solve waste problem by exploiting them as fertilizer.

Key words*: soil fertility, grain mash, vinasse, waste products, wine yeasts.*

INTRODUCTION

With annual crops from soil are removed considerable amounts of nutrients. For the reason of high prices for processing and handling fertilizers practically are not applied.
Simultaneously soil remains poor in nutrients, humus and with unfavourable physical properties. As a source of partial compensation of organic matter and biofile elements can serve wastes from the production of alcoholic beverages (wine yeasts, vinasse, grain mash). Currently the wineries and sections for obtaining alcohol from Moldova annually accumulates about 100 thousand tons of waste material (Statistical Year Book, 2013).
Accumulation and spilling without any legal norms of wastes causes a serious pollutant impact on the environment, but primarily on soil and surface water (Duca, 2011; Ruggieai et al., 2009).
However, the aforementioned wastes contain a major amount of nutrients for plants need: 28 thousand tons of organic matter, 180 tons of nitrogen, 82 tons of phosphorus and 257 tonnes of potassium. 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; Tejada et al., 2009), and in the Republic of Moldova are absent. In this context, we must solve the problem of waste through its application in agriculture as fertilizer.
The research aim is to highlight the potential of wastes from the production of alcoholic beverages as fertilizer, their influence on soil fertility and crop productivity.

MATERIALS AND METHODS

As objects of research served soil, vineyards, field grown plants and waste from the production of alcoholic beverages (wine yeast vinasse, grain mash) applied in two long-term field experiments at the Technological-Experimental Station "Codru" situated in the village Codru, municipality Chisinau, founded in 2011 on cambic chernozem.
Chemical and physic-chemical analysis of solid wine yeast, soil, grapes and wines were made by the standards adopted or approved in the Republic of Moldova, Statistical analysis was performed using the method of dispersion and correlation using MS Excel program.

RESULTS AND DISCUSSIONS

The research has established that the solid wine yeast is characterized by an acidic environment. The average pH value is 3.5 (Table 1).

Table 1. Chemical composition of solid wine yeast from wineries based on the weight with natural moisture

Index and measure unit	x	min	max	S	V, %
pH	3.5	3.2	3.7	0.1	3.5
Moisture content, %	48.0	42.0	58.9	9.6	20.0
Organic matter content, %	46.8	38.3	50.3	9.5	20.3
Ash, %	5.3	2.8	8.8	3.1	55.0
Carbon, %	23.4	19.2	25.5	1.2	5.2
Total nitrogen, %	1.5	0.77	1.81	0.6	40.0
N-NO_3, mg/100 g	1.6	0.71	2.80	0.7	42.5
N-NH_4, mg/100 g	32.9	26.9	51.7	2.4	7.3
Total phosphorus, %	0.7	0.60	0.79	0.1	18.5
Total potassium, %	2.5	2.3	2.7	0.3	10.2

Humidity ranges from 42.0 to 58.9% and constituted 48.0% on average. Chemical composition shows that yeast solid 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% 0.70%. Compared with conventional manure, solid wine yeast contains 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 wine yeast with natural moisture contains 47 kg NPK. So, we can state that solid wine yeast is 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 liquid is cloudy or slightly cloudy, with a golden-reddish color, with a distinct odor of heat treatment and a sour taste. Vinasse is characterized by an acidic environment. The average pH value was 3.4 units (Table 2).

Table 2. Chemical composition of vinasse from wineries

Index and measure unit	x	min	max	S	V, %
pH	3.4	3.0	3.7	0.26	7.8
Dry residue, g/l	15.2	7.5	24.7	7.3	47.8
Fixed residue, g/l	1.9	1.2	2.9	1.2	65.0
Organic matter content, %	13.3	6.3	21.7	10.7	80.3
Total nitrogen, %	0.02	0.007	0.05	0.02	82.5
Total phosphorus, %	0.02	0.006	0.039	0.02	82.5
Total potassium, %	0.12	0.048	0.157	0.04	37.0
N-NH_4, mg/100 g	67	52	86	25.4	37.7
N-NO_3, mg/100 g	9.3	0.31	23.8	6.4	68.6
Ca^{2+}, mg/l	106	72	120	20	19
Mg^{2+}, mg/l	84	49	146	36	43
Na^{+}, mg/l	172	125	210	44	25
K^{+}, mg/l	579	335	1127	333	61
Cl^{-}, mg/l	90	69	122	24	26
SO_4^{-2}, mg/l	155	79	280	75	48

Dry residue ranges from 7.5 to 24.7 g/l forming an average (X) 15.2 g/l. The content of organic matter makes up an average of 13.3%, with a variance (V) from 3.6% to 21.7%. Mineral compounds are an 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. Their 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.

Manufacture of spirits from cereals (wheat, barley, maize) has always been a problem with unfavorable environmental consequences. The cause is grain mash, a product highly polluting the environment. Until land reform grain mash was used as animal feed. With the dissolution of large livestock complexes that possibility has disappeared and spirits producers face serious problems in relation to environmental legislation, since most wastes are thrown into the environment.

Grain mash is characterized by a content of 93.4% of water and 6.63% of dry matter (Table 3). The average pH value is 3.7 units. From the primary elements in the composition of grain mash, prevail nitrogen content with an average of 0.28%. The average content of total phosphorous and potassium is respectively 0.12 and 0.11%, and the content of organic substances is 54.4 g/l. Among monovalent cations predominates potassium (783 mg/l) and sodium (450 mg/l). The concentration of bivalent cations of calcium and magnesium is on average 97 mg/l and 234 mg/l.

Among the anions are primarily sulfates. Their concentration is from 188 mg/l to 533 mg/l with an average of 367 mg/l. Chlorine content ranges from 202 mg/l to 397 mg/l, forming on average 299 mg/l.

Table 3. Chemical composition of the grain mash from the ethyl alcohol producing industry

Index and measure unit	x	min	max	S	V, %
pH	3.7	3.4	4.2	0.33	8.9
Moisture content, %	93.4	92.1	97.0	1.3	1.4
Dry residue, g/l	66.3	40.5	72.0	4.9	7.4
Fixed residue, g/l	14.9	9.3	21.4	1.3	8.7
Organic matter content, %	51.4	16.2	62.1	4.8	9.3
Total nitrogen, %	0.28	0.21	0.33	0.04	12.6
Total phosphorus, %	0.12	0.06	0.19	0.08	23.5
Total potassium, %	0.11	0.09	0.13	0.24	22.3
$N\text{-}NH_4$, mg/100 g	143	71	224	63.1	44.2
$N\text{-}NO_3$, mg/100 g	5.8	2.9	11.0	3.7	69.3
Ca^{2+}, mg/l	97	60	100	26.6	27.5
Mg^{2+}, mg/l	234	183	244	86.2	36.8
Na^{+}, mg/l	450	185	550	19.4	43
K^{+}, mg/l	783	649	850	166	21.2
Cl^{-}, mg/l	299	138	321	98.4	32.9
SO_4^{-2}, mg/l	357	188	533	140	39.1

Table 4 presents the data that show the influence of wastes from the production of alcoholic beverages on the content of organic matter, available phosphorus and potassium in the arable layer of cambic chernozem. Average data for 4 years demonstrated that doses of wine yeast (13 and 26 t/ha), (equivalent to 100 and 200 kg N/ha per year) led to a significant increase of organic matter content, respectively by 0.23 and 0.39% (6120 and 10400 kg/ha). The application of vinasse doses of 300 (K_{450}) and 600 m^3/ha (K_{900}) leads to significant increases in organic matter content values in average over four years by 0.22 and 0.34% (5850 and 9040 kg/ha). At fertilization with grain mash the growth of organic matter content in three experimental years was in average 0.15 and 0.25% (3780 to 6300 kg/ha).

Fertilization with wine yeast resulted in statistically significant increase of available phosphorus content for four years on average from 0.47 to 0.64 mg/100 g (from 10.6 to 14.5 kg/ha) compared to the control. The application of vinasse showed an increase of available phosphorus by 0.36 and 0.20 mg/100 g (4.5 and 8.1 kg/ha) compared to the reference variance. Statistically significant values of the content of available phosphorus were identified in the management of grain mash. The difference of the average over four years compared to the control was 0.21 and 0.46 mg/100 g (4.7 to 10.4 kg/ha). Regarding available potassium content, statistically ensured increases compared to the control were recorded in the application of vinasse in the dose of 300 and 600 m^3/ha and grain mash in the dose of 94 m^3/ha.

The results of research conducted over four years showed that applying of studied wastes to grapevine culture had a beneficial effect on plant productivity (Table 5).

Table 4. Influence of waste from the production of alcoholic beverages on the main agrochemical indicators of cambic chernozem (arable layer)

Variant of the experiment	Organic matter			P_2O_5, mg/100 g			K_2O, mg/100 g		
	Mean	Increase compared to the control		Mean	Increase compared to the control		Mean	Increase compared to the control	
		%	kg/ha		%	kg/ha		%	kg/ha
Cambic chernozem, Experimental Station "Codru", village Codru, municipality Chisinau (2011-2014)									
1.Witness	4.05	-	-	2.25	-	-	29	-	-
2.Wine yeast, 13 t/ha per year	4.28	0.23	6120	2.72	0.47	10.6	36	7	160
3.Wine yeast, 26 t/ha per year	4.44	0.39	10400	2.89	0.64	14.5	38	9	206
4.Vinasse, 300 m^3/ha per year	4.27	0.22	5850	2.45	0.20	4.5	40	11	251
5.Vinasse, 600 m^3/ha per year	4.39	0.34	9040	2.61	0.36	8.1	44	15	342
DL 0.5%	0.17	0.17	4520	0.15	0.15	3.4	6.7	6.7	153
Cambic chernozem, Experimental Station "Codru", village Codru, municipality Chisinau (2012-2014)									
1.Witness	2.93	-	-	2.31	-	-	26	-	-
2.Grain mash, 47 t/ha per year	3.08	0.15	3780	2.52	0.21	4.7	29	3	68
3.Grain mash, 94 t/ha per year	3.18	0.25	6300	2.77	0.46	10.4	32	6	136
DL 0.5%	0.12	0.12	2048	0.14	0.14	6.9	2.8	2.8	53

Table 5. Influence of wastes from the production of alcoholic beverages on Sauvignon grape harvest obtained on cambic chernozem, t/ha

Variant of the experiment	Grape harvest on the years				On average		
	2011	2012	2013	2014	Crop, t/ha	Crop increase	
						t	%
1.Witness	9.8	7.6	10.6	9.8	9.5	-	-
2.Wine yeast, 13 t/ha per year	10.8	8.7	11.9	12.0	10.9	1.4	15
3.Wine yeast, 26 t/ha per year	10.9	8.8	14.1	13.9	11.9	2.4	25
4.Vinasse, 300 m^3/ha per year	10.8	8.7	12.0	-	10.5	1.0	11
5.Vinasse, 600 m^3/ha per year	10.6	8.5	12.6	-	10.6	1.7	12
DL 0.5%	0.60	0.64	0.94				

Application of wine yeast at a dose of 13-26 t/ha annually provided a significant increase of the grape harvest averaged over four years from 1.4 to 2.4 t/ha, by 15-25% more compared to unfertilized control (9.5 t/ha). Significant impact on plant productivity of grapevines had vinasse incorporated in dose of 300 and 600 m^3/ha annually. Crop growth rate averaged over three years was 1.0-1.1 t/ha or by 11-12% more compared to the control.

Fertilization with mash grains led to statistically significant increase in productivity of field crops (Table 6).

Table 6. Effects of fertilization with mash grains on field crops productivity, kg/ha

Variant of the experiment	Grape harvest on the years			On average, grain units		
	2012, sunflower	2013, winter wheat	2014, sunflower	Crop	Crop increase compared to witness	
					kg	%
1.Witness	1230	3818	1170	2449	-	-
2.Grain mash, 47 t/ha per year	1840	5673	1790	3670	1221	50
3.Grain mash, 94 t/ha per year	2070	6183	1980	4046	1597	65
DL 0.5%	223	520	172			

Mash grains applied annually at a dose of 47 and 94 m^3/ha (equivalent to N_{120} and N_{240}) resulted in the average yield increase in three years of 1221-1597 kg/ha grain units or 50-65% in comparison with unfertilized variant.

CONCLUSIONS

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.

Fertilization with wastes from the production of alcoholic beverages resulted in significant increase in organic matter content (0.15-0.39%). There was a significant increase of mobile phosphorus (0.20-0.64 mg/100 g) and exchangeable potassium (6.0-15 mg/100 g).

Application of wine yeast provided a significant increase of grapes harvest (Sauvignon) averaged over four years from 1.4 to 2.4 t/ha. Crop increase at vinasse incorporation was on average for three years 1.0-1.1 t/ha. Applied grain mash determined the average crop production increases over three years of 1200-1600 kg/ha grain units or 50-65% compared to the unfertilized control.

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