THE INFLUENCE OF SOIL MANAGEMENT SYSTEMS OF THE INTERVAL BETWEEN VINE ROWS ON THE PENETRATION RESISTANCE OF SOILS FROM COTNARI VINEYARD

INFLUENȚA UNOR SISTEME DE LUCRARE PE INTERVALUL DINTRE RANDURILE DE VIȚĂ DE VIȚĂ ASUPRA REZISTENȚEI LA PENETRARE A SOLURILOR ÎNTR-O PLANTAȚIE DE VIȚĂ DE VIE DIN POGORIA COTNARI

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Abstract.
Soil is not only the physical support but also the main reserve of nutrients and water for the vines, which, together with meteorological factors and the level of agricultural techniques used, determine the quantity and quality of grape production. Vineyard mechanisation technology is the totality of all production processes, agricultural works, and operations carried out in a certain sequence, in optimal conditions and in compliance with agricultural technical requirements. The volume of work and the order in which it is carried out constitute the tillage system. The tillage systems used in vine plantations influence the physico-mechanical properties of the soil by using different systems of machinery and equipment during the course of a vineyard year. The studies were carried out on the western slope of Bejeneasa Farm, Cotnari Vineyard, in the Moldavian Hills Wine Region. The studied area is 0.31 ha. It is located in the upper part of the slope with a western exposure, and the slope of the land is <5%. The altitude is 170 m, and the mean annual precipitation and mean annual temperature values are 508.9 mm and 10.9°C, respectively. In order to highlight the effects of tillage systems in the plot cultivated with vines on the land with 8% slope and western exposure, three tillage systems were practised: a tillage system with a tiller, a tillage system with ridging, and a tillage system with a cultivator. For each tillage system, determinations were made on both the tractor wheel tracks and the mechanical spacing between the vine rows. Penetration resistance was determined using a penetrologger to a depth of 80 cm. The analytical data obtained showed that the penetration resistance of soils was influenced by the tillage system used. The range of variation of the values of penetration resistance for the wheel tracks of agricultural equipment was higher compared to those recorded on the vine rows.

Key words: penetration resistance, tillage system, vineyard plantation

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Rezumat.
Solul nu este doar suportul fizic, ci și principala rezervă de nutrienți și apă pentru vița-de-vie, care, împreună cu factorii meteorologici și nivelul tehnicilor agricole utilizate, determină cantitatea și calitatea producției de struguri. Tehnologia mecanizării viticole reprezintă totalitatea proceselor de producție, lucrărilor agricole și operațiunilor efectuate într-o anumită succesiune, în condiții optime și cu respectarea cerințelor tehnice agricole. Volumul de lucru și ordinea în care se efectuează constituie sistemul de prelucrare a solului. Sistemele de lucrare a solului utilizate în plantațiile de viță-de-vie influențează proprietățile fizico-mecanice ale solului prin utilizarea diferitelor sisteme de mașini și echipamente pe parcursul unui an viticol. Studiile au fost efectuate pe versantul vestic al Fermei Bejeneasa, Podgoria Cotnari, în Regiunea Viticolă Dealurile Moldovei. Suprafața studiată este de 0,31 ha. Este situată în partea superioară a versantului cu expunere vestică, iar panta terenului este <5%. Altitudinea este de 170 m, iar valoarea medie anuală a precipitațiilor și a temperaturii medii anuale sunt de 508,9 mm și, respectiv, 10,9°C. Pentru a evidenția efectele sistemelor de lucrare a solului în parcela cultivată cu viță-de-vie asupra terenului cu panta de 8% și expunere la vest, s-au practicat trei sisteme de lucrare a solului: un sistem de lucrare a solului cu motocultor, un sistem de lucrare a solului cu crestere și un sistem de lucrare a solului cu cultivator. Pentru fiecare sistem de prelucrare a solului s-au făcut determinări atât pe șenilele roților tractorului, cât și pe distanța mecanică dintre rândurile de viță de vie. Rezistența la penetrare a fost determinată folosind un penetrolog până la o adâncime de 80 cm. Datele analitice obţinute au arătat că rezistenţa la pătrundere a solurilor a fost influenţată de sistemul de prelucrare a solului utilizat. Gama de variație a valorilor rezistenței la pătrundere pentru șenilele de roți ale utilajelor agricole a fost mai mare comparativ cu cele înregistrate pe rândurile de viță de vie.
Cuvinte cheie: rezistență la pătrundere, sistem de prelucrare a solului, plantație viticolă

INTRODUCTION

Soil penetration resistance is an indicator that mechanically characterises the state of soil tilth in vineyards by determining the degree of soil compaction.

The penetration resistance characterises very significantly the physico-mechanical properties of the soil and is particularly used in comparative studies of tillage systems carried out with different agricultural machines. Penetration resistance depends largely on the degree of compaction of soil and its bulk density, moisture, organic matter content, granulometric composition, and crop.

Bulk densities and penetration resistance generally increase with depth in soil profiles, and these changes in physical properties can be mitigated and/or eliminated by using soil loosening machines appropriate to wheel gauge, controlled traffic practices, deep ripping and conservation tillage [Ţopa *et al.*, 2013].

Soil compaction can occur either at or near the surface (shallow compaction) or deeper in the soil (subsoil compaction) and is influenced by the loss of soil aggregation caused by soil erosion, reduced organic matter levels and forces exerted by the weight of agricultural equipment. Soil compaction is attributed to wheel loading, not tillage [Van Dijck and Van Asch, 2002].

Soil compaction, especially just below the cultivated layer, hinders root penetration, limiting the ability of plants to absorb water and nutrients from the lower soil horizons [Chan *et al.*, 2006].

Compaction is also exacerbated by the intensity and frequency of maintenance work between plant rows through the repeated movement of heavy-wheeled agricultural machinery on approximately the same routes to carry out disease and pest control treatments [Pagliai *et al.*, 2004].

The pressure exerted on the contact surface of the wheels varies with the size of the machines and the slope. The mass of commonly used tractors ranges from 2.6 to 3.7 Mg, and the width ranges from 1.15 to 1.40 m. Therefore, the wheel tracks are located close to the vine row and, thus, may affect soil conditions in the root zone [Ferrero et al., 2005].

Compaction is also significantly influenced by the water content of the soil at the time of tillage because when soil is wetter than the plasticity limit, it can become severely compacted if tilled or subjected to traffic. This occurs because soil aggregates are pushed into each other, forming a dense and stretched mass, favouring increased dilution of organic matter [Laudicina *et al.*, 2014].

Compacted soils generally have a higher penetration resistance at a given moisture level than well-structured soils. Penetration resistance for high-quality, moist soil is usually well below the critical level at which root growth ceases for most crops.

Soil compaction often reduces soil porosity and increases soil bulk density and resistance to penetration, leading to increased surface runoff and degradation by erosion [Bogunovic *et al.*, 2019; Pijl *et al.*, 2020].

The consequences of soil compaction can also be seen from the fact that the loss of large pores in aggregates is very detrimental for fine and medium-textured soils, which depend on these pores for good water infiltration and percolation as well as for air exchange with the atmosphere, whereas for coarse-textured soils the impact is less severe.

The technologies applied and the tillage systems practised in vine cultivation influence the distribution of vine roots in the soil in terms of rooting depth and, in particular, root density. The presence of interspersed rows covered by permanent grass or continuous tillage between rows can cause a different development of the root system, influencing the number, diameter and density of roots [Linares Torres *et al.*, 2018].

The degree of soil compaction influences the stage of development of the root system of crop plants and their ability to penetrate the soil. Measured values below 300 PSI (2.00 MPa) do not negatively influence root penetration into the soil. At recorded values above 400–500 PSI (2.70–3.40 MPa), roots do not penetrate into the soil [Rusu *et al.*, 2012].

By practising different tillage techniques between the rows, the root system of the grapevine can be affected, playing an important role in the quality and quantity of grape production, which in turn are the basis for wine production [Smart et al. 2006].

The main effect of increasing the values of penetration resistance is the restriction of root penetration as well as their density, which implies a slowed development of the root system and, consequently, a reduction in their capacity to absorb water and nutrients [Răus and Jităreanu, 2007].

As soil penetration resistance increases, root elongation and growth decrease. In terms of vine growth, at values above 3 MPa, root growth is retarded, except in cracks and old root canals. The critical values (2.85 MPa) achieve resistance to penetration at depths of 35–40 cm in the wheel tracks of agricultural machinery, while between these tracks, the measured values do not approach this value. The highest value was 2.31 MPa, which was recorded at depths of 30–35 cm (plow hardpan). At 40–50 cm deep, the values ranged from 1.93 in the middle of the alley to 2.59 MPa on the wheel tracks [Țopa *et al.*, 2013].

Agronomic practices in vineyards, in particular inter-row management, influence the response of soil properties and root development of grapevine plants [Bordoni *et al.*, 2019].

This paper aims to present the research carried out in a vine plantation under vines operated by SC Cotnari SA in the period 2021–2023 on the influence of three tillage systems.

MATERIAL AND METHOD

Soil penetration resistance studies were conducted in a vineyard located on the western slope of Bejeneasa Farm, Cotnari Vineyard, Iași county, northeastern Romania (Figure 1).

The experimental field was organised between the years 2022 and 2023 in a plot cultivated with grapevines. The geographical coordinates determined with the Global Positioning System (GPS) had the following values: latitude 479°17´58´N, longitude 269°59´36´E, and altitude of 170 m, located in physical block 993, T 25. The slope of the land is <5% with western exposure on carbonate diluvial deposits. In the vineyard plot with the total area of 2.70 ha, of which the area taken in the study was 0.31 ha, three intervals of vine rows with a length of 95 m were considered. The distance between the rows of vines was 3.00 m and the distance between the vines on row was 1.00 m. For each grading of A factor (tilled, trellised, cultivated with cultivator), a number of three repetitions were considered and between each variant/repetition, neighbouring rows of protection, tilled in the system specific to the area, were left (interleaved).

The experimental field was organised using the randomised block design.

Fig. 1. Experimental field, Bejeneasa Farm

In order to achieve the aim of this study, the following stages were completed:
- determining the volumetric water content;
- determining the soil bulk density;
- determining the soil penetration resistance;
- gathering data regarding rainfall and air temperature;
- storing and processing data obtained in the field.

The device used to determine the soil penetration resistance was the Eijkelkamp Penetrologger (2010), measuring down to 80 cm in depth. The device was equipped with a GPS system for precise localisation of the determination point and can be connected to up to 12 satellites. Special attention was paid to the penetration speed of the penetration tip into the soil, which is recommended to be 2 cm/s. The determinations were carried out on the same day and performed both on the spacing between the rows of vine stumps and on the wheel tracks of the machines used to carry out the work in 10 replicates on each cropping system up to a depth of 80 cm in order to obtain a representative value. The data collected could be viewed graphically or numerically on the penetrologger screen in the field and then downloaded to the computer and processed with the corresponding software.

The state of soil compaction was established both on the basis of morphological indicators observed in the field during the soil profile description and on the basis of bulk density values determined from soil samples taken in natural settlement in stainless cylinders with a volume of 100 cubic cm.

RESULTS AND DISCUSSIONS

In the spring of 2021, the penetration resistance values in all three variants were lower than 3 MPa. The compactness state was not restrictive for the development of the vine root.

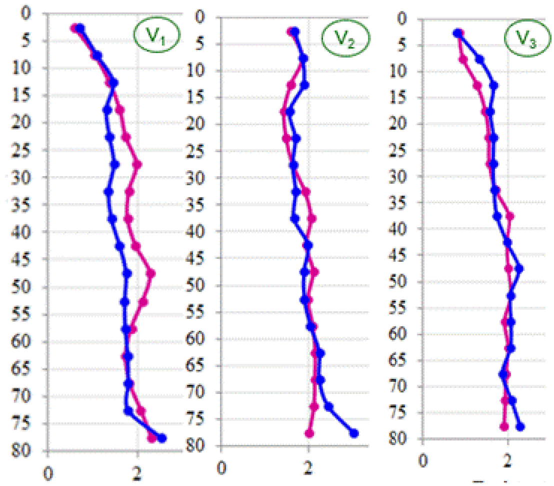

Fig. 2. V_1 – soil worked with the tiller; V_2 – soil kept grassy;
V_3 – soil worked with the cultivator.

In the middle of the interval between the vine rows, the penetration resistance values exceeded 5 MPa, starting with the depths of 15 cm (V_1) and 25 cm (V_2 and V_3). Penetration resistance values higher than 5 MPa from tractor wheel tracks were recorded starting with depths of 15 cm (V_1), 30 cm (V_2) and 45 cm (V_3). The state of soil compaction changed differently in the three variants only at a depth of 0–30 cm.

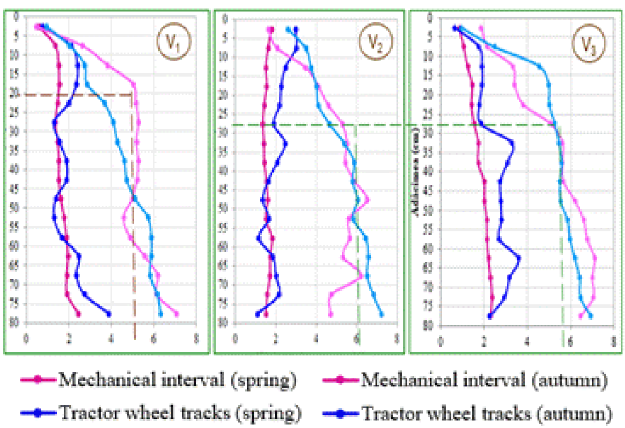

Fig. 3. Interval between the vine rows

CONCLUSIONS

The penetration resistance values were lower than 3 MPa in all three variants.

Between the wine rows, in the middle, the penetration resistance values were higher than 5 MPa, starting at 15 cm depth for the first variant and 25 cm for the other two variants.

The results of the study found that determining penetration resistance before establishing the experimental field is useful for establishing the state of soil compaction.

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