Slope viticulture risk factors impacting on the environment equilibrium. The case of north-west Italy

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ABSTRACT

Slope viticulture may harm the environment and soil fertility with direct impact on the socio-economic equilibrium of rural communities. Soil is to a large extent a not renewable resource and it is subjected to pressures which may damage its functional stability and fertility. Topography (especially steep slopes), abundance and distribution of rainfall (modified by climate change) and anthropic factors (great movement of soil during vineyard establishment, strong mechanization, soil tillage) may induce surface erosion and landslide formation and deplete soil fertility, with a decline in soil organic matter content. Organic matter, in particular, has a significant function in the soil because of its importance in maintaining chemical fertility, structure, water retention capacity and providing an energy source for soil micro-organisms. For these reasons it is essential to protect the soil, also through appropriate agronomic practices. In fact, agricultural activity, should guarantee the achievement of adequate quantitative and standards of yields, but should also take care of its role in protecting the environment and rural economy. Risk factors for an environment related to steep slope viticulture and the agronomic consequences are identified and described; environmental implications are discussed with special reference to the Langhe area (Piedmont, North-West Italy).

Keywords: hilly vineyard, soil erosion, compaction, organic matter, biodiversity.

1 INTRODUCTION

Soil is a dynamic system performing many functions and essential services for ecosystem survival and human activities, but it is a substantial non-renewable resource. Thus, it must be protected and safeguarded against agents that constitute a serious threat for its functionality and for agricultural crop lifespan. The main soil threats that have been identified are "erosion, decline in organic matter, local and diffuse contamination, sealing, compaction, decline in biodiversity, salinisation, floods and landslides" (1). Agriculture is one of the main factors blamed for soil degradation, despite the fact that the soil is one of the main factors for any farm production. For these reasons, identifying preventive agronomic practices to counteract soil threats and to maintain the efficiency of the soil, can not be postponed.

Erosion causes losses of topsoil and a decrease of its fertility and usability. It is caused by uncontrollable natural factors, such as meteoric events (rain/storm, wind) and by anthropic actions. The latter is linked to land-use, crop and agronomic management practices and food demand. Land topography, pedological features, organic matter content, nature of cover crops and anthropic actions may accentuate or constrain such degradation. Soil tillage is an anthropic factor whit strong impact, especially when performed in the same direction as the slope. Great displacement of soil masses, performed to establish specialised tree crops, and the lack of a field drainage system are also associated to potentially cause great harm to the soil. In similar conditions, it is common to observe catastrophic soil erosion rates, even over the tolerable threshold (2). Despite the fact that much of the Italian territory is under high erosion risk (3), policies of soil conservation do not perceived it as an environmental threatening problem (4). Strategies for protecting the soil against erosion, however, should be urgently introduced, even considering climatic changes that could exacerbate the harm to an already fragile environment. Another anthropic factor threatening the functionality of the soil, is **compaction**. It decrease soil macroporosity and cause structure decay (5). It also reduces water retention capacity, increasing the soil susceptibility to erosion. Its magnitude strongly depends on the soil texture, being particularly relevant when fine size particles are present. Soil compaction is particularly evident where deep tillage is performed repeatedly. Nevertheless, for permanent crops, where tillage is sporadic and not always necessary, soil compaction is mainly generated by repeated transits of farm implements, such as tractors, trailors, spraying equipment ecc. (6). The use of crawler tractors, that are particularly widespread in slope agriculture for increasing vehicle stability, may contain this phenomenon by exerting a lower force per unit area, compared to the wheel vehicles. At the same time, it increases the surface disturbance, due to the high adhesion of tracks and to the more aggressive movement and turning.

Soil **organic matter** (OM) may mitigate both erosion and compaction, thanks to its capability to improve soil structure by promoting aggregation between particles. By promoting infiltration and water retention, it reduces runoff and erosion and supports water supply for vegetation in dry and sandy soils; it regulates the cation-exchange capacity and buffering capacity; it may inactivate polluting substances by adsorbing organic molecules and it is a source of nourishment for pedofauna. In addition, it may sequester atmospheric carbon, limiting undesirable consequences of the greenhouse effect (7). As a consequence of its role in soil health, soil OM decline is an index of degradation of soil fertility and **biodiversity** (8). Organic matter decline is caused by natural factors, with reference to warm and dry climates (9, 10), or anthropic factors, that may accelerate its decomposition. However, it actually, appears to be linked to cultivation practices (tillage and fertilizer management) rather than to climate change (11, 12). It can be preserved reducing soil disturbance (13, 14). By altering the natural soil stratification tillage practices alter mass and distribution of pedofauna and promotes topsoil oxygenation and mineralization processes (15). The specialization of agriculture induces simplification of agro ecosystems and the aforementioned loss of OM that, in turn, is involved in the decline of the environmental biodiversity at all trophic levels (16, 17, 18). Nevertheless, biodiversity conservation is very important for contributing to the maintenance of soil fertility and for the services that it provides to ecosystems (19). Cultivation techniques that facilitate the preservation of OM in the soil (animal manure, cover crops, green manure, mulch, crop rotation) promote an increase in biodiversity (8, 20). In a vineyard agro system, soil biodiversity can be influenced by tillage, soil compaction, use of herbicides and pesticides, and cover crops. Shallow tillage, especially when made in alternating rows, is more compatible with the maintenance of natural soil biodiversity. Soil compaction, instead, contributes to the creation of a non-favourable habitat both to the deep-penetration of roots and to the maintenance and development of plant and pedofauna. The use of pesticides is prone to cause the development/spread of resistant species and to diminish the richness of soil arthropods, whereas cover crops may have a positive effect (20-25.

2 THE CONDITIONS IN "LANGHE" TERROIR

In Piedmont, North-West Italy, the grape cultivation is of considerable economic importance (approx. 46,000 hectares and 2,680,000 hl of wine). The high level and the reputation of wine production in the "Langhe" area (Barolo e Barbaresco wines, in particular), allow great gains from viticultural activity. This high profitability has led to an increase in vineyard surface, often to the detriment of the forest; this implies a loss of natural areas bordering the vineyards, and loss of potential role of the woods in protecting both biodiversity and stability of the territory against geological hazards (26). The new vineyards are often established after great strengthening of the slopes has taken place, with the purpose of reducing the high, typical declivity of the Langhe hills, levelling the surfaces and making mechanization easier. Thanks to the high profitability of viticulture that allows expensive investments, these practices are still in use in this area, as justified by the steep slopes that, often, restrict the possibility of using lands for other agricultural purposes. Actually, in the Langhe area, land use is strongly limited by slope (10°-20°), high soil erodibility, caused by the high proportion of fine sand and silt, and low fertility (high limestone content and less than 1 % of OM content) (27). Grapevines, known as being able to grow in low fertility environments has, therefore, allowed the economic well-being of rural communities in these areas, where viticulture is almost exclusively grown. Nevertheless, the strong establishment practices have made hill sides particularly vulnerable to landslides and mudslides, especially if not effectively combined with adequate drainage networks (28). Nowadays hydraulic layout and consolidation of the slopes are made, both for restoring the slope stability, affected by landslides, accentuated in recent years by the increase in rain intensity, and for taking preventative measures against environmental damages. The conspicuous earth movement that accompanies these works, has often profoundly changed the face of the hills and the natural characteristics and profile of the soil, frequently causing permanent loss of fertility; growers are not always aware of the gravity of that.
To combat the surface erosion, vineyards are planted, almost everywhere in this area, with rows across the slope. In order to ensure the safety of mechanization, the use of crawler tractors is necessary. Due to the aggressiveness against the soil, their movement increases the soil vulnerability to erosion, especially when cover crop is absent, or not uniformly present. Permanent inter-row cover crop is becoming increasingly widespread in the Langhe region, but it is considered too competitive for vines especially with respect to water use. Therefore, autumn tillage often, is carried out, in alternating rows, by harrowing or, more rarely, milling. Although not performed over the entire surface, autumn tillage may keep the soil bare in the rainy period of the year and, even in summer, the grass cover remains uneven. Especially in the steeper slopes, this exposes the soil to a raindrop impact during spring-summer storms, that occur with increasing intensity and frequency. Water surface erosion occurs, in particular, on vineyard roads when they are positioned along the maximum hillslope gradient and when parcels are particularly long (29). In these sensitive part of the vineyard, especially when there are no water canalization, the total absence of spontaneous vegetation is observed; furthermore, rill/gully erosion phenomena are often present, making movement dangerous and difficult. Growers are forced to extraordinary costs for restoring the functionality of headrows. Because of the low organic fertilisation, OM content in Langhe vineyards is chronically insufficient; this contributes not only to the maintenance of the low levels of soil fertility, but also restricts soil biodiversity that, on the contrary, is preserved and enhanced by maintaining grass cover and limiting tillage. Nevertheless, preliminary studies conducted in Langhe on soil biodiversity, showed good health of vineyard soils.

3 CONCLUSIONS

All the factors threatening land stability are present in Langhe vineyards. Climatic variations, resulting in increasing temperatures (9) and volume and intensity of the rain, are also included. Since vineyards are estimated to be the most eroded cultivations over time (30, 31), it would have been impossible to grow vines in this area with the currently used systems, if the purpose was to preserve hills from erosion and land degradation. In view of that, increasing knowledge and dissemination of good agronomic and environmental agricultural activities (GAEC, 32) appear urgent. Identifying specific agronomic improvements for environments where topographic conformation and anthropic practices increase threats to the functionality and vulnerability of soil, is necessary, also with the aim to helping growers and rural communities to develop conservation plans for their lands.

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Innovative method for wine quality and safety control by means of 1H-Nuclear Magnetic Resonance profiling

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ABSTRACT
Quality and safety of wine are major issues, for producers who want to protect their high-value products, for merchants or distributors who would like to control the products they are buying and for consumers.