

RESEARCH OF INFLUENCE OF WASTES FROM THE WINE INDUSTRY ON FERTILITY OF CAMBIC CHERNOZEM AND PLANT PRODUCTIVITY OF GRAPE-VINE

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Abstract

This article presents the results of field-testing of two wastes: wine lees and vinasse, from grape processing. The results demonstrated that administration of two doses of wine lees (13 and 16 t/ha), the vinasse (300-600 m³/ha) favoured the significant increase of organic matter, phosphorus and exchangeable potassium in the arable layer of soil. Application of wine lees at a dose of 13 to 26 t/ha annually ensured a significant increase grape 1.4-2.3 t/ha, or 15-25% more than the unfertilized control, which made 9.3 t/ha. Significant impact on the productivity of plants of wine lees and vinasse was at a dose of 300 to 600 m³/ha. Average growth was 0.9-1.0 t/ha or 10-11% more than the control.

Key words: wine lees, vinasse, plant productivity, soil fertility.

INTRODUCTION

Currently the wineries from the Republic of Moldova accumulate as waste about 25-30 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. The wastes contain primary elements very necessary for plant nutrition and soil fertility, which require recovered permanently. One hundred cubic meter 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. 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; Luz et al., 2009; Tejada et al., 2009).

MATERIALS AND METHODS

The research was conducted during 2011-2016 years on different wastes from wine making industry. Object of the study were the lees and vinasse. The research and observations of appreciation of fertilizer potential of them were made at technological - experimental station “Codru”, Chisinau minicipality. Experience is located on silty clay leached chernozem: humus content 4.31%; P₂O₅ - 34.2 ppm; K₂O - 430 ppm; pH - 6.8. Wastes were applied to a plantation of Sauvignon grapevines in bearing. Experience scheme is shown in table 1. The surface evidence of the plot - 55 m². The number of repetitions - 3. For soil analysis were used the following methods: organic matter - Tiurin method, N-NO₃ - after Grandval-Leaju, mobile phosphorus and potassium - Machighin method; The statistical processing of the results obtained in the investigation was carried out by Dospehov method.

RESULTS AND DISCUSSIONS

Organic matter content. Average data for 6 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 in 0-30 cm layer of soil

(Table 1). 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 6 years by 0.18 and 0.27% or 4788 and 7182 kg/ha.

Table 1. The influence of wine wastes on organic matter content in the 0-30 cm layer of cambic chernozem, % of soil mass. Technological-experimental Station "Codru"

| Variant | Years | | | | | | Average for 6 years | Increase compared to the control | |
|-------------------------------|-------|------|------|------|------|------|---------------------|----------------------------------|-------|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | | % | kg/ha |
| Witness | 4.28 | 4.25 | 3.90 | 3.76 | 3.79 | 3.97 | 3.99 | - | - |
| Wine yeast, 13 t/ha per year | 4.39 | 4.38 | 4.08 | 4.28 | 3.98 | 4.23 | 4.22 | 0.23 | 6118 |
| Wine yeast, 26 t/ha per year | 4.46 | 4.55 | 4.27 | 4.46 | 4.13 | 4.29 | 4.36 | 0.37 | 9842 |
| Vinasse 300 m^3/ha per year | 4.44 | 4.63 | 4.11 | 3.91 | 3.94 | 4.00 | 4.17 | 0.18 | 4788 |
| Vinasse 600 m^3/ha per year | 4.48 | 4.73 | 4.23 | 4.12 | 4.00 | 3.99 | 4.26 | 0.27 | 7182 |
| DL 0.5% | 0.10 | 0.11 | 0.10 | 0.13 | 0.14 | 0.10 | 0.17 | - | - |
| P, % | 4.9 | 6.3 | 8.2 | 7.8 | 7.8 | 8.4 | 5.1 | - | - |

Mineral nitrogen. Influence of wastes from the production of alcoholic beverages on the content of mineral nitrogen in the arable layer of cambic chernozem is presented in Table 2.

Table 2. Waste wine influence on mineral nitrogen in 0-30 cm layer of cambic chernozem, mg N/kg sol

| Variant | Years | | | | | | Average for 6 years | Increase compared to the control | |
|-------------------------------|-------|------|------|------|------|------|---------------------|----------------------------------|-------|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | | mg/kg | kg/ha |
| Witness | 8.1 | 8.4 | 4.3 | 2.1 | 1.3 | 0.60 | 4.13 | - | - |
| Wine yeast, 13 t/ha per year | 11.,7 | 12.9 | 5.0 | 9.2 | 2.4 | 1.30 | 7.08 | 3.0 | 6.8 |
| Wine yeast, 26 t/ha per year | 14.1 | 13.7 | 5.5 | 11.4 | 3.1 | 1.19 | 8.17 | 4.0 | 9.0 |
| Vinasse 300 m^3/ha per year | 11.6 | 10.9 | 2.4 | 2.2 | 4.2 | 0.75 | 5.34 | 1.2 | 2.7 |
| Vinasse 600 m^3/ha per year | 10.0 | 11.5 | 2.1 | 3.9 | 4.7 | 0.64 | 5.47 | 1.3 | 2.9 |
| DL 0.5% | 1.6 | 1.4 | 1.1 | 1.9 | 1.0 | 1.1 | 1.2 | - | - |
| Sx, % | 8.3 | 9.1 | 3.9 | 4.2 | 9.4 | 10.3 | 5.1 | - | - |

It emphasizes that fertilization with wine yeast at doses containing 100 and 200 kg N/ha resulted in significant increase of mineral nitrogen content.

The mean value of the six years of mineral nitrogen content compared to the control increased by 3.0-4.0 mg/kg. Fertilization with vinasse doses of 300 and 600 m^3/ha decreased significantly soil mineral nitrogen only in the first and second year of action.

Phosphorus and potassium. Table 3 shows data which reveals the effects of fertilization of waste wine on accessible phosphorus arable layer of cambic chernozem and emphasize that: fertilization with wine lees at doses of 13 and 26 t/ha (equivalent to N_{100} and N_{200}) resulted in statistically significant increase of the content of available phosphorus.

For six years the average value of available phosphorus compared to the control increased by 0.62 to 1.00 mg/100 g (from 16.4 to 27.0 kg/ha).

Application of vinasse in the dose of 300 (K_{450}) and 600 (K_{900}) resulted in statistically significant increases in the values of accessible phosphorus content in all six years of experimentation (2011-2016).

Phosphorus average increase was 0.30 and 0.31 mg/100 g (8.1 to 8.4 kg/ha).

Table 3. Waste wine influence on accessible phosphorus content in layer 0-30 cm of cambic chernozem, P_2O mg/100 g soil. Technological-experimental Station "Codru"

| Variant | Years | | | | | | Average for 6 years | Increase compared to the control | |
|-------------------------------|-------|------|------|------|------|------|---------------------|----------------------------------|-------|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | | mg/kg | kg/ha |
| Witness | 2.08 | 2.11 | 2.54 | 2.26 | 2.22 | 1.79 | 2.17 | - | - |
| Wine yeast, 13 t/ha per year | 2.55 | 2.54 | 3.09 | 2.68 | 2.61 | 3.27 | 2.79 | 0.62 | 16.4 |
| Wine yeast, 26 t/ha per year | 2.80 | 2.68 | 3.25 | 2.81 | 2.79 | 4.67 | 3.17 | 1.00 | 27.0 |
| Vinasse 300 m^3/ha per year | 2.20 | 2.31 | 2.91 | 2.37 | 2.39 | 2.28 | 2.47 | 0.30 | 8.1 |
| Vinasse 600 m^3/ha per year | 2.31 | 2.39 | 3.26 | 2.46 | 2.53 | 1.95 | 2.48 | 0.31 | 8.4 |
| DL 0.5% | 0.19 | 0.18 | 0.32 | 0.10 | 0.16 | 0.15 | 0.15 | - | - |
| Sx, % | 11.4 | 12.8 | 11.5 | 10.4 | 8.2 | 10.3 | 8.9 | - | - |

Regarding accessible potassium content, increases were recorded only to the application of vinasse in the dose of 300 and 600 m³/ha (Table 4).

Table 4. Waste wine influence on accessible potassium content 0-30 cm layer of cambic chernozem, K₂O mg/100 g soil. Technological-experimental Station "Codru"

| Variant | Years | | | | | | Average for 6 years | Increase compared to the control | |
|-----------------------------------------|-------|-------|-------|------|------|------|---------------------|----------------------------------|-------|
| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | | mg/100 g | kg/ha |
| Witness | 28 | 32 | 29 | 27 | 28 | 23 | 28 | - | - |
| Wine yeast, 13 t/ha per year | 32 | 36 | 33 | 31 | 34 | 49 | 36 | 8 | 183 |
| Wine yeast, 26 t/ha per year | 33 | 38 | 35 | 34 | 36 | 65 | 40 | 12 | 274 |
| Vinasse 300 m ³ /ha per year | 39 | 41 | 41 | 40 | 38 | 27 | 38 | 10 | 229 |
| Vinasse 600 m ³ /ha per year | 42 | 45 | 44 | 45 | 42 | 28 | 41 | 13 | 297 |
| DL 0.5% | 5.3 | 4.4 | 7.9 | 5.9 | 7.4 | 6.6 | 6.7 | - | - |
| Sx, % | 14.11 | 13.82 | 14.31 | 8.9 | 9.1 | 10.3 | 9.1 | - | - |

The ionic composition of the water extract. Application doses of wine lees (13 and 26 t/ha, equivalent to N₁₀₀ and N₂₀₀) and vinasse (300 and 600 m³/ha, equivalent K₄₅₀ and K₉₀₀) for six years did not change the essential content of soluble salts, reaction of soil, nor the composition of the aqueous extract (Table 5). The composition of the soluble salts is constant, which is determined by the presence of calcium bicarbonate [Ca (HCO₃)₂] and to a lesser extent of magnesium sulfate (MgSO₄). Stability of saline indices and current reaction of cambic chernozem at action of wine lees and vinasse can be explained by the high buffering capacity of the soil.

Productivity of grape-vines. Results of research conducted over six years and applying of wine wastes during grape-vine cultivation proves that they act beneficially on plant productivity (Table 6). Application of wine lees at a dose of 13 and 26 t/ha annually ensured a significant increase of grape harvest on average in six years by 1.4-2.3 t/ha, with 15-25% more compared to unfertilized variant (9.3 t/ha).

Table 5. The ionic composition of the water extract of cambic chernozem on application of winery wastes

| Variant | Dry residue % | pH | HCO ₃ ⁻ | Cl ⁻ | SO ₄ ²⁻ | Ca ²⁺ | Mg ²⁺ | Na ⁺ | K ⁺ |
|-----------------------------------------|---------------|-----|-------------------------------|-----------------|-------------------------------|------------------|------------------|-----------------|----------------|
| | | | me/100 g sol | | | | | | |
| Witness | 0.027 | 7.3 | 0.38 | 0.09 | 0.28 | 0.39 | 0.23 | 0.05 | 0.09 |
| Wine yeast, 13 t/ha per year | 0.031 | 7.0 | 0.25 | 0.08 | 0.21 | 0.28 | 0.20 | 0.05 | 0.02 |
| Wine yeast, 26 t/ha per year | 0.030 | 7.0 | 0.19 | 0.08 | 0.24 | 0.24 | 0.21 | 0.05 | 0.02 |
| Vinasse 300 m ³ /ha per year | 0.037 | 7.2 | 0.34 | 0.07 | 0.21 | 0.37 | 0.18 | 0.05 | 0.01 |
| Vinasse 600 m ³ /ha per year | 0.038 | 7.2 | 0.20 | 0.08 | 0.23 | 0.39 | 0.17 | 0.05 | 0.02 |

Significant action on plant productivity of grape vines had vinasse at dose of 300 and 600 m³/ha annually. Harvest growth averaged over six years was 0.9-1.0 t/ha or 10-11% more compared to the control.

Table 6. Wine wastes influence on grape Sauvignon harvest on cambic chernozem, t/ha. Technological-experimental Station "Codru"

| Variant | Years | | | | | | Average for 6 years | |
|-----------------------------------------|------------|---------------------------|------|------|------|------|---------------------|--------|
| | Yield t | Increase for 6 years % | | | | | | |
| | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | |
| Witness | 9.8 | 7.6 | 10.6 | 9.8 | 10.8 | 7.4 | 9.3 | - - |
| Wine yeast, 13 t/ha per year | 10.8 | 8.7 | 11.9 | 12.0 | 11.9 | 8.6 | 10.7 | 1.4 15 |
| Wine yeast, 26 t/ha per year | 10.9 | 8.8 | 14.1 | 13.9 | 12.8 | 9.0 | 11.6 | 2.3 25 |
| Vinasse 300 m ³ /ha per year | 10.8 | 8.7 | 12.0 | - | 11.7 | 7.6 | 10.2 | 0.9 10 |
| Vinasse 600 m ³ /ha per year | 10.6 | 8.5 | 12.6 | - | 11.8 | 7.6 | 10.3 | 1.0 11 |
| DL 0.5% | 0.60 | 0.64 | 0.94 | - | 0.67 | 0.92 | 0.85 | - - |
| P, % | 14.3 | 15.1 | 17.2 | - | 14.6 | 15.3 | 14.8 | - - |

CONCLUSIONS

Fertilization with wine wastes (wine lees and vinasse) resulted in a significant increase of organic matter content (0.12-0.37%). There was a significant increase in mineral nitrogen (0.30-4.00 mg/kg), mobile phosphorus (0.24-0.62 mg/100 g) and exchangeable potassium (6.0-12.0 mg/100 g). Wastes did not essentially change the content of soluble salts, soil

reaction, aqueous extract composition. Stability of saline indices and current soil reaction of cambic chernozem on action of wastes is explained by the high buffering capacity of the soil.

Applying wine lees conducted to a significant increase in the production of grapes (Sauvignon) on average for six years 1.4-2.3 t/ha. Harvesting increase at the incorporation of vinasse was on average for six years 0.9-1.0 t/ha.

The mentioned wine wastes must be included in agricultural circuit as fertilizers.

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