THE IMPACT OF DIFFERENT TILLAGE SYSTEMS USED IN VINEYARDS ON SOIL PHYSICAL PROPERTIES

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Abstract

It is well known that global climate change represents one of the greatest threats to the environment social and economic sector. Current trends in adopting sustainable agriculture are increasingly based on the implementation of agricultural practices designed to protect the environment and ensure the food needs of a growing population. Vineyards are among the oldest crops in the world, with the highest level of soil degradation. In vineyards there are several different cultivation technologies with different soil management systems, but all of them have the common objectives of creating optimal, favorable conditions for the growth and development of vines while maintaining or even improving soil health. Protecting the physico-chemical properties of the soil as well as conserving its productive capacity is a permanent concern of mankind, and the success of well-defined development clearly depends on it. In order to identify the stability patterns, this research assesses the protecting impact of grass cover, conventional and minimum-tillage system on physical soil properties in traditional vineyards. The study was carried out at the Vasile Adamachi Student Research and Practice Station of the "Ion Ionescu de la Brad" University of Life Sciences in Iasi, from the north-eastern part of Romania. To maintain environmental quality, vineyard yields and grape quality at a high level, as a response to an increased awareness of the value of soil health, the adoption of sustainable soil management practices is becoming increasingly common in wine-growing regions worldwide.

Key words: grass cover, tillage systems, vineyard, climate change.

Viticulture is of high economic value, with approximately 7 million hectares of grapevines planted worldwide, of which 50% are located in Europe (OIV, 2020).

Vineyards are recognized as an agricultural land use vulnerable to soil degradation, mainly because they are typically located on steep slopes and managed with heavy machinery and agrochemicals (Prosdocimi *et al*., 2016).

Although vineyards are intensively managed agro-ecosystems, they can host a large biodiversity (Bruggisser *et al*., 2010; Fernandez-Mena *et al*., 2021; Geldenhuys *et al*., 2021), can provide a range of ecosystem services due to their perennial nature, and form landscapes rich in high quality natural and semi-natural areas and special habitat structures (Winkler *et al*., 2017; Garcia *et al*., 2018).

In viticulture, management is commonly done in a trellis system with different degrees of management intensity in inter-rows between the vines, depending on local environmental conditions and the wine grower's attitudes, knowledge and experience (Chen *et al*., 2022).

Several studies have highlighted that frequent tillage, machinery traffic, and agrochemical use in vineyards are responsible for the increase on soil compaction (Biddoccu *et al*., 2016) and the decrease in aggregate stability, soil organic matter (SOM), and nutrient content (Catania *et al*., 2018; Mondini *et al*., 2018).

Vineyard inter-rows can support sustainability in viticulture by allowing a management system which supports a permanent or temporary vegetation cover with non-crop plant species, either as sown cover crop mixture or spontaneous vegetation. The positive effect of cover crops on different biodiversity levels and the associated ecosystem services has been demonstrated by many studies (Geldenhuys *et al*., 2021; Zanettin *et al*., 2021).

Cover crops stabilize soil aggregates by enhancing root networks in soils and thereby

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allow a higher soil porosity and connectivity supporting a better water infiltration, retention and refilling of soil water reservoirs (Abad *et al.*, 2021; Novara *et al.*, 2021).

The effect of cover cropping on vine growth and grape quality might vary with the intensity of vegetation cover, plant species composition, pedo-climatic conditions and the timing of disturbance by mulching or tillage (Blanco-Canqui H., Wortmann C.S., 2020).

The quality of the grapes grown in vineyards depends on climate, crop management, soil properties and cultural practices such as tillage, protection and others (Abu-Hamdes, 2000).

Soil in vineyards is subject to frequent tractor traffic associated with soil tillage, the application of chemicals and grape harvesting. In highly mechanized viticulture, the number of tractor passes per year can be up to 22 in traditionally cultivated and 20% less in grass covered vineyards (Lisa *et al.*, 1995).

Soil aeration is another important physical property of the soil which is very dynamic and varies substantially with a range of factors, in particular, with water content and bulk density (Bhandral *et al.*, 2007).

Soil erosion is the major drawback of soil tillage which is amplified by gravel soils, low soil organic matter contents and the usage of hillslopes as vineyards (Biddoccu *et al.*, 2016; Garcia *et al.*, 2018).

Farmers decisions for these different soil management strategies in inter-rows largely depend on viticulture traditions, pedo-climatic conditions, vineyard inclination, available machinery and very often personal preferences (Steenwerth and Belina, 2008).

MATERIAL AND METHOD

The study was carried out at the Vasile Adamachi Research and Student Practice Station, belonging to the University for Life Sciences "Ion Ion Ionescu de la Brad" of Iasi, located in Iasi, in the north-eastern part of Romania.

In terms of viticultural placing, the plantations within the Station are part of the viticultural zone C1, the wine-growing region of Dealurile Moldovei, Iași Vineyard, Copou Viticultural Center.

The exploited land is drained, on the N-S direction, by the Podgorenilor stream, a left tributary of the Bahlui river, contouring through its slopes the shape of an amphitheater with a southern opening. The slopes, which are approximately symmetrical in the transverse plane, have a gradient of between 8 and 25%, and the altitude varies between 80 and 170 m. The area is characterized by a temperate continental climate with predominantly drought conditions.

The average air temperature in 2023 was 12.2 ^{o}C, registering a positive deviation of +2.4 ^{o}C compared to the multiannual average, a value that confirms the gradual increase in the mean annual temperature values, a phenomenon that indicates we are in a process of global warming. The precipitation amount of about 510 mm, with a deficit of 70 mm compared to the multiannual amount, with an uneven distribution of precipitation, mainly accumulated due to heavy rainfall. In the experimental field of the Pinot Noir vineyard, a soil profile, according to the Romanian System of Soil Taxonomy 2012, was identified as an cerno-cambic aric anthrosol.

Figure 1 **Soil profile – cerno-cambic aric anthrosol**

In the experimental plot, 3 variants of management inter row spacing of vine-yard were implemented: grass cover (GC), conventional tillage (CT) and minimum-tillage (MT).

In GC system, the natural vegetation and plant debris are chopped and mulched on the surface using a vineyard shredder, without soil mobilization.

For the minimum tillage system we used the chisel plow, mobilizing the soil without turning the furrow.

Also, the plow and rotary harrow was used for the conventional tillage.

The differences between soil management practices on the inter-row spacing were evaluated

and compared during the growing season and soil sampling/determination depths.

As an indicator that provides information on soil compaction, bulk density (BD) was determined in undisturbed soil samples, taken from different depths (0-10, 10-20, 20-30 and 30-40 cm) using stainless steel cylinders with 100 cm^3 volume.

For BD determination, soil samples were dried at 105 °C to a constant weight. Bulk density (g/cm^3) = (weight of oven dried soil)/(volume of the soil).

Also, as an indicator of compaction, the penetration resistance of soil was determined to a depth of 80 cm using the Eijkelkamp Penetrologger in 10 replicates on each plot (expressed in MPa).

RESULTS AND DISCUSSIONS

For all variants of inter-row management, the values of soil penetration resistance are within normal limits throughout the growing season, values that have no impact on the growth and development of the root system.

However, under CT and MT, due to soil mobilization, the penetration resistance (PR) decreases in the soil surface horizon, compared to the grassed variant, where it remains constant throughout the growing season *(figure 2)*.

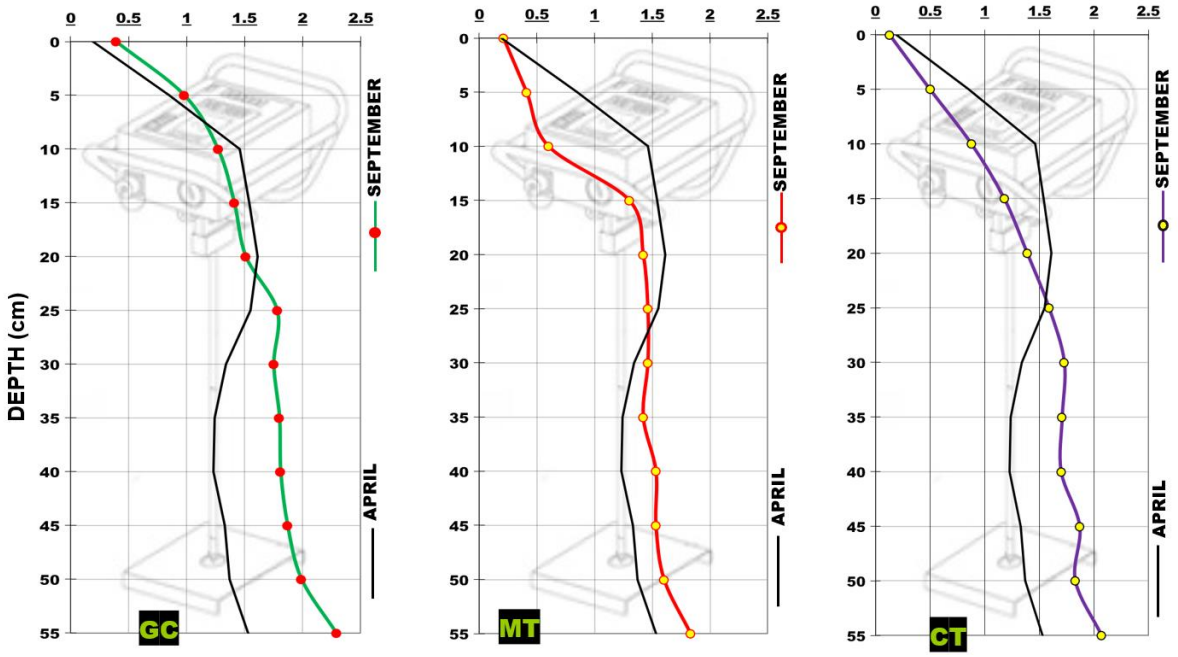

Figure 2 **Mean values of penetration resistance (MPa)**

In the GC system, from the beginning of the growing season (in April) until the grapes were harvested (in September), the BD values were not significantly modified due to the lack of soil mobilization tillage, with values ranging from 1.23 to 1.35 g/cm^3 *(table 1)*.

The significant difference is observed in chisel plow tilled variant (MT), in the zone of action of the active bodies, where from early spring until harvesting, the values decrease to 1 g/cm^3, indicating a very loose soil. This change also occurs in the conventional tillage, but with a downward trend in the soil depth.

Table 1

Mean values of bulk density (g/cm^3) registered in 2023 growing season on the 3 systems of management inter-row of vineyard

SYSTEM / DEPTH (cm)	Spring	GRASS COVER (GC)		MINIMUM TILLAGE (MT)		CONVENTIONAL TILLAGE (CT)	
		Vegetation	Harvesting	Vegetation	Harvesting	Vegetation	Harvesting
0-10	1.23	1.26	1.27	1.09	1.01	1.01	1.09
10-20	1.27	1.26	1.23	1.27	1.29	1.2	1.23
20-30	1.33	1.32	1.23	1.3	1.32	1.33	1.27
30-40	1.35	1.3	1.27	1.37	1.36	1.35	1.3

CONCLUSIONS

Soil management systems between the rows of vines have both advantages and disadvantages, but these need to be adapted to the eco-pedoclimatic conditions of the vineyard area. The lack of a plant debris layer reduces trafficability in rainy periods and can increase the compaction of the topsoil from the tracks of agricultural machinery. Tillage in soil mobilization systems reduces bulk density values but amplifies water evaporation, with negative effects also on soil structure.

In summary, many factors influence grape yield, grape quality and wine styles worldwide and therefore vineyard management decisions may be different depending on the local conditions.

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