ISSN 2447-4924 (Impressa)
ISSN 2447-598X (Digital)

# AGRONOMIA

# CULTURAL SOIL PROFILE AND RISK OF EROSION IN VINEYARDS WITH DIFFERENT SOIL MANAGEMENTS

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**ABSTRACT:** The objective of this work was to evaluate the soil quality of vineyards with different managements using the cultural soil profile method. The vineyards were in the Paysage de Corton, Burgundy, France. The managements used were chemical control of weeds (1), plant cover in the inter-rows and chemical control in the rows (2), plant cover in every two inter-rows and chemical control in the rows (3), plant cover in the work inter-rows where the agricultural machinery passes, and turning of the soil in the other inter-rows (4), surface turning of the soil (<10 cm) in the entire area with and without addition of shredded tree barks (5), and deep turning of the soil (>10 cm) in the entire area (6). A compacted soil layer at depth of about 20 cm was found in all managements, but the adopted managements affected the characteristics of the surface layers, with more compactness in managements with deep turning of the soil, followed by surface turning of the soil, and chemical control; and less compaction in areas with plant cover. The highest risk of erosion was found in the 5 and 6 managements, which had turning of the soil; areas with deep turning of the soil presented greater susceptibility to erosion, and a very compacted soil layer in the center of the inter-rows. The management with surface turning of the soil showed that plant residues (tree barks) can be used to reduce the risk of erosion. The cultural soil profile method was efficient in identifying physical problems in soils of vineyards and is a low-cost, accessible tool to producers.

**Keywords:** *Vitis vinifera* L., water erosion, qualitative evaluation, rain simulation, Burgundy, wine.

# PERFIL DO SOLO CULTURAL E RISCO DE EROSÃO EM VINHEDOS COM DIFERENTES MANEJOS DE SOLOS

**RESUMO:** O objetivo deste trabalho foi avaliar a qualidade do solo de vinhedos com diferentes manejos, utilizando o método do perfil cultural do solo. As vinhas estavam em Paysage de Corton, Borgonha, França. Os manejos utilizados foram controle químico de plantas daninhas (1), cobertura vegetal nas entrelinhas e controle químico nas fileiras (2), cobertura vegetal em todas as duas entrelinhas e controle químico nas fileiras (3), cobertura vegetal a cada duas entrelinhas onde o maquinário agrícola passa, e superfície do solo nas demais entrelinhas (4), preparo superficial do solo (<10 cm) em toda a área com e sem adição de cascas de árvores desfiadas (5 ) e preparo profundo do solo (> 10 cm) em toda a área (6). Uma camada de solo compactada a uma profundidade de cerca de 20 cm foi encontrada em todos os manejos, mas os manejos adotados afetaram as características das camadas superficiais, com mais compactação em manejos com preparo profundo do solo, seguido de preparo superficial do solo, controle químico e menor compactação em áreas com cobertura vegetal. O maior risco de erosão foi observado nos manejos 5 e 6 manejos, onde o preparo do solo é adotado; áreas com preparo profundo do solo apresentaram maior suscetibilidade à erosão e uma camada de solo muito compactada no centro das entrelinhas. O manejo com o preparo superficial do solo mostrou que resíduos de plantas (cascas de árvores) podem ser usados para reduzir o risco de erosão. O método do perfil cultural do solo foi eficiente na identificação de problemas físicos em solos de vinhedos e é uma ferramenta acessível e de baixo custo para os produtores.

**Palavras-chave:** Vitis vinifera L., erosão hídrica, avaliação qualitativa, simulação de chuva, Borgonha, vinho.

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# PERFIL CULTURAL DEL SUELO Y RIESGO DE EROSIÓN EN VIÑEDOS CON DIFERENTES GESTIONES DEL SUELO.

**RESUMEN:** Se objetivó evaluar cualitativamente el suelo en áreas de viñedo con diferentes tipos de manejo, por medio de la técnica del perfil cultural. Los viñedos se encuentran en la Paysage de Corton, Borgoña, Francia, y tienen diferentes manejos: (1) control químico de plantas dañinas, (2) cobertura vegetal en las entrelíneas y control químico en las líneas, (3) cobertura vegetal cada dos entrelíneas y trabajo superficial del suelo en las demás entrelíneas, (4) cobertura vegetal en las entrelíneas del tratamiento (paso de implementos agrícolas) y trabajo de suelo en las demás, (5) trabajo superficial del suelo (<10 cm) en toda el área con y sin aporte de cáscara de árbol triturada y (6) trabajo profundo del suelo (> 10 cm) en toda el área. Se evidenció que en todos los manejos se tiene una capa compactada que se encuentra a unos 20 cm, siendo que el manejo adoptado hace que las características de las capas superficiales sean bastante distintas, con mayor compactación en los manejos con trabajo profundo (> 10 cm), seguido de trabajo superficial (<10 cm), control químico y menor compactación en el manejo con cobertura vegetal. El mayor riesgo de erosión en los manejos 5 y 6 fue observado donde se adopta la práctica de trabajar el suelo, siendo que el trabajo profundo es el que presenta mayor susceptibilidad a la erosión, aliado a una capa muy compactada en el centro de la entrelínea. Para el trabajo superficial del suelo fue visto que el aporte de restos vegetales (cáscaras de árboles) puede ser una práctica adoptada para reducir los riesgos de erosión. El método del perfil cultural fue eficaz para identificar problemas de orden físico en suelos vinícolas y, de esta forma, se constituye en una herramienta de bajo costo y de rápido acceso para los productores.

**Palabras clave:** Vitis vinifera L., erosión hídrica, evaluación cualitativa, simulación de lluvia, Borgoña, vinos.

## INTRODUCTION

Burgundy is a French region recognized worldwide by the production of wines, especially its five main regions: Chablis and Grand Auxerrois, Côte de Nuits, Côte de Beaune, Côte Chalonnaise and Mâconnais (BIVB, 2012).

This work was developed because of the need for researches of the producers' association of the Paysage de Corton, located in Côte de Beaune, which encompasses the wine-growing areas of three towns (Pernand-Vergelesses, Aloxe-Corton and Ladoix-Serrigny) (Hocde, 2010; Herbin, Fabbri, Ambroise, 2015). As a response to these producers and local leaders, Hocde (2010) identified the potentialities and main problems of this region; one of these problems was soil erosion, as reported by the farmers interviewed and seen in field evaluations. In this context, Herbin et al. (2015) made a more detailed analysis of this region to obtain more information about soil occupation, susceptible areas to erosion, and biodiversity. Thus, a model was created to evaluate the risk of erosion in the areas, mainly based on visual aspects. The model created classified some regions as highly susceptible to erosion, especially areas in the Corton hill.

Erosion causes visible soil losses; the soil is carried to lower areas. Thus, many producers adopt a common practice in the region for replenishing the soil, moving soil from lower areas to eroded areas (Herbin et al., 2015).

Some practices can be used to reduce erosion; the presence of plant cover or crop residues on the soil surface helps to reduce erosion problems. The plant material in the soil surface reduce the impact of raindrops and thus, the disaggregation of the soil. Plant cover increases the macroporosity of the soil, resulting in a higher water infiltration rate (Brandão et al., 2007). In the case of soils of vineyards, plant cover is the most effective method to control runoff and, therefore, the risk of erosion (Curmi, Chatelier, Trouche, 2006; Gril, 2003).

Soils of vineyards respond differently to water infiltration. Grapevines are perennial plants, thus, the agricultural machinery used for cultural practices always passes on the same places—in the inter-rows. The use of agricultural machinery in vineyards is intensive, the soil is strongly compacted, presenting low macroporosity and, consequently, greater susceptibility to runoff and erosion. Therefore, the soil structure of the inter-rows is different than the soil structure of the rows; the latter does not undergo compaction processes and is more structured, with a higher water infiltration rate (Curmi et al., 2006).

The cultural soil profile method can be used to evaluate the changes in the soil profile due to intensive mechanization. This method assesses how human actions modify physical attributes of the soil, with emphasis on the soil morphological characteristics, and allows the differentiation of these soils regarding its compaction level and form (Gautronneau and Manichon, 1987; Tavares Filho et al., 1999; Boizard et al., 2017; Roger-Estrade et al., 2017). According to Muller et al. (2003), the cultural soil profile method describes the relationship between root growth and soil structure. This method is easily understood and accessible to farmers, which extends its use and makes it a practical, useful method for technical guidance in field conditions.

Therefore, the hypothesis in this work is that the cultural soil profile method can be applied in soils of vineyards for a rapid soil diagnosis, without the need for costly laboratory analysis to identify physical problems due to the soil management applied; and assist farmers in the correction of the affected soil layer. Thus, the objective of this work was to evaluate the soil quality in vineyards under different soil managements using the cultural soil profile method. The soil profile of the areas was evaluated according to the soil management, and a rain simulation was performed to measure the risk of erosion in the areas.

## MATERIAL AND METHODS

This work was developed in partnership with the National Institute of Agronomic, Food and Environmental Sciences (AgroSup, Dijon, France). The study was conducted in March and April 2012, in vineyards located about 30 km southwest of Dijon, in the wine-producing areas of the towns of Aloxe-Corton (47°3′56″N, 4°51′34″E), Ladoix-Serrigny (47°3′58″N, 4°53′12″E) and Pernand-Vergelesses (47°04′51″N, 4°51′06″E), which form the Paysage de Corton, Burgundy, France (Hocde, 2010; Herbin et al., 2015). According to the FAO classification (WRB, 2006), the soil of the region is a Calcaric Cambisol of silty clay texture, with gravel and stones (Brenot, Quiquerez, Petit, Garcia, 2008). The annual rainfall in the region is less than 800 mm (Meteo France, 2018).

The vineyards were divided into six categories of soil management, representing the main land use practiced for soils of vineyards, based on a current map of soil management practices employed in vineyards (Herbin et al., 2015; Hocde, 2010). These managements were chemical control of weeds in the rows and inter-rows without turning of the soil (1); plant cover in the inter-rows and chemical control in the rows without turning of the soil (2); plant cover in every two inter-rows and surface turning of the soil in the rows using an enjambeur (a large vineyard tractor) and a chenillard (a small vineyard machine) (3); plant cover in the work inter-rows where the agricultural machinery passes, and turning of the soil in the other inter-rows (4); surface turning of the soil (<10 cm) (scarification) in the entire area with and without the addition of shredded tree barks (5); and deep turning of the soil (>10 cm) in the entire area (6). Soil treatment with deep turning of the soil is performed in the winter; it consists of making a heap in the plant rows, i.e., the inter-row soil is deposited in the rows, near the base of the vines. This turning of the soil aims to protect the base of the plants from the low winter temperatures; when the plants begin to develop in the spring, the soil is again spread in the area.

The cultural soil profile methodology was used as described by Gautronneau and Manichon (1987). A trench was opened in each area with horizontal dimensions restricted to the inter-row spacing—about one meter. The depth of the profile used was about 30 cm, since the objective of this procedure was to evaluate the effect of cultural managements. Subsequently, the soil profile was cleaned with a pedological hammer and a pocketknife to observe the morphological characteristics of the profile. The evaluated characteristics were soil structure, aggregation, consistency, compaction, presence of organic matter by color, and root distribution; these characteristics were correlated with the management practices.

For a better understanding of the descriptions of the cultural profiles, pictures were taken with a professional photographic camera, and the layers found in the field were identified and described as C+ (very compacted), C (compacted), C- (little compacted), A (with presence of aggregates), FE (fine earth), and F (friable). The different volumes found were delineated with solid lines, the end of the vertical part of the profile was delineated with a dashed line, and dotted lines highlight horizontal parts in some areas.

After the evaluation of the cultural profile, a rainfall simulation was performed in the areas 1, 2 and 5, using two sprinklers on 10 m of three inter-rows of each area, to measure the risk of erosion on the soil surface. The amount of sprayed artificial rain represented a water depth of 20 mm, measured by three pluviometers, one in each tested inter-row. The erosive processes were evaluated by measuring the amount of soil that was carried by the water to the lower area of the vineyards, and the presence of surface channels of erosion and surface runoff.

## RESULTS

*Cultural soil profile and description of the study areas*

Figure 1 shows the profile opened in the inter-row of the treatment in an area with slope of 17% managed with weed control. The F / C- layers had faint color and friable consistency, and were less compacted than the C+ layer, which had lighter coloration, lower level of soil aggregation, and presence of horizontal cracks (Figure 1a).

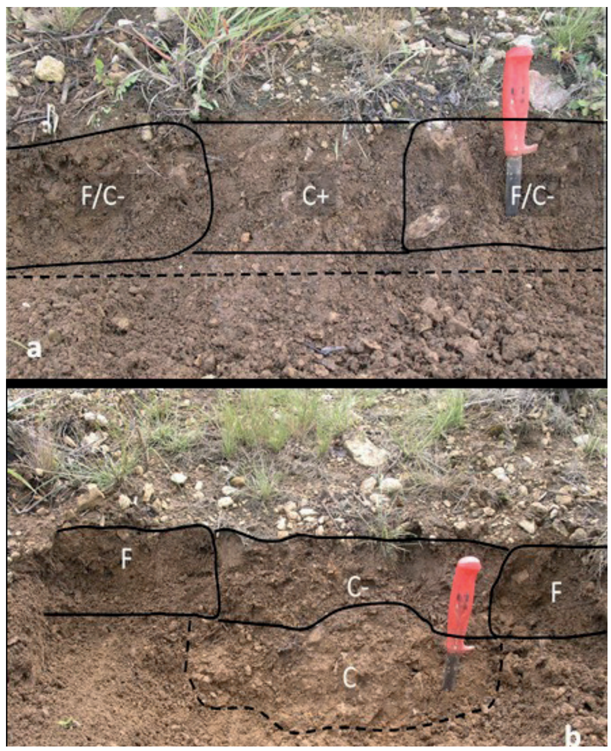


**Figure 1.** Cultural soil profile of the inter-row of the area managed with chemical control of weeds, without turning of the soil. **Author**: Daniela Schmitz.

Another inter-row with the same management (Figure 1b) presented lower compaction than the first (Figure 1a). However, in the inter-rows where the agricultural machinery passes for chemical treatments, the C- layer is slightly more compacted than the F- layer, and less compacted than the C layer just below it; and the color of the soil is more yellow throughout the horizon.

**Figure 2** shows an area with slope of 21% managed with plant cover in the inter-rows and chemical control in the rows.


**Figure 2.** Cultural soil profile of the area with plant cover in the inter-rows and chemical control of weeds in the rows. **Author:** Daniela Schmitz.

This area had plant cover in the inter-rows for two years (cover plants were sown in September 2010) and was already well established, with a significant root system of 5 cm. It presented significant organic matter content in the first 10 cm; the soil color was black and very friable, represented by the layer F. The layer C had yellowish color, compaction, and traces of water retention from 10 cm. The C layer presented compaction and high microporosity, thus, water moves slowly in it. The accumulation of water was visible around the decomposing organic matter. This decomposition generates oxygen consumption, making visible some reduction spots (mottling). Before having permanent plant cover in the inter-rows, this area received shredded tree barks, which were already decomposed.

Figure 3 shows an area with slope of 25% managed with plant cover (clover; Trifolium sp.) in every two inter-rows and surface turning of the soil (<10 cm) in the other inter-rows using a chenillard (a small agricultural machine used in vineyards), and the opened profile in the inter-row with turning of the soil.

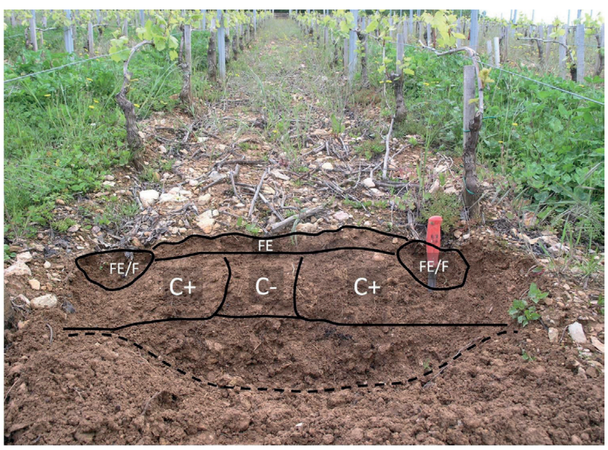


**Figure 3.** Cultural soil profile of the area with plant cover in every two inter-rows and surface turning of the soil in the other inter-rows.
**Author:** Daniela Schmitz.

This area presented very compacted layers (C+) due to the type of agricultural machine used for cultural practices; and differences from the others, since these compacted layers were at the inter-row ends—the place where the chenillard wheels pass—and not in the center, as seen in Figure 1. Thus, the less compacted layer (C-) was found at the center of the inter-row. FE (fine earth) was found on the surface layer, up to about 5 cm. This characteristic was also found at the inter-row ends, where the detached layer is also friable. A significant presence of millimeter-sized vine roots was found throughout the profile.

Figure 4 shows areas with slope of 25% managed with plant cover in every two inter-rows and surface turning of the soil (<10 cm) in the other inter-rows, using an enjambeur (a large agricultural machine used in vineyards). Figure 4a highlights the opened profile in the inter-row with the plant cover, and Figure 4b shows the inter-row with turning of the soil.

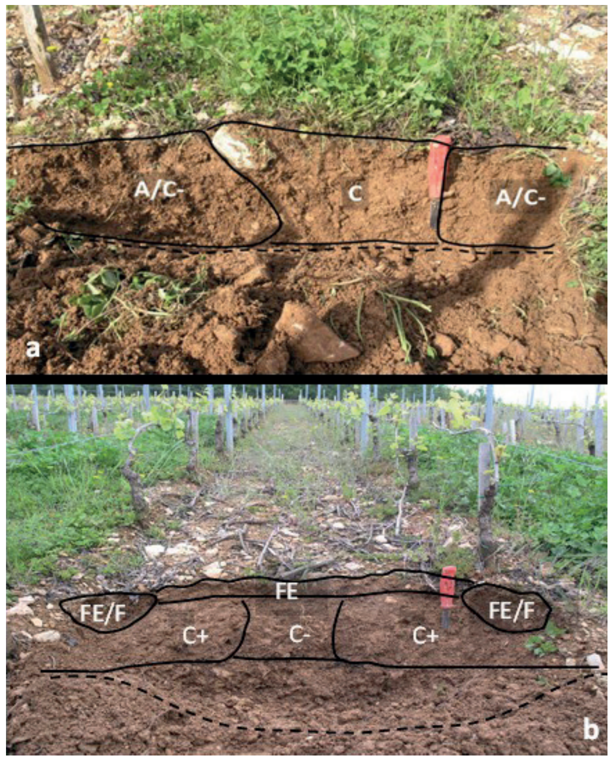


Figure 4. Cultural soil profile of the inter-row of the area managed with plant cover in every two inter-rows and surface turning of the soil in the other inter-rows.
**Author:** Daniela Schmitz.

In the inter-row with plant cover (Figure 4a), the C layer was more compacted than the A / C- layer, where the presence of aggregates can be highlighted. In general, no significant compaction was found; clover roots are present but not forming a significant root system. Bacterial nodules in red clover roots were also found, indicating a high bacterial activity. The C- layer had intermediate compaction in the inter-row with turning of the soil (Figure 4B) contrasting with the C+ layer, which presented strong compaction probably due to the passing of the enjambeur wheels. A layer composed of soft, friable FE (FE / F) was found in the surface at the inter-row ends. This was associated with the turning of the soil at that position. The layer just below had its upper limit in the range of the agricultural implement used in the soil management, and was compacted.

Figures 5a and 5b show areas with slope of 24% managed with deep turning of the soil (>10 cm), highlighting the inter-rows with planed (b) and heaped (A) earth.

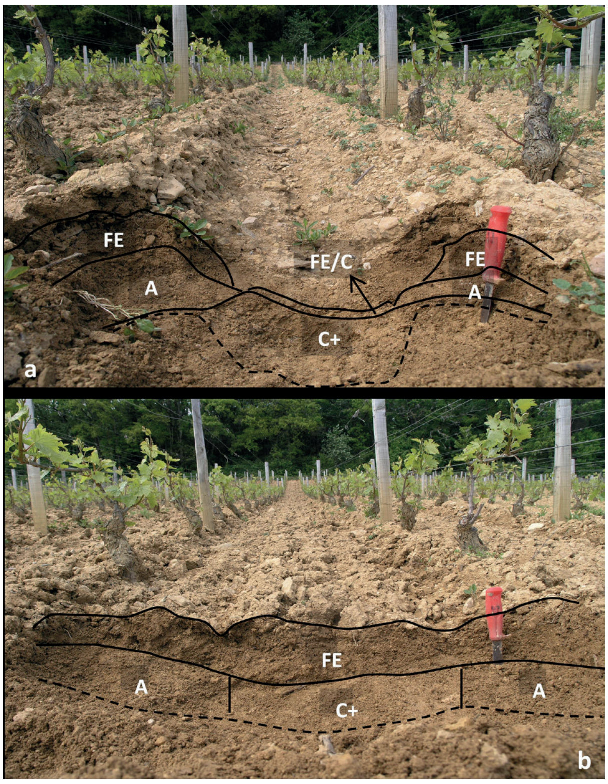


**Figure 5**. Cultural soil profile of the area with deep turning of the soil, highlighting the opened profile in the inter-rows with planed (b) and heaped (a) earth.
**Author:** Daniela Schmitz

A very compacted soil layer (C+) was found in the center of the inter-row with heaped earth (Figure 5a). The FE layer was shown in the earth that was heaped along the rows with a very soft aspect. Part of the soil that presents some degree of structuring was found below this layer, being possible to visualize the aggregates (A).

A layer composed of very compacted fine earth (FE / C) was found in the surface, at the center of the inter-row. Erosion, and the preferred water paths in the center of the inter-rows, were very evident in this area. A marked characteristic was the abundant presence of bare roots—surface roots that are visible due to the erosion of the earth that covered them.

The first 10-cm layer was very friable and soft in the inter-row with planed earth (Figure 5b), consisting of very little structured FE; and a very compacted layer (C+) was found below it, with more evident compaction in the center of the inter-row. The soil presented aggregates at the inter-row ends (A). A hilling was performed at the time of the profile opening (2012) in this area (Figure 5), but the heavy rains of April and May (Meteoblue, 2018) caused erosion of a large part of the soil. Erosion marks are well visible throughout this area.

Figure 6 shows an area with slope of 20% managed with surface turning of the soil (<10 cm) with no addition of shredded tree barks.

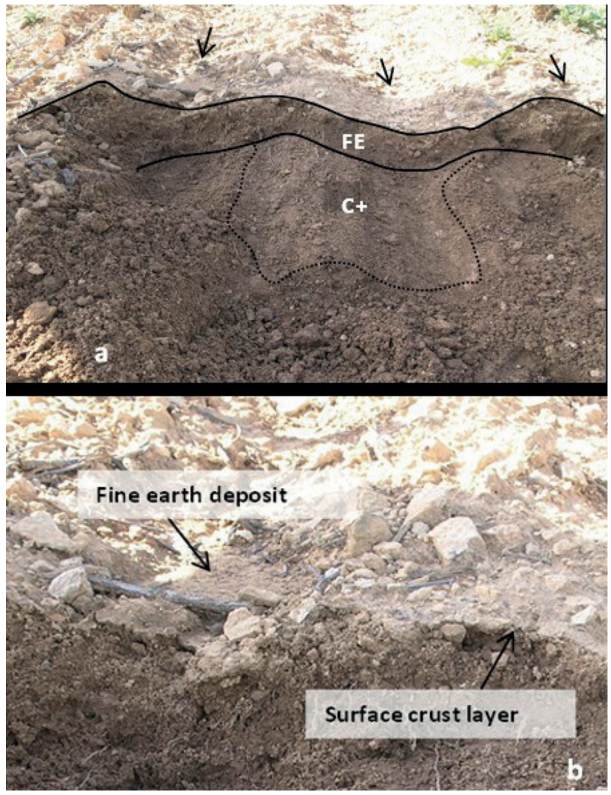


**Figure 6**. Cultural soil profile of the area with surface turning of the soil (a) and soil surface with surface turning of the soil (b). Arrows indicate the preferred paths of the surface-runoff water.
**Author:** Daniela Schmitz

The soil surface in this area presented a layer composed of strongly bonded fine particles, evidencing the surface sealing of the soil due to the rains (Figure 6 a and b). The soil surface layer was composed of FE on a very compact layer (C+) (Figure 6a). The soil in the area was little structured, so the impact of the rain drops easily disaggregate the soil and the FE is detached and carried by the water. At first, this phenomenon causes clogging of the pores in the soil surface by deposition of FE. This creates a surface crust layer that saturates with water rapidly, preventing its infiltration (Figure 6b), even if the layer below has good permeability. Then, when the surface runoff begins and this FE is carried by the water, initiating the erosive process.

The FE deposits were also very noticeable (Figure 6b). When the water of the surface runoff that carries the FE finds an obstacle it infiltrates slowly, creating sediment deposits. The surface sealing is less evident in the work inter-rows. The C- layer was more compacted due to the passing of the enjambeur. The FE layer was found only in the inter-row ends, as well as the preferred water paths indicated by the arrows in Figure 6. The layer with the upper part delineated by the depth of the turning of the soil presented high compaction (C+). Erosion was less evident in the lower part of the work inter-rows, probably due to the strong mechanical aggregation because of the compaction by the agricultural machine wheels.

Figure 7 shows an area with slope of 20% managed with surface turning of the soil (<10 cm) with addition of shredded tree bark.

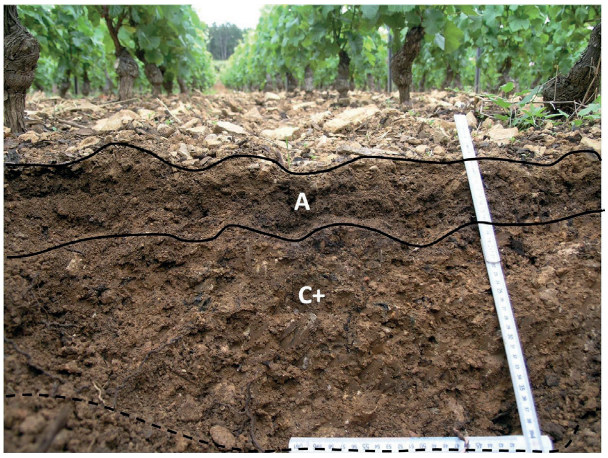


**Figure 7.** Cultural soil profile of the area managed with surface turning of the soil and addition of shredded tree barks. **Author:** Daniela Schmitz

Surface turning of the soil has been performed in the last three years in this area. The soil surface layer was aggregated and presented dark color due to the decomposition of the plant material in this area (A). A very compacted (C+) layer of yellowish color showing reduction spots around the decomposing organic matter was found in the center of the inter-row, below the surface layer.

## DISCUSSION

*Cultural soil profile*

The results found in this study are confirmed by other studies (Mueller et al., 2009; Giarola, Tormena, Silva, Ball, 2009; Guimarães, Ball, Tormena, 2011) using the cultural soil profile method and visual evaluation of soil structure quality in different soils and managements. These studies concluded that this method allowed distinguishing the quality of soils of different use and management systems by evaluating the structure of the studied layer.

The cultural soil profile showed the effect of each management on the soil characteristics. A common characteristic was the presence of a very compacted layer at depth of approximately 20 cm, which was more evident in areas with turning of the soil (Figures 3 to 7), presenting an abrupt, easily distinguishable transition from soft to very compacted soil. The areas with inter-rows managed with plant cover or chemical control (Figures 1 and 2) presented more gradual transitions of the layers.

Two factors explain the presence of compacted layers in these areas. The first one is the variation of the soil management practices over the years in most areas; producers adapt their management according to the climate—very humid soils impede mechanization of the areas—and the time available for the treatments of the crops. Thus, the soil of these areas had probably had some previous mechanization, making distinguishable the surface soft layers and deeper compacted layers. The second factor is the stabilization of the microbiota because of the lack of turning of the soil; the soil structure develops with the presence of aggregates when plant cover roots are present. However, the agricultural machines pass in the inter-rows, causing compaction. The microbiota and roots are located only in the surface soil layer, thus having a certain restructuring capacity, which does not happen in deeper layers, which present more evident compaction.

A marked characteristic of all areas was the soil friability with presence of aggregates in the planting rows. However, the passage of agricultural machines on the same places, due to the perennial characteristic of the crop, generates a strong horizontal contrast in the soil, with compacted soil in the inter-rows and no compaction in the rows.

The risk of erosion of exposed soils is great; and the turning of the soil in areas without plant cover made it clearer the occurrence of erosive processes. Moreover, some traces of the agricultural machines on the soil make the water that flows in the surface find preferential paths easily, potentiating erosive processes, especially in high slopes.

The results found through the cultural soil profile method and presented in this study are confirmed by those of Valois et al. (2014). These authors found traffic of agricultural machinery causing soil compaction in vineyards, with more significant compaction in the inter-rows due to the greater traffic intensity.

*Cultural soil profile after rain simulation*

The inter-rows of the areas managed with chemical control, and plant cover (Figures 1 and 2, respectively), and the area with turning of the soil (<10cm) with addition of shredded tree bark (Figure 7) presented no surface runoff. This was because of the soil characteristic (less compacted), which presented greater infiltration capacity than the simulated rainfall (20 mm). The soil surface layer was very wet after the test in these areas (Figures 1, 2 and 7), but the water concentrated mainly in the first 10 cm, i.e., just above the compacted layer (C or C+).

The soil of the area managed with chemical control (Figure 1) presented aggregates in the surface layer, which were characterized as very friable. This characteristic combined with the plant residues (dried material) left on the soil surface with this management, which reduces the impact of the raindrops, maintained the soil aggregates, resulting in water infiltration throughout the surface layer to the lower compacted layer (C).

These same characteristics were found in the area with turning of the soil (<10 cm) (Figure 7). Despite this treatment was performed in the surface layer, this area showed traces of shredded tree barks that was added to the soil 3 years before this evaluation. This result implies two positive characteristics to reduce surface runoff and risk of erosion: the fragments protect the soil surface from the raindrops, and the decomposition of this plant material increases the amount of organic matter, contributing to the aggregate stabilization.

The area with plant cover (Figure 2) showed similar characteristics to the two previous ones, but the element protecting the soil from the raindrops and decreasing its shear force is the plant cover present in the inter-rows.

The areas with turning of the soil >10 cm (Figure 5), and <10 cm (Figure 6) were similar, but differing from the other managements. The aggregates of the turned soil, without plant cover or elements protecting it from raindrops (Figure 6) are easily destroyed, generating surface sealing of the soil. This sealing is a surface layer formed of fine earth that are rapidly saturated with water. The fine earth has high water retention capacity, but very low transferability, thus, the water infiltration capacity of the soil decreases and the surface runoff begins when this saturated layer is formed. The fine particles are then suspended and carried, causing erosion.

The areas with deep (>10cm) and surface (<10cm) turning of the soil presented water accumulation in the first centimeters due to the surface sealing, and the layer formed just below, still in the turned soil, was slightly moist.

Previous fieldwork had found strong risk of erosion in areas with deep turning of the soil in the winter period, when the land is heaped on the planting row, since these areas presented the greatest deposits of FE in their lower slopes (Hocde, 2010, Herbin et al., 2015). This risk of erosion was related to high compaction (C+, Figure 5) and very little permeability of the center of the inter-row; the FE is detached from the heaped soil and is easily carried by the flowing water.

The soil planed throughout the area (Figure 5B) form a soft soil layer on the compacted layer; thus, the water infiltration capacity was thought to be higher than that in the areas managed with surface turning of the soil (Figure 6). However, the soil was very little structured and when the surface sealing occurred, the erosive process began, and the amount of FE remaining in suspension was carried by the water, with formation of small channels in the center of the inter-rows, and large deposition of soil in the lower parts of the area.

The area managed with surface turning of the soil (<10 cm) without addition of shredded tree bark (Figure 6) was affected by the rain, generating small channels in the center of the inter-rows, but they were smaller than those found in the area with turning of the soil >10 cm. The area with turning of the soil <10 cm with addition of shredded tree bark (Figure 7) had not formation of channels, however, the surface runoff carried a large amount of tree bark fragments that were in the surface of the soil to the lower part of the area.

## CONCLUSION

The soil of all areas had a compacted layer in the inter-rows at a depth of approximately 20 cm, regardless of the management used. The characteristics of the surface layers were different, according to the adopted soil management. The greatest compactions were found in the soil management with deep turning of the soil (>10 cm), followed by surface turning of the soil (<10 cm), and chemical control; and less compaction was found with the management with plant cover.

The greatest risk of erosion was found in areas with turning of the soil. Areas managed with deep turning of the soil (heaps in the winter) presented greater susceptibility to erosion combined with a very compacted soil layer in the center of the inter-rows.

The practice of addition of plant residues can be adopted to reduce risks of erosion in areas with surface turning of the soil; it provides a better structuring of the soil due to the input of organic matter and elements that protect the soil from raindrops, optimizing the water infiltration.

The cultural soil profile method was efficient in identifying physical problems in soils of vineyards and is a low-cost, accessible tool to producers. It allows producers to identify the effects of inappropriate practices for the maintenance of the soil structural quality in vineyards.

## LITERATURE


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