7. Afforestation of vineyards in Italy

Chiara Ferré[1], Roberto Comolli[1], Gianni Facciotto[2], Sara Bergante[2]

[1]Department of Earth and Environmental Sciences, Milano Bicocca University, Italy

[2]Council for Agricultural Research and Agricultural Economy Analysis CREA –Research Centre for Forestry and Wood, Casale Monferrato, Italy

1. Practice(s) used

Afforestation of agricultural land

2. Description of the case study

The effect of conversion from vineyard (VY) to tree plantation (TP) on soil organic carbon (SOC) stocks was investigated by sampling paired plots in a hilly area of Monferrato (Italy).

The study area includes a VY and a nearby 30-year-old TP for wood production that was established in the winter 1985-1986 on an area formerly cultivated as vineyard. Eight poplar clones (*Populus x canadensis* I-214, Luisa Avanzo, Neva, Ongina, Panaro, Zero*; Populus x canadensis x P. maximoviczii* Eridano*; Populus alba* Villafranca) were consociated with some timber species (wild cherry - *Prunus avium* L.-, European ash – *Fraxinus excelsior* L., manna ash – *Fraxinus ornus* L.-, himalayan cedar – *Cedrus deodara* (Roxb) G.Don.-). In contrast with the VY, where the soil was deeply ploughed (till about 70 cm) before planting the vine and then annually surface tilled, at TP soil tillage involved the first ten-planting years only. Before the tree establishment, the soil has been ploughed to a depth of 30 cm and the harrowing has been carried out twice a year for three years and then annually for the next seven years, after which no further tillage has been carried out. The study area (3 ha) extends along a slighty-wavy slope (average gradient of 15 percent).

The impact of land use change on SOC stock was evaluated testing for autocorrelation among the model residuals. Soil sampling was performed from 0-10 cm, 10-40 cm and 40-70 cm layers at 61 and 69 points in the VY and the TP respectively, to characterize spatial distribution of SOC stock and other soil properties. At TP the organic horizons were sampled and analyzed for OC content determination.

Statistical analyses showed significant (p-value < 0.05) differences between the investigated land uses up to 70 cm in depth.

The VY showed in the 0-70 cm layer a SOC stock of 59.2±23.6 t/ha, a weighted average pH value of 7.9±0.1, and a C:N ratio of 7.8±0.7. TP was characterized by higher SOC stock (74.4±21.1 t/ha) and C:N ratio (8.8±1.0) and lower pH value (7.5±0.5) than VY; the SOC stock of the organic layer was 10.2 t/ha.

Our study showed that: (1) 30 years of TP changed SOC stock, resulting in an increase of 26 percent in the first 70 cm, which becomes 43 percent if the organic layers were included; (2) soil acidification and change in SOM type were also observed in TR compared to VY; and (3) the spatial distribution of soil properties in the VY was affected by erosive and depositional dynamics unlike the TR where vegetation controls erosion.

3. Context of the case study

The process of abandonment of the agricultural sector that characterized Italy since the 1960s, especially in the less fertile mountain and hilly areas, continued in the 1980s. In the study area, the bulk wine that was produced did not have a large market and many farmers abandoned the vineyards. Today, on the contrary, there is a recovery of vineyards, with construction of modern and technological cellars and the support of expert winemakers. However, tree plantations, that take the place of arable land, are quite widespread in the region (17 700 ha; INARBO Project, 2017) also promoted by financial support in rural development plans.

The investigated tree plantation, that substituted for a vineyard, extends along a slightly-wavy slope on the hilly area of Rosignano Monferrato, Piedmont, Italy (45.09°N, 8.42°E). Among selected trees, poplars, being a fast-growing species, were planted with the aim of favoring the growth of the valuable tree species; they should have been cut after about 10 years of planting but the poplar cutting was not carried out to prevent the breakage of other trees due to the reduced planting distance.

As monitored by the long-term meteorological station near the study site, the yearly average rainfall is 877 mm and the mean air temperature is 11.7 °C. The slope is exposed to northwest, not so favorable for obtaining high quality grapes. We relied on space for time substitute study using a paired plot design. The common pedological origin of soils within the study area was verified and confirmed by comparability of soil texture and carbonates content of the deeper layer. According to the WRB classification (IUSS Working Group, 2015) the soils are Calcaric Cambisols (Loamic).

4. Possibility of scaling up

It is a context-specific case study, however, tree plantations on former arable land are quite widespread in the region.

5. Impact on soil organic carbon stocks

The tree plantation was characterized by a SOC of 74.4±21.1 t/ha (0-70 cm), higher than that of the nearby vineyard, which represents the SOC stock before afforestation (baseline SOC stock). In addition, OC stock in the organic horizons (not present in the vineyard) was 10.2 t/ha (Ferré *et al.*, 2019;

Table **28**).

Table 28. Additional SOC potential from afforestation of a hilly area of Monferrato (Italy)

Location	Climate zone	Soil type	Baseline SOC stock (tC/ha)	Additional SOC storage (tC/ha/yr)	Duration (Years)	Depth (cm)	More information	Reference
Piedmont, Italy	Warm temperate moist	Calcaric Cambisol (Loamic)	59.2 ±23.6	0.51	30	0-70	Baseline stock is the SOC stock of the vineyard, representing the land use before afforestation	Ferré *et al.* (2019)

30 years of tree plantation resulted in a SOC stock increase of 26 percent in the first 70 cm, representing an additional SOC storage potential of 0.51 tC/ha/yr.

6. Other benefits of the practice

6.1. Benefits for soil properties

An increase in SOC stock in the mineral soil (from 59±23 to 74±21 t/ha) and the formation of an organic layer were observed.

Physical properties

We observed a slight improvement of the soil structure; the bulk density in the first 10 cm slightly decreased compared to VY (significant difference between tree plantation –1.2±0.1 g/cm^3- and vineyard -1.3±0.2 cm^{-3} was found.

Biological properties

The formation of an organic layer was observed; the main humus forms were Mull and Amphi, both characterized by a biomacrostructured A horizon.

6.2 Minimization of threats to soil functions

Table 29. Soil threats

Soil threats	
Soil erosion	The spatial distribution of soil properties in vineyard were affected by erosion and deposition dynamics unlike in tree plantation where vegetation reduced erosion. While at tree plantation the spatial distribution of SOC and pH were quite homogeneous, at vineyard there were variations along the slope with accumulation of SOC at the change of slope gradient and at the foot of the slope and with increase in pH values in the lower part of the slope, likely linked to redistributionof soil carbonates.
Soil biodiversity loss	We observed the formation of organic horizons and different humus forms like Mesomull, Oligomull, Dysmull, Leptoamphi and Eumacroamphi, characterized by different features and biological activity.
Soil compaction	The bulk density slightly decreased (see Section. 6.1).

6.3 Increases in production (e.g. food/fuel/feed/timber/fiber)

The afforested area is suitable for timber exploitation. The large part of tree plantations of the region is for timber and biomass energy as they are mainly poplar plantations, but polycyclic tree plantations are also common. The tree plantation showed also production of truffles.

6.4 Mitigation of and adaptation to climate change

Tree plantations favour C sequestration. SOC storage increased (organic matter input increased, soil temperature and thus OC mineralization decreased and soil tillage was carried out in the initial phase of plantation only) and soil erosion decreased.

6.5 Socio-economic benefits

On slope with exposure not favorable for obtaining high quality grapes as the investigated one, the planting of valuable species may be a possible option to the vineyard.

6.6 Other benefits of the practice

Tree plantation can favor the presence of fauna that helps to control parasites of the vineyard.

Tree plantation benefits people well-being by acting as a buffer zone between cropland (vineyard may require recurring pesticide applications to control *Peronospora* and leafhoppers (*Empoasca flavescens*)) and the small hilly villages.

7. Potential drawbacks to the practice

7.1 Tradeoffs with other threats to soil functions

Table 30. Soil threats

Soil threats	
Soil acidification	Soil acidification (pH average difference of 0.4) was observed linked to a change in SOM type.

8. Recommendations before implementing the practice

It is important to carefully choose the tree species to be cultivated among those typical of the area taking also into account the soil properties.

9. Potential barriers for adoption

Table 31. Potential barriers to adoption

Barrier	YES/NO	
Economic	Yes	Currently the land use change from vineyard to forest is hampered mainly by economic reasons, since wine production is more profitable than timber exploitation and biomass energy production although, on the slopes with not optimal exposures for the vineyard or in areas with other limitations to the vine cultivation, forestry could be a possible alternative to the vineyard. At the moment in Italy the establishment (ranging 487–2591 € ha^{-1} depending on type of plantation and tree number) and initial management of tree plantation are quite completely financed by the regional rural development plans. Costs of vineyard removal and soil preparation are excluded only (InBioWood Project, 2018).
Institutional	No	Tree plantation introduction (land use change from cropland to tree plantation) is promoted and financed by rural development plans.
Legal (Right to soil)	Yes	Permanent conversion from agricultural land to forestry use; there is a worry of farmers for the conversion. As long as the agricultural use remains, they can choose and rotate tree plantation with any other crop.

Photos

Photo 17. The vineyard, representing the land use before afforestation (9.9.2019)

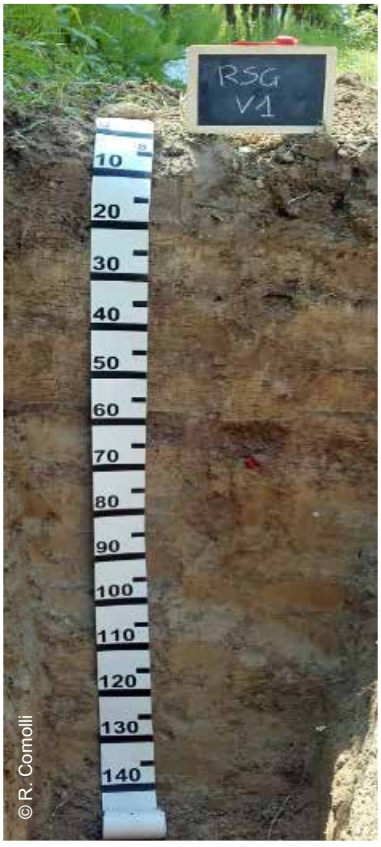

Photo 18. Calcaric Cambisols (Loamic, Aric, Ochric) at vineyard (1.07.2016)

Photo 19. Afforestation of vineyard: the tree plantation (9.09.2019)

Photo 20. Calcaric Cambisols (Loamic, Humic) at tree plantation (1.07.2016)

References

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