OBSERVATION ON SOME SOIL PHYSICAL PROPERTIES IN COTNARI VINEYARD

OBSERVAȚII ASUPPRA UNOR PROPRIETĂȚI FIZICE ALE SOLULUI DIN PODGORIA COTNARI

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Abstract. *Soil compaction is one of the major causes of soil degradation in modern agriculture and forestry. Neither runoff nor soil erosion were measured in the field, but the proportions of water-stable aggregates were determined as a relevant soil erodibility indicator. The highest percentage (80.10%) of* WSA_{1-2mm} *was recorded on 30-40 cm depth fallowed by 20-30 cm laye.*
Key words: *soil degradation, penetration resistance, water stable aggregates, bulk density*

Rezumat. *Compactarea solului este una dintre cauzele majore ale degradării solurilor în agricultura modernă. În câmp nu s-a determinat eroziunea propriu-zisă a solului dar s-a cuantificat stabilitatea hidrică a agregatelor de sol, un indicator foarte relevant al erodabilității. Cel mai mare procent la macroagregatelor hidrostabile s-a regăsit la 30-40 cm adâncime (80.10%) urmat de orizontul 20-30 cm*
Cuvinte cheie: *vin, degradare solului, rezistența la penetrare, stabilitatea hidrică, densitatea aparentă.*

INTRODUCTION

Viticulture is an important economic activity in Cotnari area. A large part of the territory is devoted to this crop. According to the latest data from the International Organisation of Vine and Wine (OIV, 2009), there were just over 7.8 million ha of vineyards worldwide in 2008.

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).

Very little research has been done to investigate soil compaction effects in vineyards. Few papers showed (Ferrero et al., 2001; Van Dijck and van Asch, 2002) that long-term traffic in vineyards results in topsoil and subsoil compaction below the frequent tillage depth. Van Dijck and van Asch (2002) revealed that subsoil compaction in a vineyard is mostly attributed to wheel load.

Soil compaction is one of the major causes of soil degradation in modern agriculture and forestry. The overuse of machinery has been identified as the main reason contributing to soil compaction. Due to its persistence, subsoil compaction can be considered as a long-term degradation, although compaction also concerns

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surface layers. Compaction affects soil physical fertility adversely, in particular by impeding the storage and supply of water and nutrients. This leads to decreased porosity, increased soil strength and hence soil resistance to root penetration and plant emergence, and decreased soil water infiltration and holding capacity. These adverse effects also reduce fertilization efficiency and crop yields, increase waterlogging, runoff and soil erosion with undesirable environmental problems (Soane and van Ouwerkerk, 1994). Thus, knowing the changes in soil compaction with changes in water content and bulk density is essential when planning farm operations at appropriate water contents (Arvidsson et al., 2003), or when decreasing soil bulk density by increasing its organic matter content through the retention of crop and pasture residues or appropriate soil tillage (Hamza and Anderson, 2005).

Poor structure resulting from soil compaction by tractor traffic in vineyards has been shown to reduce root development and yields of grapes (Louw and Benni, 1991; Van Huyssteen, 1988). Soil compaction has been described as the most serious environmental problem caused by conventional agriculture because, it not only affect crop productivity, but also the workability and sustainability of the soil (McGarry, 2001).

MATERIAL AND METHOD

The plots from Cotnari vineyard are mostly located on slopes with gravelly soils, where surface crusts cause downslope rills and colluvial deposits and increased runoff leads to fertilizer and pesticide loss to surface waters.

The investigations were done in the Cotnari vineyard, situated in a climatic transition zone with cool climate elements in the Suceava Plateau and more continental in the Moldova Plain, on a Aric Haplic Chernozem (WRB-SR, 2006) with secondary calcium carbonate accumulation in the upper part of the soil, as a results of climatic changes (rising the temperatures and less precipitation), with a clay texture.

The following varieties are planted: *Grasa de Cotnari, Feteasca alba, Francusa and Tamaioasa romaneasca.* The quality of the grapes and wine depends on natural factors such as climate, soils, tillage techniques that attempt to control the hydrological functioning of soils and to maintain their fertility

The relief of Cotnari vineyard is very fragmented, with a general orientation to S-E, with some famous parts: Catalina Hill (395 m), Stanca Hill (360 m), Voda's Hill (347 m), Piciorul Racului (337 m), Liteanca (330 m). The average slope does not exceed 20°. The geological substrate is „Sarmatiene", within which are two different stories: one in the lower floor whose altutide is around 250-260 m, composed of marle and clay and an upper floor consisting of limestone, marle, sand oolithe, sandstone, and fossile-rich elements (Rotaru Liliana et al., 2010).

Observations were conducted at Rotila Farm which belongs to SC Cotnari SA, 233 m above sea level, 3-4% slope and the ground water level at 15 m depth. A soil profile was dig (Figure 1) before the tillage treatments and soil samples were collected in every layer to analyze the most relevant properties to their soil types. The pit was dug perpendicularly to the tillage direction. It was used both for bulk density measurements and for morphological characterisation. On the soil profile (0-100 cm) the pH is weak-moderately alkaline (7.22-8.5) and the content of organic matter range form 1.62 to 2.16%.

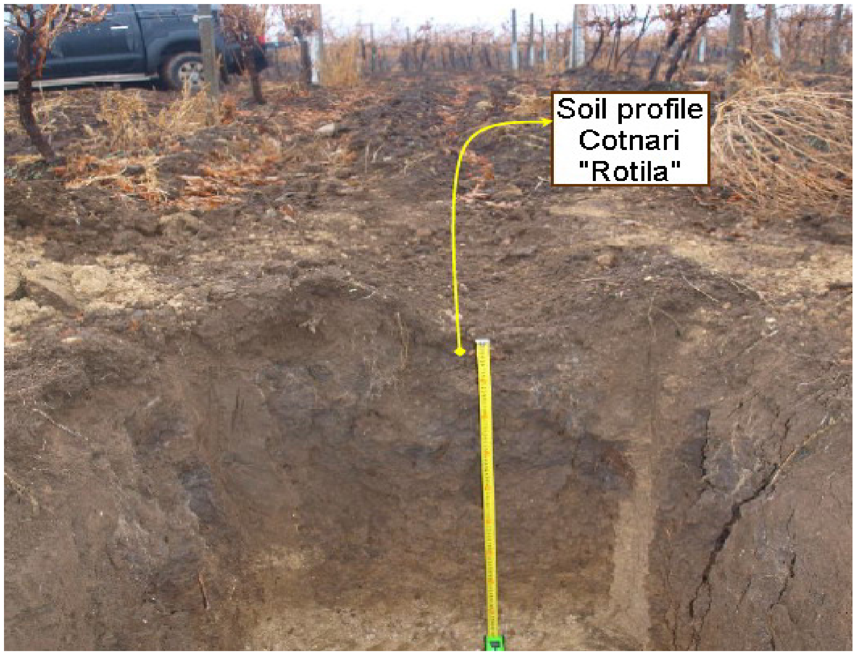

Fig. 1 - Profile no. 1 – Cotnari Rotila Farm, 47º57'46" N latitude, 26º56'2" E longitude (16th December, 2011)

The average annual temperature reaches approximately 9.1-9.3°C; the amount of active temperature (°C>10) exceeds 3200°C each year, sunshine hours are more than 2100 and 340-390 mm rainfall/growing season (Barbu et al., 2002). In the last decade it can be seen that in general the temperature regime increased and the rainfall was reduced.

The vineyards of the study area are planted in straight rows separated by three-meter side unvegetated lanes by 1.2 m between plants on row, semi-high training, bilateral cordon. The survey was performed in December 2011 and October 2012 that being most critical period for machinery traffic;

Vineyards in this area are normally managed through tillage, using the commonest farming techniques in the region. Tillage and other management practices are carried out following the direction of the contours. Tractors use the lanes to plough (one time in fall and one time in spring at 18-22 cm depth), harrowing to remove any spurious vegetation, spread fertilizer, apply herbicides and pesticides.

Then, the stainless steel pan containing the soil derived from the sieving was dried at 105°C until water evaporated. Aggregate stability was only measured on the smaller soil fraction as this particle size is usually responsible for sealing the soil. The water stable soil aggregates (WSA) were measured using the procedure of Kemper and Rosenau. Briefly, replicate 4 g samples of soil aggregates per subplot were moistened with deionised water by capillary action for 10 min. Air-dried sieved soil (1-2 mm diameter) was placed in a 0.250 mm sieve and immersed in an stainless steel pan with distilled water for 3 min with a stroke length of 1.3 cm and a frequency of 35 cycles min^{-1}. The soil retained in the sieve was immersed again in a sodium hexametaphospate solution (2 g L^{-1}) for 15 min and 35 cycles min^{-1} and the stainless steel pan was also dried. After drying, aggregate fractions (from water and hexametaphospate) were weighed to obtain the $WSA_{1–2\ mm}$ percentage. The initial and final weights of aggregates were corrected for the weight of coarse particles using the formula: final weight = initial weight - coarse particles weight. Coarse particles were fraction of soil contained in the last sieve of the manipulation.

The $WSA_{1–2\ mm}$ was calculated by weighting the mass of soil aggregates remaining after wet sieving and expressed as a percentage of the total mass of aggregates at the beginning of the experiment.

Bulk density was determined by the core method (Blake and Hartge, 1986). Undisturbed soil cores (100 cm^3) were taken horizontally at 10 cm depth intervals from 0 to 50 m on the soil profile. Three replications were performed per pit (Figure 2).

Fig. 2 - Core sampling for bulk density determination

The penetration resistance of the soils was determined using a digital penetrologger *(Eijkelkamp Equipment, Model 0615-01 Eijkelkamp, Giesbeek, The Netherlands*) which had a cone angle of 30^0 and a base area of 1 cm^2. It was carefully inserted into the soil profiles in 1 cm increments from the surface to a depth of 50 cm by the same person. 30 parallel records performed in each plot and averaged, on both wheel tracks and in the middle of an alleyway.

RESULTS AND DISCUSSIONS

Neither runoff nor soil erosion were measured in the field, but the proportions of water-stable aggregates were determined as a relevant soil erodibility indicator. The highest percentage (80.10%) of $WSA_{1–2mm}$ was recorded on 30-40 cm depth fallowed by 20-30 cm layer, probably caused by absence of influence of tillage (figure 3). The poorest aggregate stability was measured on the top layer (53.00%), indicating a serious problem and a poor soil physical quality.

Generally, the higher the index value the better the soil's capacity to transmit water and air and to promote root growth and development. The differences in aggregate stability were more pronounced in the surface soil samples than in the 30–40 cm samples.

Several studies have shown that the proportion of water-stable aggregates is related to soil loss measured in fields varying in scale from square metres to hectares (Bradford et al. 1987; Barthes & Roose 2002, Goulet E., et al., 2004).

On vineyard hillsides, the frequency index of erosion features was relatively high and was negatively correlated with the topsoil content of water-stable aggregates .200 mm, especially in the absence of conservation practices (Barthes B. and Roose E., 2002).

Alterations in soil structure due to topsoil and subsoil compaction by vehicular traffic influence many soil properties which control crop production and quality of yield.

The PR is an empirical measure of soil strength and it is widely used for assessing the compacting and loosening effects of agricultural implements. Root elongation and growth decreased by increasing soil penetration resistance.

With regards to grapevine growth, at values higher that 3 MPa the root growth is retarded except through cracks and old root channels.

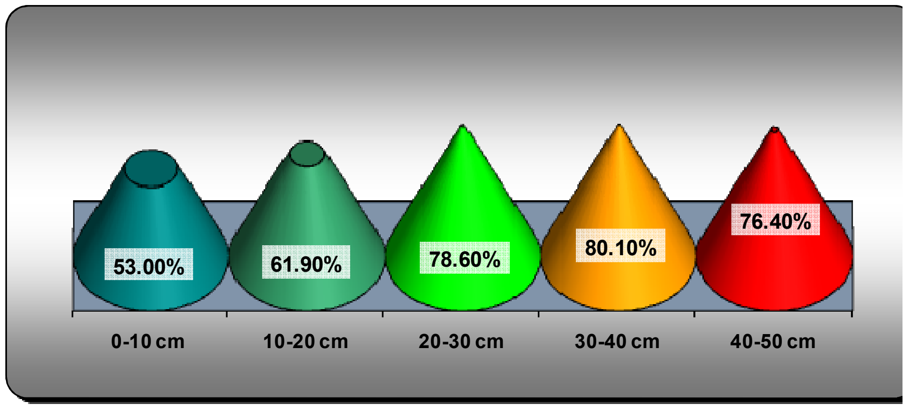

Fig. 3 – Water stable aggregates – mean values 2011-2012

From the comparison of values shown in Figure 4 results that penetration resistance varied in a wide range and is very clear influenced of passing of machinery in wheel tracks.

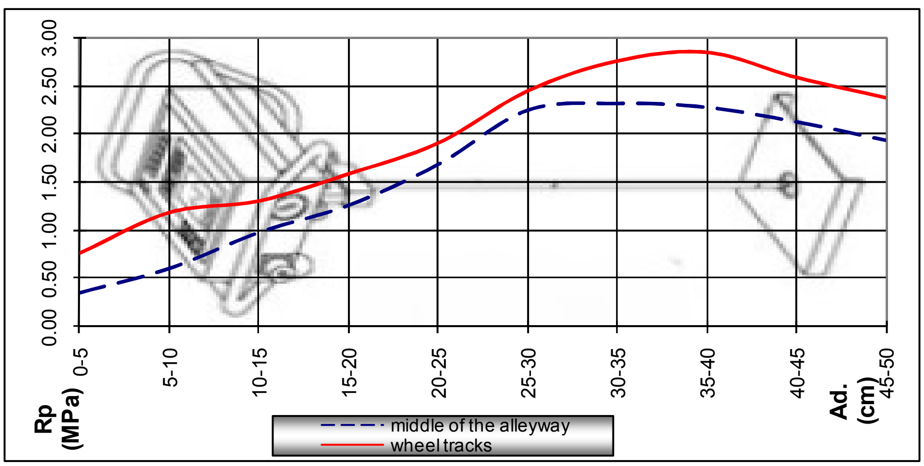

Fig. 4 – Soil penetration resistance on the middle of the alley and on the wheel tracks – mean values 2011-2012

The critical values (2.85 MPa) achieve penetration resistance at 35-40 cm depths on wheel tracks, while in the middle of the alleyway almost all measurements were not close to this value. The highest value, 2.31 MPa, was recorded at 30-35 cm depths (due to a plough pan). On 40-50 cm depth the values ranged from 1.93 in the middle of the alley to 2.59 Mpa on wheel tracks.

The strongly compacted zones were also identified on soil profile thanks to their specific features, i.e. no visible macropores, massive structure and smooth breaking surfaces.

Many authors have shown that compaction of soil particularly just below the cultivated layer, limit the penetration of roots and restrict the ability of plants to absorb water and nutrients from the subsoil (Chan et al., 2006).

Bulk densities and penetration resistance generally increased with depth within the profiles. The bulk density values ranged from 1.17 g/cm^3 in 0-10 cm depth to 1.51 g/cm^3 at 30-40 cm, as average in 2011-2012. On the last layer analyzed the bulk density slightly decreased (1.48 g/cm^3). Increases in soil strength and bulk density are a common characteristic of hard-setting soils during drying (Mullins et al., 1990).

CONCLUSIONS

The unfavourable soil compaction in the wheel track of the tractors and the machines can be eliminated by using looseners corresponding to the wheel track, controlled traffic, deep ripping and conservation tillage practices are recommended for increasing the soil physically status. Another suggestion would be to apply organic mulch, in order to decrease erosion without decreasing yields

ACKNOWLEDGMENTS: *This study was realised and published within the research project POSCCE-A2-O2.1.2-2009-2 ID.653, code SMIS-CSNR 12596.*

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