Effects of cover crops on grapevines in Mediterranean Italy

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Introduction
Italy has about two million hectares of vineyards and olive groves. Aft Spain these are the largest areas in the world and most of them are on slopes and are affected by soil erosion (Basso and Postiglione 1994).

Due to the topography the use of cover crops in vineyards and olive groves goes back to the times of the Roman Empire when cereals were cropped in the inter-rows. The increased depth and frequency of cultivation that followed as a result of mechanisation has increased the problems of erosion. The demand for increased productivity and for simplified management has contributed to the temporary abandoning of cover cropping in recent times.

Soil erosion in Italy is an important issue (Landi 1984), especially in the central regions (Santilocchi and Talamucci, in press) where with steep slopes and heavy soils that crack in the summer and retain too much water in winter, it is necessary to cultivate and plant down the slopes to avoid catastrophic landslides. This practice however causes strong superficial erosion. Results of recent trials confirm earlier reports in the literature that up to 1 cm of soil can be lost each year under such circumstances.

Today there is strong pressure to reduce cultivation and herbicide use in order to develop more environmentally friendly practices and to further increase the existing quality of the product. The latter problem is particularly important after the recent issues on food contamination by chemicals (dioxin) and diseases (mad cow) which have been reported elsewhere in Europe. Excessive and prolonged use of herbicides can be responsible for the destruction of the seed bank in the soil and the excessive reduction of biodiversity. Sometimes the soil has become inert and soil structure damaged due to the absence of organic matter and the vineyard microclimate has deteriorated. A fter several years of chemical use, traces of simazine and atrazine have been found in French wines in the past.

The escalating lifestyle in Europe and the abundance of food in the market place encourages people to spend more on quality foods. The safety of these foods for health reasons must be guaranteed at every stage of production.

To meet market demand it will be necessary to develop low risk techniques to limit soil erosion and especially to avoid the use of herbicides. Thus cover crops are considered a necessary step to complete the agronomic control of weeds and erosion and to allow sustainable production.

Erosion control, increased quality of the must and improved ecological conditions are the expected positive results of using cover crops. Problems may arise depending on the species of cover crop used and the management techniques used.

The competition for water and nutrients between the cover crop and the vines causes changes in the depth and the length of the root system of the vine and productivity is also reduced for the first three years. It is worth considering some of these aspects further.

Choice of the cover crop species
Due to the extreme variability of climates and soils, each vineyard within a region may require different species for the cover crop to succeed. Within a space of a few kilometres in Italy we can pass from a very warm Mediterranean climate to a mountain climate where snow can cover the ground for more than six months of the year.

Consequently species that fit well in one valley may not be suitable for another nearby.

It is not possible to make any generalisation; however perennial grasses have proved to be better in northern Italy with moister and cooler climates while annual legumes fit better for the Mediterranean parts (Piano and Talamucci 1996; Piemontese et al. 1997).

Many species and cultivars have been tested for warm areas and Table 1 shows the most interesting results.

Among the grasses, Bromus willdenowi and Dactylis glomerata sometimes had a poor germination and persisted for only a few years. Festuca arundinacea has even more difficulties with germination and requires good preparation of the soil but becomes more vigorous and persistent with time. This species can be too vigorous and the choice of the cultivar is extremely important. Short cultivars should be chosen for low rainfall areas and tall cultivars could be used to reduce the excessive vigour of the vine. The ‘Mediterranean’ Festuca arundinacea types, collected in North Africa and characterised by low growth habit, winter productivity and complete summer dormancy have limited potential in Italy due to their sensitivity to cold winters but could be interesting for warmer Mediterranean areas without winter frost. Two cultivars are available, ‘Maris Kasbah’ and ‘Maris Jebel’. Lolium multiflorum and L. rigidum can be too vigorous in late spring and because they need to set seed each year they have limited potential in Italy due to their sensitivity to cold winters but could be interesting for warmer Mediterranean areas without winter frost.

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Generally, while perennial legumes such as Medicago sativa or Hedysarum coronarium are competitive for water and do not tolerate frequent mowing, some of the annual legumes give better results.

Table 1. Some of the species tested for Mediterranean Italy

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Legumes</th>
<th>Fit</th>
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<tbody>
<tr>
<td>Bromus willdenowi</td>
<td>Medicago polymorpha</td>
<td>+</td>
</tr>
<tr>
<td>Dactylis glomerata</td>
<td>Medicago scutellata</td>
<td>-</td>
</tr>
<tr>
<td>Festuca arundinacea (cv)</td>
<td>Trifolium brachycladum</td>
<td>++</td>
</tr>
<tr>
<td>Lolium multiflorum</td>
<td>Trifolium repens</td>
<td>-</td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>Trifolium subterranean</td>
<td>+</td>
</tr>
<tr>
<td>Lolium rigidum</td>
<td>Trifolium yanninicum</td>
<td>-</td>
</tr>
</tbody>
</table>

+- depends on the climate soil interaction
+(cv) good but depends on the cultivar
- not suitable
++ highly suitable
All the annual medics start well with dense canopies in early spring which die off quickly allowing weeds to take over in the second year when most of the hard seeds of the medics do not germinate. This group of plants could probably fit better in a hot and dry Mediterranean climates with low rainfall and very short growing season that definitely do not allow perennials to survive (Fardini et al. 1995; Piemontese et al. 1995).

Trifolium brachycalycinum cultivar ‘Clare’ is probably the best for the clayey-heavy soils in medium hot and dry Mediterranean climates. It is more vigorous than the other species of subclovers and competes better against the weeds. Trifolium michelianum competes well by having a dense and tall growth that effectively controls weeds quite well. Trifolium repens is usually too short to compete with the weeds. Better results have been obtained with the giant ‘Lodigiano’ type. Some cultivars of Trifolium subterraneum are quite persistent—usually those whose genetic composition has not changed significantly because they have been recently collected in Italy. A good example is the cultivar ‘Denmark’. They can be a poor fit with the common heavy soils. Trifolium yanninicum has not given good results and may perform better in waterlogged soils for which vineyards or olive groves are not recommended.

Management of the cover
Reducing the number of management operations on the sward can reduce costs.

Technically the sward can be managed by sheep grazing. The period the animals can be kept in the vineyard without damaging the vines (up to budburst), is quite long and one mowing in late spring is often enough to control the weeds (Figure 1). Unfortunately our farms are all very specialised. Those who have vineyards do not have sheep and farmers are also reducing the number of livestock to meet the European Regulations concerning agriculture.

Small animals can graze for a longer period with one mowing being sufficient. Geese can be used for grazing and sold at the end of the growing season to provide an accessory income. Their management however requires care and, in reality, farmers prefer to mow two or three times from spring to summer rather than use livestock.

Mowing of the natural sward in which legumes are abundant can reduce management costs.

The highest biodiversity in a natural sward allows improved ecological conditions, which result in less disease, reduced need for pesticides and less sensitivity to seasonal and inter-annual fluctuation of climate.

Parasites will feed only on the vine if the soil is cultivated. They can feed also on a grass cover crop if it is available. If the sward is composed of many species it can also support different species of insects which usually compete among themselves which in turn can limit the possible growth of parasites on the vine. This happens when an area that is kept in good ecological condition, such as is experienced in Italy, has a diversity of integrated natural vegetation and agricultural activities.

In different conditions the introduction of a cover crop may allow an increased number of specialised parasites of the vine. This could occur with recently introduced crops where a native population of insects that can feed on those species does not exist. It can also happen if the territory has been excessively modified so that it is occupied by just a few species and human activities and agricultural land use have excessively modified ecological conditions.

Provided the sward is properly managed, the root systems of the weeds will not develop too deeply and competition can be limited. We can roughly consider that the development of the root system in a native sward, which is well managed and frequently mowed, is not significantly different from that of a sown annual clover sward. What definitely changes, of course, is the enhanced uptake of nitrogen from the natural sward compared to the nitrogen fixation of the clover. A s well the different growing rhythm of a natural sward interferes and competes more for moisture especially in summer.

Distribution of the root systems of the sward, differences in nutrient requirements and different growth rhythms are greatly responsible for the effects on the vine. The effects concern especially the root system and consequently, sensitivity to drought and, consequently, quality and quantity of the must.

Effects on the root system of the vine
We have compared the effects on the root system of the vine by traditional cultivation (harrowing); a cover crop of Trifolium brachycalycinum cultivar ‘Clare’; and the cover that spontaneously comes after harrowing is suspended. Swards were mown three times a year (Figures 2 and 3).

In our trials we have found that the depth of the roots was reduced to 45% and length was doubled when we compare harrowing to the native sward. Subterranean clover had an intermediate effect (Longhi, pers. com. 1999) on the depth and length of the root system.

The presence of the natural sward reduces the availability of water causing the deeper roots of the vine to die and the superficial roots are stimulated to grow longer. Subterranean clover has an intermediate effect because it has a shorter root system and a complementary growing time that competes less (Figure 4).
In the soils that we have been studied, the root system of the vine explores only half of the harrowed inter-row area. As this area is used by machinery we can consider it as wasted space which is not explored by roots because it can be cultivated, sprayed with herbicides, easily eroded and compacted by machinery. The presence of the sward will reduce the compaction of the soil. With the cover crops there is higher efficiency in the use of the soil, which is completely explored by the roots of the vines. In terms of ecology and sustainability of production this condition is preferable.

Effects on productivity and quality
Changes in the root system enhance sensitivity to drought and can cause a consistent reduction in productivity that can go as low as 39% of normal production. Fortunately the reduction in production is balanced by a higher quality of the must.

Long term sustainability, using the practices above, may require the immediate reduction in productivity. Consequently production in the first year after the cover is sown is always reduced. Productivity increases as the root system of the vine attains equilibrium with the new ecological condition of the soil. This normally happens by the third year.

From a trial conducted in Tuscany, in the first year with harrowing as the control, it was demonstrated that one quarter to almost one half of the production was lost (Figure 5). It can be expected with proper management of the sward that productivity in the fourth year will be around 85% with subterranean clover and 80% with a natural sward. If the sward is not mown the reduction in productivity can be stabilised on 60% which is too low.

It is necessary to be aware that in other trials (Intrieri, pers. com.) it has not been possible to get back to the original production level even if water and nutrients were applied ad libitum, this suggests the possibility of some allelopathic activity.

Fortunately the improvement in the quality of the must compensates for the reduced productivity.

This is especially important when wine consumers are able to make distinctions in terms of quality. Sensory analysis conducted in 1999 on the cultivar Sangiovese in Montalcino has shown that colour tonality and intensity and smell intensity are enhanced by the presence of a cover crop. The influence on the character however, is not very clear as it may depend more on cultivar and the parameters of the soil. It should also be noted that cover crops reduce the bitterness (Storchi communication, Ministry of Agriculture Politics 1999).

References

Figure 3. Different length of the vine roots if grown in cultivated soil (harrowed) or with a native sward (mown three times a year)

Figure 4. Different times of competition of natural sward and clover

Figure 5. Changes in grape production during the first three years after a cover crop is sown, compared to the cultivated soil (considered 100%)