COVER CROP TO IMPROVE VINEYARD ECOLOGY

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Abstract

Most of the Italian vineyards are planted in hilly areas, where yields are lower and quality higher than in the plains. Of course agronomic management of the slopes must be environmental friendly, above all concerning soil erosion that can be controlled by cover crops.

Effects of sown subterranean clover swards on soil erosion, vine productivity and wine quality has been studied in this research. Farm scale results have been extended to the vineyards of the whole Tuscany by a GIS application.

Subterranean clover cover crops remarkably reduced soil erosion and vine productivity and influenced positively wine quality. Yields partially increased again at the third year to levels admitted by regulations. It has been possible to attribute different soil erosion risk classes to the vineyards and to suggest different sowing techniques to each class.

Key words: subterranean clover, sowing techniques, soil erosion, must quality.

Introduction

About 40% Italian vineyards are planted in hills, this percentage goes up to 60% if we refer to Northern Italy only (Fregoni, 1998). The concentration of viticulture in hilly areas suggests the utility of cover crops to control erosion and to improve the soil carrying capacity of agricultural machines. Cover crops might be useful especially where harvesting is done in Autumn and machines have to pass on dump soil. These problems contribute to develop the interest about simple and cheap management that must be also environmental friendly (Poni, 1983; Intrieri e Lalatta, 1989; Rebucci, 1992).

Vine plantation and soil cultivation in clayey hills must be done down the slope to reduce water retention and consequently landslide risks, unfortunately these practices enhance soil erosion.

The quantity of eroded soil varies much according to climate, slope, soil type, vegetation cover and management. About 32 t ha^{-1} of soil losses have been recorded in cultivated slopes during the rainy season (De Simone et Al., 1995), this can be reduced to 25% by cover crops (Bonari et Al., 1996; Fregoni, 1998 l.c.). Drafting point distance from the soil suggests soil losses of about 1 cm per year in vineyards of Central Italy, equivalent to about 115 t ha^{-1} per year (Pardini, unpublished data).

The search of low impact management, the remarkable reduction of wine annual consumption per head in Europe, and the increasing preference for high quality and guaranteed foods, suggest to reduce productivity and to improve the existing good quality further. These changes favour cover crops diffusion in vineyards, as well as in olives and orchards.

However also negative effects have been reported, especially grape yield reduction. The level of reduction depends on sown species, sowing techniques, sward management (Skrijka et Al., 1988; Pisani et Al., 1984).

Research has pointed out the good soil cover and scarce competitivity of some annual self-reseeding legumes in Mediterranean climate, above all, *Trifolium brachycalycinum* and *T. subterraneum* (Campiglia e Caporali, 1996; Egger et Al., 1993; Masson, 1991; Masson e

Gintzburger, 2000; Piano, 1999; Piemontese et Al., 1995; Pardini et Al., 1997; Piemontese et Al., 1997; Santilocchi and Talamucci, 1999). Nevertheless these species have given cases of poor results (Grossi et Al., 2000). More competitive cover crop species can be suggested in the flat areas where higher yields than allowed by regulations are possible, such forage species are used in others Countries to reduce vine vigour (Elliott, 1998).
A trial has been carried out in Montepaldi (Florence, Central Italy) to compare subterranean clover sowing techniques aimed to soil erosion control, yield limitation and wine quality improvement.

Materials and methods

Compared treatments

The mixture *Trifolium subterraneum* "Woogenellup" + *T. brachycalycinum* "Clare" at 50% has been sown with 35 kg ha^{-1} of seed. Three different sowing modalities were compared with the native sward:

1. overseeding after grass mowing;
2. seeding after disk harrowing at 10 cm depth;
3. seeding after ripping at 30 cm followed by disk harrowing at 10 cm;
4. control cover by native species spread after soil cultivation.

The trial was designed on randomised blocks with 4 repetitions. Each treatment was repeated in two contiguous interrows, measurements on the vine were conduced in the row between. The trial interested a Sangiovese vineyard.
Cover crop fertilisation was done with 20 kg of N, 80 of P_20_5 and 40 of K_20 per hectare the first year, distributing 50% at seeding and the remaining at spring start of vegetation growth. Fertilisers doses were reduced at 0-80-40 the following years. The crop was mowed twice a year in spring.
Measurements carried out

1. Monthly temperatures and rainfall;
2. Evolution of soil cover and botanical composition (linear analysis at spring start of vegetation growth, at clover death and in full summer);
3. Soil erosion (dry weight of the soil found in collectors);
4. Grape production (vine-harvesting and weighing of all the bunches produced from ten vines in each repetition);
5. Vine root size (extraction of three whole plants per treatment at the end of the trial by a mechanical digger and following root cleaning by hand tools);
6. Wine quality (valuation carried out from an expert on the grape harvested at the final year and subjected to microvinification);
7. Erosion risk class (classification of Tuscany vineyards extrapolated by Corine Land Cover on the bases of parameters of rainfall erosivity (calculated by Arnoldus formula, 1980) and slope (DTM map).

Farm results of measurements 1 to 6 were compared to results of territorial analysis (7) to give agronomic recommendations for the different vineyards.

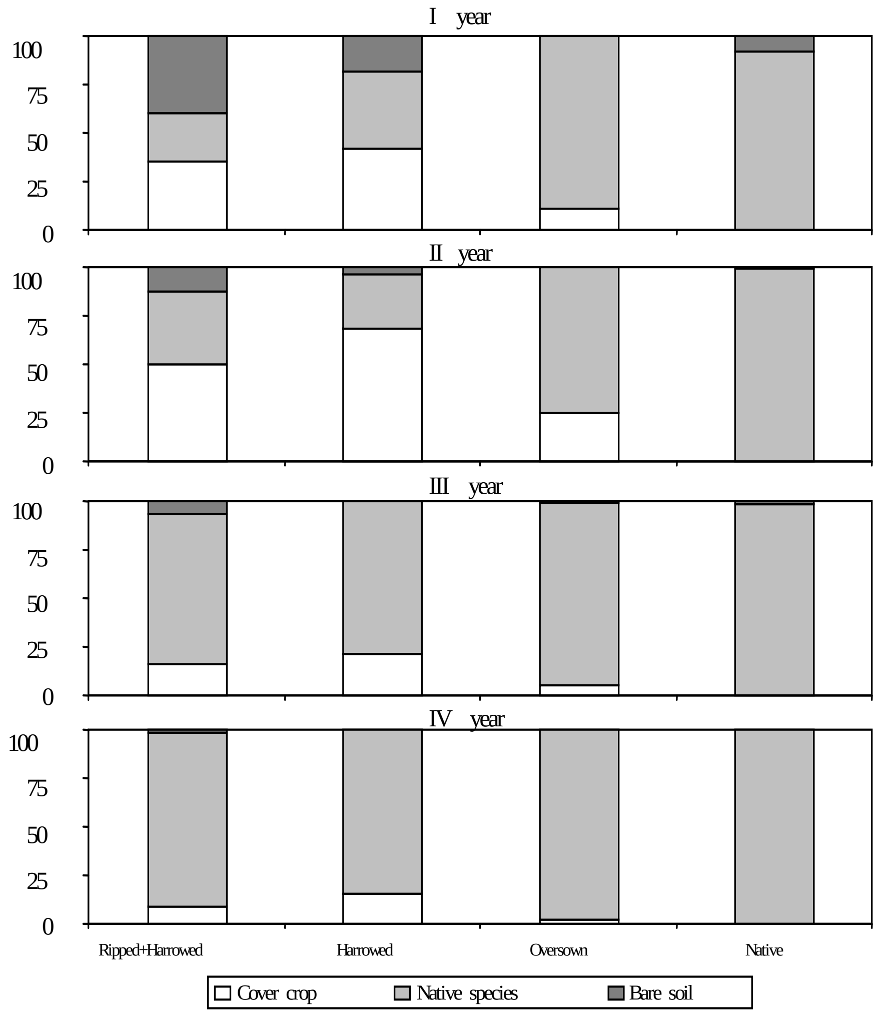
Results and discussion

Soil cover and botanical composition evolution

Cover crop establishment was affected by strong rainfall after seeding, negative effects were recorded especially in ripped + harrowed plots. Native species spread more in oversown and native swards.

Bare soil (figure 1) was found especially in ripped + harrowed and harrowed plots, this was reduced in native sward and completely absent in oversown interrows thanks to the addition of sown and native plants.
Seeded legumes spread and covered better in the second year thanks to good seed production, however native species increased their covering up to 77-98 % at the third year, and was never less than 85 % at the fourth year.
Overseeding gave only poor results and therefore a good management of the native sward is preferable rather than this technique. Ripping + harrowing resulted dangerous in the first year due to rainfall and it is not advisable in steep slopes. Harrowing gave the best results and it is suggested for most of the vineyards of the area.
Some native species widespread more than others, especially *Cynodon dactylon*, *Hordeum murinum*, *Avena fatua*, *Medicago arabica*, *Scorpiurus muricatus*, new cover crops might be selected from some of the legumes.

Figure 1 – Soil cover and botanical composition evolution

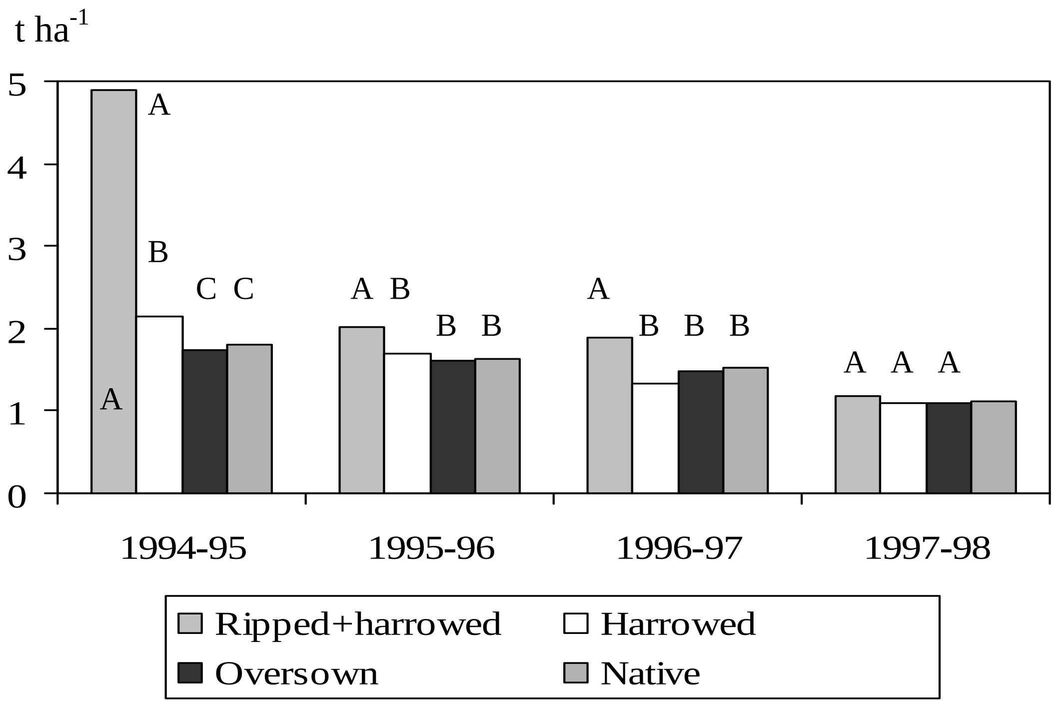


Soil eros

Soil erosion values (Figure 2) were the highest in ripped + harrowed plots, smaller after only harrowing, and minimal in oversown and native swards.
Ripping + harrowing exposed soil to erosion in the first year due to rainfall before the sward estblishment, losses were reduced by native species in the following years.
Oversown protected soil as well as native sward, however subterranean clover was replaced by native species from the second year.

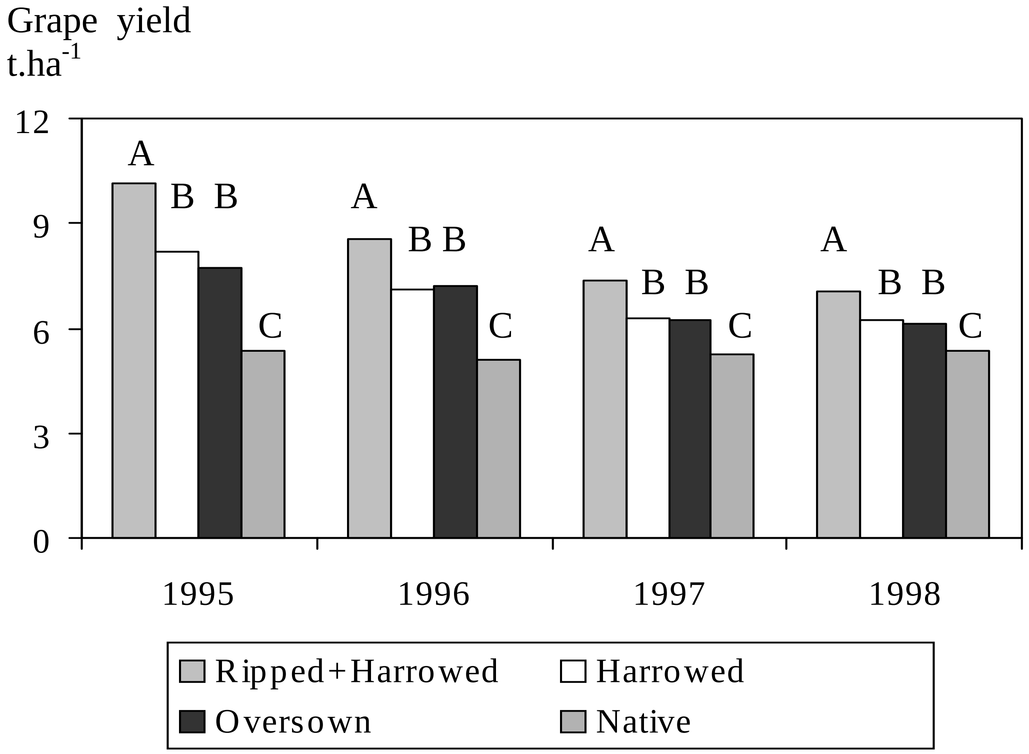
These results confirm that ripping + harrowing is not advisable in steep slopes. Harrowing had good results and is suggested in hilly areas. Overseeding do not persist enough and a well managed native sward is preferable to this technique.

Fig. 2: Soil erosion per collector (calculated in t ha^{-1}). Values not having a same letter are significatively different per P=0.05.



Grape production (figure 3)

Figure 3: Annual grape yield (t ha^{-1}). Values not having the same letter are significatively different at P = 0,01.

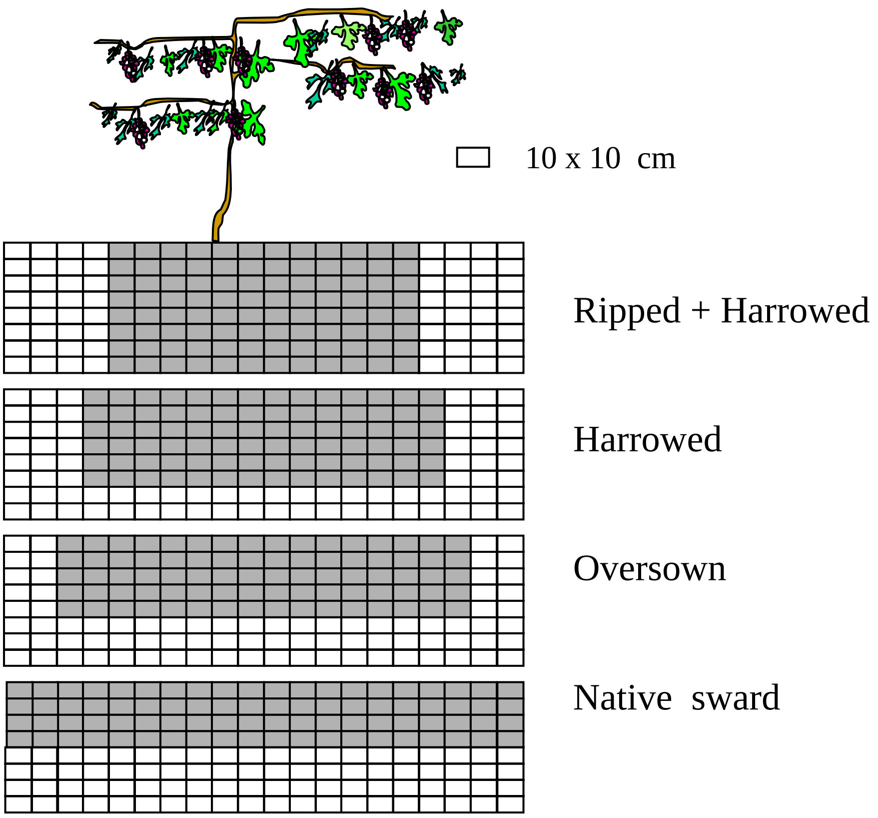


Grape production in the first year was lower in native sward than in seeded plots average (5.35 t ha^{-1}). The highest yields were got in ripped + harrowed plots (10.15) where competition by weeds was well reduced, harrowing score medium (8.19) and overseeding caused the lowest production (7.74).
Grape productions of the second year (1996) did not change considerably in harrowed and oversown plots in comparison to the first year.
Grape yield reduction was recorded in 1997 in all the plots, comprised those sown with subterranean clover, because this legume was definitely replaced by vigorous native perennials. Nevertheless, reductions have been limited, likely thanks to the vine root adaptation to the new ecological condition in the soil.

Vine root size

All the main roots were removed, however some of the thinner were probably lost due to sticky clayey soil and this should be taken into account when considering the results.
Root system depth decreased progressively but contemporarily increased in side extension (figure 4).

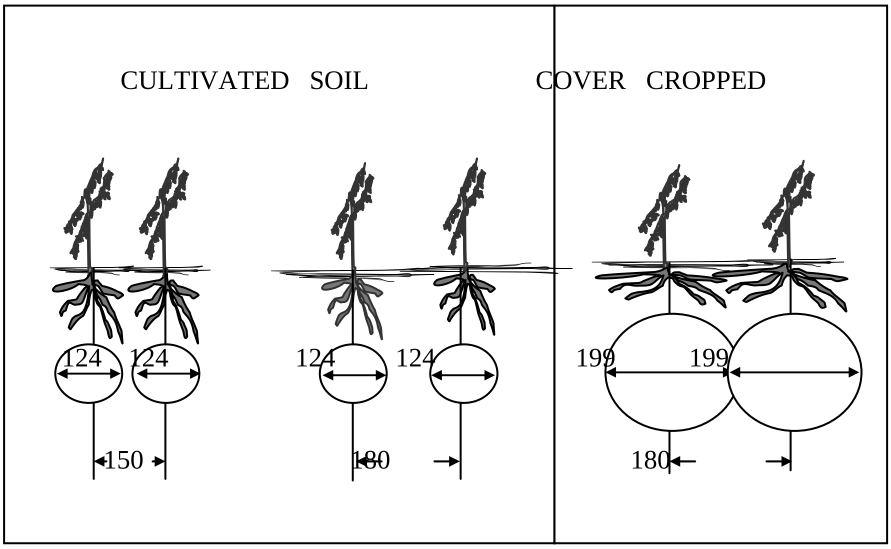
Figure 4: Size and distribution of the root system of the vine. Each square is 10 by 10 cm.



Ripped + harrowed plots left roots at the lowest depth (77 cm), in fact the sown clover has shallow roots and its little influence on water balance of the soil was not excessive. Furthermore, the poor success of the seeding left high percentage of bare soil and maintained competition very low initially.
The most competitive species diffused in native sward and comprised deep rooted perennials that probably limited water percolation. Water shortage into deep layers caused death of deep vine roots (vine roots were only 40 cm deep in plots with native sward), while the most superficial roots were stimulated to grow beside (199 cm, with 100% increase in comparison

to the average length in ripped + harrowed plots) and to increase water absorption in superficial layers. This hypothesis however can not be generalised, because water percolation depends on temperature and rainfall regimes, slope, soil texture, stone presence, percentage of soil covered by vegetation, botanical composition. Similar trials should be carried out to control our results also in different environmental conditions.
Both harrowing and overseeding treatments allowed intermediate vine root growth: respectively 56 cm depth per 137 width (former treatment) and 48 depth per 160 width (latter).
Root system in plots sown after ripping + harrowing reached 124 cm width (figure 5) that is almost the interrow size (150 cm). The same root system could explore only a part of the larger interrow necessary to a modern mechanisation. Native sward can cause vine roots to become almost 200 cm wide and to overlap with consequent - competition if weeds are not controlled by frequent mowings or soil cultivation at list under the rows. We conclude that vine root sizes reached in native or sown swards fit well to large interrows necessary for a modern mechanisation.

Figure 5: Vine roots width in cultivated soil or with cover cropping in comparison to interrow width (all measures in cm).



Wine quality

Evaluations by wine testing experts showed an increment in the parameters of tipicity and colour intensity and bitterness reduction in wine made from grape harvested in cover cropped plots in comparison with those harvested in tilled rows. Sowing techniques of the clover had not significantly different effects, probably because the swards present at the end of the trial had already very similar botanical compositions. Bitterness reduction is probably related to an increase of sugar content, that however was not measured. These results agrees with those found by Storchi in trials conducted on Sangiovese (1999, pers.com.).

Erosion risk class of vineyards

Almost 5% vineyards turned out in first class erosion risk (no risk), 13% resulted in second class (low), 38% in third class (medium), 28% in fourth class (high) and 15% in fifth class (very high).
The geographical distribution of the five classes of erosion risk is rather homogeneous: however first class vineyards resulted more common in south eastern Tuscany, second to fourth classes are more frequent in central Tuscany and fifth class is present especially in the

north western part. Vineyard distribution in erosion risk classes and on the territory is available as GIS file on CD (Longhi, 2001).
Erosion risk calculation was based on few parameters that should be integrated with soil texture and organic matter content, providing more accurate estimations. However utilised methodology can be used for further research.

Farm results transfer to the territory

The vineyards in high erosion risk class (classes 4 and 5) will better be kept with native sward. We suggest that legumes introduction to limit sward competition is done only by oversowing or harrowing (table 1), ripping should be avoided if soil conservation is the priority.
Vineyards in lower erosion risk classes (1 and 2) can be sown after ripping + harrowing or only harrowing, this should promote the establishment of the sown species and native weeds can be controlled.
Sowing technique choice for vineyards of intermediate erosion risk classes (2, 3, 4) is more flexible and the choice will depend on priority being given to soil protection or to grape yield.

Table 1: Sowing techniques suggested for vineyards of different erosion risk classes.

	Class 1 (no risk)	Class 2 (low)	Class 3 (medium)	Class 4 (high)	Class 5 (very high)
Ripping + harrowing	X	X			
Harrowing		X	X	X	
Overseeding		X	X	X	
Native				X	X

Conclusions

Subterranean clover cover cropping has proved useful for soil erosion control, however results were differentiated on the bases of sowing technique.
Ripping + harrowing increased erosion during first year autumn and should be applied in flat areas only. Harrowing without ripping gave better results because limits erosion risk at establishment and contemporarily allows good covering and persistence of the sown species.
Overseeding controlled soil erosion very well and suggest the use of this technique in very slope areas. Unfortunately overseeding did not give better results than native sward concerning botanical composition, weeds diffusion was excessively rapid and caused competition with the vine, moreover persistency of sown legume was reduced. These results suggests that the good management of native sward can be preferable to overseeding.
Short persistency of sown clover cultivars and rapid diffusion of weeds suggests the utility to search new cover crops among different native species and, possibly, to develop the market for diffusion of locally selected varieties.
Grape yields were reduced in all treatments, however less at the first year in ripped + harrowed plots were the sward arrived late. Yields reduction was interrupted at fourth year thanks to new vine roots distribution in the soil, however these results can not be generalised because influenced also by parameters of climate, soil and native species comprised in the seed bank.

Improved wine quality balanced yield reduction. No significant differences among treatments were recorded on sensorial analysis at the end of the trial, probably differences were present when botanical composition was still differentiated. However sensorial analysis must be controlled by chemical analysis comprising sugar content.
Cover crops diffusion in vineyards might have immediate and long term economic relevance. Immediate positive aspects are related to quality improvement of the final product and consequent increased incomes. Long term benefits comprise conservation of soil and its fertility and good ecological conditions of territory. Maintenance of agricultural land and land care development will also be positively influenced.
Farm scale results formed a bases for a GIS map of erosion risks that also suggests specific sowing technique per each class.
However the choice of species and cultivar also should be taken into account. Unfortunately this problem must take into account many parameters (climate, soil, grape cultivar, training, possible management) and might request the availability of a specific computer program.

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