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SUSTAINABLE VITICULTURE SOLUTIONS FOR PRESERVING SOIL STRUCTURE IN THE CURRENT CLIMATE CONTEXT

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ABSTRACT

We are currently facing extreme weather phenomena, and their extension and intensity negatively influence the entire viticultural ecosystem with an impact on production yields and grape quality. For a sustainable conservation of natural resources in viticulture, it is necessary to ensure a scientific basis for all the actions and measures that can prevent and mitigate the consequences of current environmental changes resulted from human intervention. Our study investigates some conservative viticulture strategies that aim at soil improvement and erosion reduction; higher organic matter ratios in superficial soil layers; improving physical properties for arable layer; achieving optimal soil aero-hydric and nutritional regime; creating optimal conditions for water infiltration and conservation throughout soil structure; reducing air pollution as a result of lower green house gas emissions.

INTRODUCTION

Environmental protection issues and increased sensitivity on the part of agricultural entrepreneurs drive scientific research to sustainable production techniques for the environment (Di Natale et al. 2019). To achieve sustainable viticulture, innovative techniques with low environmental impact must be identified and used, ensuring that productivity and quality are maintained over time (Sadras et al. 2017).

Agriculture must be the natural balance between plant and atmosphere, to obtain healthier products and ward off environmental degradation (Zaller et al. 2016, Wheeler et al. 2005).

Vineyard soil management has implications for wine quality: soil conservation, weed management, improvement of soil nutrients, water content, biodiversity for pest control, and resource availability regulation (i.e., water, nutrients) is very important aspects to control vine vigor, vine growth, and influencing desirable targets in wine quality (Thomson et al. 2007, Sharley et al. 2008).

Inter-row vegetation, in vineyards, is controlled by grassing, green manure, mulching, tillage, and/or the application of broadband herbicides. The knowledge about the effects of tillage on soil biodiversity and soil biological properties is of great interest (Agnelli et al. 2014, Likar et al. 2015).

It has been shown that the vineyard inter-row soil management affects grapes; nonchemical weed control (harrowing, mulching), tillage and nutrient application, and other interventions affect vine functioning to varying extents (Zehetner et al. 2015).

Soil management methods have an effect on photosynthesis and stomatal conductance of the vines and the nutrient uptake of the grapes is affected by soil temperature, soil compaction, and soil moisture. For example, a positive correlation between the high soil temperature and the uptake of nitrogen (N), potassium (K), calcium (Ca), and magnesium (Mg) exists (Pickering et al. 2006).

Unfavorable soil conditions, such as low water content due to mishandling of soil, can cause plant stress, with negative effects both on growth and yield. Water deficit also decrease photosynthetical activity and affects the differentiation and abortion of flowers, fruit sets, and berry sizes (Marangoni et al. 2001).

Cover cropping, in territories with very low summer rainfall and with high evaporative demand, can be detrimental if the competition for water leads to severe vine water stress and consequently to negative effects on berry quality, yield, and growth. Grapevines growing under heat stress experience a significant drop in photosynthesis due to stomatal limitations, leading to a reduction in water use efficiency. In high vigor situations, the management of the green soil covers can lead to an improvement in the state of the vines because the increase in water consumption can lead to reduction of the vegetative growth of the vine and as a result an advantage in the microclimate of the fruit area and in the quality of the grapes can be obtained (Shellie 2006, Lu et al.1998). Many scientific experiments and tests have been carried out to better detect the influence of different floor covers in grapevine vegetative growth, yield, berry, and wine quality. In the Mediterranean basin vineyard cover cropping is still debated and the few results of the scientific experiments are often contradictory and conflicting (Judit et al. 2011).

Cover cropping is considered as the practical application of ecological principles such as diversity, crop interaction, and other natural regulation mechanisms. Available resources, such as light, water, and nutrients are more efficiently used by the intercrop than by the main crop. Management of these differences in competitive capacities between crops and intercropping species could lead to yield advantages and produce crop quality improvements with consequent changes in grape quality, and decrease the herbicide use and associated risks, such as vine damage by spray drift, evolution of weed resistance (Muscas et al. 2017).

Cover cropping in vineyards was a common practice in Europe. Nowadays, vineyard cover cropping is widely used in areas with frequent summer rainfall to remove excess water and nitrogen, but the benefits of cover crops also include soil erosion control, nitrogen and organic matter management. For example, a reduction in the soil nitrate can induce a low level of must nitrogen content, improve soil structure, increase water penetration and retention, decrease direct soil water evaporative losses, reduce grapevine vegetative vigor, thus enhancing grape and must quality (Reeve et al. 2018, Mercenaro et al. 2014). Cover crops can improve soil and vine health, and may influence vine vigor by adjusting parameters such as canopy efficiency and shoot growth period. Moreover, cover crops increased juice anthocyanins, soluble solids, and other phenolic components and decreased titratable acidity.

It is necessary to have a balanced vineyard system/intercropping, picking out crop species accurately and applying a suitable management to obtain benefits; the same studies have shown that the use of cover crops in vineyards has detrimental effects, such as yield reductions due to water and nutrients competition.

Several studies found that pH were reduced by cover cropping relative to tillage due to an increase in the ratio of tartaric to malic acids; another observed an increase in juice anthocyanins and tannins as affected by permanent cover crop this is probably due to a yield reduction and subsequent must concentration (Caspari et al.1997, Nauleau 1997).

Mulch is any material, other than soil, placed or left on the soil surface for soil and water management purposes (Krohn et al. 2005) and mulching involves leaving crop residues or other materials on the soil surface for soil and water conservation and keeping favorable and stable environments for vine growth (Smart et al. 2006). The positive effects of mulching can be summarized as follows: soil protection against the impact of rain and consequent erosion reduction, major water storage,improved infiltration capacity, decrease in evaporation, improved soil structure and organic content, better root development, higher density in some species of earthworms and growing activity of crops (Jordán et al. 2011).

Use of mulches in orchards has been found to increase plant growth and yields (Wang et al. 2014); the yield increase as a result of mulch treatment was attributed to the improved soil environmental conditions of reduced diurnal temperature fluctuations and increased soil water availability for vine production (Karami et al. 2012). Moreover, mulched compost can reduce water loss by evaporation and drainage into deeper soil horizons and increased photosynthesis per vine (µmol CO2 plant−1 s−1) at flowering, when the berries were pea sized and at maturity.

MATERIAL AND METHODS

Experiments were carried out using two experimental variants: V1- black field; V2-composted grape pomace.

Soil amedment was implementes to ecological vine plantation whit local grape pomace composting started in september of 2024 and continued throughout 2025.

Soil organic matter amendment analysis was done for each experimental variant using standardized analytical procedures:

• Electrochemical method — potentiometric, in aqueous suspension 1:2.5 - pH determination;

• Volumetric method, STAS 7184/21 -82 - determination of humus content (%);

• Egner Riehm-Domingo method and UV-P7S molecular absorption spectrometric method, in aqueous extract - determination of mobile phosphorus (P-Al, ppm);

• Egner Riehm-Donlingo method and photometry method in each case in aqueous extract - determination of mobile potassium (K-A1, ppm).

For each experimental variant 5 repetitions were carried out.

RESULTS AND DISCUSSIONS

Grape pomace composting process at Bujoru research station was done using an adapted method described by Vișanu (2022). Fertilization with composted pomace – for composting in piles, a tamped, dry place is chosen where the pomace is placed on a platform in layers of 20-30 cm, alternating with layers of soil 10-15 cm thick. To ensure the oxygen and humidity necessary for microorganisms, the layers are placed loosely. If the material is dry, it is moistened with water or manure must. Over each layer of pomace, either lime powder (2 kilograms for every 100 kilograms of pomace) or Thomas slag is spread, in a proportion of 4%, to neutralize the acidic reaction of the pomace. The composted pomace is left to ferment for 20 days. After this interval, the platform is dismantled and the layers are vigorously mixed by shoveling, then the platform is rebuilt.

Photo 1. Composting platform intiation

Photo 2. Initial soil pH determination

Initial soil pH monitoring was done using portable devices, showing a variation mainly between 7-8 and very rarely 7, it was found that soil pH had a alkaline reaction, being slightly lower than recomended.

Soil amedment whit composted grape pomace was intiated during the month of April 2025 whit the aim at obtaining an even 10 cm thickness of grape compost throughout the experimental variant.

Photo 3. Experimental variant composted grape pomace administration

Soil organic matter is classified as: a. chemically: • humic substances (humic acids soluble in alkaline solutions, precipitates in mineral acids and fulvic acids soluble in alkaline solutions, humins insoluble in sodium hydroxide) • non-humic substances b. functionally: • stable humus, • nutritious humus c. morphogenetically: • raw humus is the most imperfect type of humus for an aerated environment, the composition is formed by unbroken organic residues, it has a strongly acidic reaction with a low nitrogen content.

In our experiment we analyzed humic input as for experimental variant 2 as a result of compost presence. Humus concentrations spiked for this experimental variant when compared to initial humus values. Fig.1 showing concentration variations.

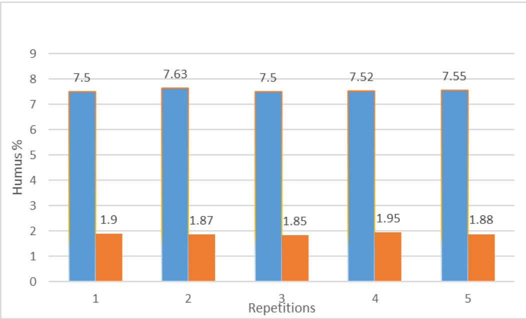

Figure 1. Humus content variation for the 2 experimental variations

Humus content varied between 7.5-7.63 g\100g (SD: 0.05431) of soil in the case of the amended variant and between 1.87-1.95 g\100g (SD: 0.03807) of soil for the control variant V1. The obtained results are promising showing pomace potential. Similar results were highlighted by Gabur et al. (2024) in a scientific literature review that also took in to account the potential of vinification by products obtaining high quality compost via the use of vermicompost techniques. Organic matter increases were also evident due to soil nitrogen content that reached average values of 7.54 % (V2).

Investigations regarding compost inorganic amendment potential showed important modifications of mobile phosphorus and potassium ratios.

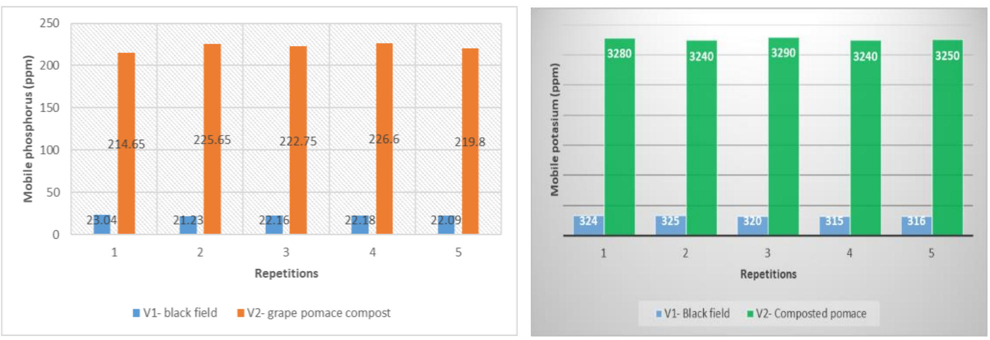

Figure 2. Mobile phosphorus and potassium amendment

Soil mobile phosphorus started at a medium demand value (V1), with average values of 22.14 ppm. V2 determinations showed average values of 221.89 ppm whit a maximum of 226.6 ppm classing this variant in to very well supplied category whit a tendency towards excessive for some crops. with an average value of 221.89 ppm, in the sample with composted pomace. Concentration levels regarding potassium followed similar trends whit maximum concentrations of 3290 ppm representing a 10-fold increase. These results highlighting the energetic and constitutional contribution of this mineral element, obtained from organic matter. Studies conducted in Turkey using as is dried pomace showed limited improvements on terroire characteristics whit some positive effects on table grape quality parameters (Tangolar et al. 2024).

CONCLUSIONS

The use of composted grape pomace has showed promising results as a soil amendment tool. Our data reveals important improvements regarding organic matter, nitrogen, potassium and phosphorus ratios.

Composted grape pomace can become an important element in vineyard sustainability practices applicable according to Balkan climate parameters.

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