Soil & Tillage Research 117 (2011) 140–147

Contents lists available at SciVerse ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Soil erosion assessment on tillage and alternative soil managements in a Sicilian vineyard

A. Novara [a,*], L. Gristina [a], S.S. Saladino [a], A. Santoro [a], A. Cerdà [b]

[a] Dipartimento dei Sistemi Agro-ambientali – Viale delle Scienze – 90128, Palermo, Italy

[b] Department de Geografia, Universitat de València, Blasco Ibáñez, 28, 46010 Valencia, Spain

ARTICLE INFO

Article history:
Received 10 June 2011
Received in revised form 23 September 2011
Accepted 25 September 2011
Available online 22 October 2011

Keywords:
Cover crops
Mediterranean
Soil erosion control
Vineyard
Sicily

ABSTRACT

Mediterranean crops favor high erosion rates. Vineyards use to reach the highest soil and water losses due to the lack of vegetation cover. A topographical approach by means of the use of vineyards poles as fixed reference point as erosion markers allowed to quantify high and non-sustainable soil erosion rates on the Sicilian vineyards during 9 years. In order to develop strategies to control the soil losses, seven land managements were selected and applied in a typical blanc wine grape irrigated vineyard located in southwestern Sicily. Comparable plots were managed traditionally using conventional tillage and alternatively using various cover crops: (1) *Vicia faba*; (2) *V. faba* and *Vicia sativa*; (3) *Trifolium subterraneum*, *Festuca rubra*, and *Lolium perenne*; (4) *T. subterraneum*, *F. rubra*, and *Festuca ovina*; (5) *Triticum durum*; and (6) *T. durum* and *V. sativa*. To estimate the soil losses the *C* factor of the USLE was calculated. And to monitor the water and sediment yield, Gerlach troughs were installed on the vineyard inter-row. Runoff and erosion were measured after each rainfall event from November 2005 to April 2007. Both runoff and erosion were significantly reduced when cover crops of *T. subterraneum*, *F. rubra*, and *L. perenne*; and *T. subterraneum*, *F. rubra*, and *F. ovina* were sown. The least effective management systems for soil erosion were conventional tillage and alternative management using the *V. faba* cover crop. Our results suggest that planting the appropriate cover crops provides an effective soil and water management system for Sicilian vineyards which will make sustainable the wine and grapes production under Mediterranean climate conditions.

1. Introduction

Soil erosion processes are highly active on agriculture land (Cerdà et al., 2007, 2009). Soil in Mediterranean-type ecosystems causes land degradation and triggers desertification (Oldeman, 1994; Shrestha et al., 2004; Cerdà et al., 2010). Mediterranean lands are particularly prone to soil erosion due to high rainfall intensity, the steep slopes, soil poor nutrient content and low organic matter. Moreover, the amount of organic matter is closely related to the formation of aggregates which are a key factor on soil erodibility (Cerdà, 1996; Le Bissonnais and Arrouays, 1997). Organic matter loss causes soil aggregates to break down easily and increases soil erodibility (Wu and Tiessen, 2002; Cantón et al., 2009). Soil erosion depends not only on soil characteristics, climate, and slope (Ruiz Sinoga and Martinez Murillo, 2009), but also on land use and cover plants (García-Ruiz, 2010). In the Mediterranean, in particular, vineyards on hilly areas have the highest measured soil losses compared to rainfed cereals, olives, eucalyptus plantation or scrubland (Kosmas et al., 1997). Such high erosion rates are primarily attributable to: (i) the bare soil under the vines for most of the year, especially during the rainy season; and (ii) the planting of vine rows along the fall line, which creates more favorable conditions for water runoff and sediment loss.

The range of soil erosion rates in vineyards is diverse due to the different land managements, climate conditions, parent material and soil properties, but generally the soil and water losses are usually high and always non-sustainable. De Santisteban et al. (2006) measured rates from 3.3 to 161.9 Mg ha^{-1} year^{-1}, depending primarily on the soil management systems. In vineyards, the most common soil management systems are tillage and chemical weeding with no tillage. Both systems result in bare soil during the whole year. Lasanta and Sobrón (1988) estimated that only 5% of the ground in an old vineyard is covered by cover plants during the rainy season and several studies under different environmental conditions have shown positive effects of vegetative cover for reducing water erosion (Cerdà, 1998). Cover crops increase infiltration of winter rain into the soil profile (Folorunso et al., 1992; Gulick et al., 1994). Vegetation also protects the soil surface from the impact of raindrops, reduces the energy of runoff, and stimulates the formation and stabilization of soil aggregates (Bouchet et al., 1999; Mataix-Solera et al., 2002; García-Orenes et al., 2005; Durán-Zuazo and Rodríguez-Plequezuelo, 2008).

* Corresponding author. Tel.: +39 3206983438.
E-mail address: agata.novara@unipa.it (A. Novara).

0167-1987/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.still.2011.09.007

Switching from conventional tillage to alternative cover crop management practices in autumn and winter reduce soil erosion and enhance the organic matter and microbiological function of soil (Quinton and Catt, 2004; Steenwerth and Belina, 2008; García-Orenes et al., 2009, 2010). In Sicily, experimental cover crop soil management suggests a benefit only during the fall and winter grape dormancy period, with cover crops being removed and buried no later than April to avoid such competition (Gristina et al., 2006).

To monitor and predict the extent of soil degradation and to improve soil management and soil conservation planning is essential the quantification of sediment yield (Boardman and Poesen, 2006; Gristina et al., 2005). Soil erosion assessment by means of experimental plots use to measure the soil losses during short periods of time. This is fundamental to understand soil erosion processes and their spatial and temporal variability. Under Mediterranean climatic conditions, where the erosion processes are controlled by the high magnitude – low frequency rainfall events the measurements on experimental plots use to do not show the long term soil losses. To measure the soil losses during a long period of time contribute to a better understanding of the soil erosion processes and is complementary to the measurements done in plots. In the present study, we propose the use of simple poles as fixed reference points against which soil loss is readily monitored and erosion rates in a longer period are easily determined simply by measuring the over-ground height of the poles. Using the plot method, we compare the effects of various cover crops and conventional tillage on soil erosion rates in vineyards. The purposes of this paper are: (i) to assess erosion rates during a 9-year period using vineyard poles as markers and (ii) to evaluate the role of conservative and alternative soil management in vineyards to control erosion risk testing the effectiveness of different cover crops. The comparison of the longer period and two-year data will shed light on the significance of these measurements.

2. Materials and methods

2.1. Study area

The research was conducted in irrigated vineyards located in Sambuca di Sicilia, in southwestern Sicily (37°39′17″N and 13°00′53″E). The vineyards selected for the study lie between 350 and 373 m.a.s.l.; the plot is located in an ENE facing slope. The climate in the area is typical Mediterranean with dry, hot summers and moist winters. Precipitation data from Sciacca weather station located 6 km from the site were used. Mean annual rainfall is 648 mm and means annual temperature is 17.4 °C with the mean monthly maximum in August (26.2 °C) and minimum in January (9.7 °C). Fig. 1 shows the mean temperature and rainfall for the period of runoff observation. From the implantation of the vines to 2010 the mean rainfall was 589 ± 175 mm. Soil was classified as Vertic Haploxerept according to Soil Taxonomy (Soil Survey Staff, 2006) with 58.3 ± 2.5% sand, 11 ± 1.47% silt, and 30.7 ± 2.32% clay (pipette method; Day, 1965) in the top soil (0–20 cm). The average organic carbon content was determined following the Walkley and Black (1934) method, is 7.81 g kg^{-1}.

2.2. Experimental design

The research was carried out in a 9-year-old vineyard of the Sauvignon blanc variety on a wet regime with a density of 5000 plants ha^{-1} and a row width of 2.2 m. The randomized block design with three replications is represented in Fig. 2 (first replication). Each cover crop was seeded on 3 inter-rows (2.2 m × 3 m = 6.6 m) for a total of 21 inter-rows (3 inter-rows × 7 7 treatments = 21 inter-rows) by replication. Cover crops were also seeded in the experimental site one year before the study period. Cover crops were chosen following certain criterions: plant adaptability, seed price and availability, speed emergence and soil cover. Soil and plant samples were collected in the middle inter-row. Rows were 140 m long with a slope of 15.9%. The inter-rows were managed with conventional tillage (CT) and alternative tillage using cover crops: (1) *Vicia faba* (VF); (2) *V. faba* and *Vicia sativa* (VV); (3) *Trifolium subterraneum*, *Festuca rubra*, and *Lolium perenne* (TFL); (4) *T. subterraneum*, *F. rubra*, and *Festuca ovina* (TFF); (5) *Triticum durum* (T); and (6) *T. durum* and *V. sativa* (TV). For CT, 3–4 ploughings per year, 0.15 m deep, were started after the first rain in September or October to bury weeds and aerate the topsoil. TFL and TFF were permanent meadows with a vegetative stasis during the summer period. Cover crops were seeded in October using special sod seeding equipment (1.60 m wide) and biomass was buried during the month

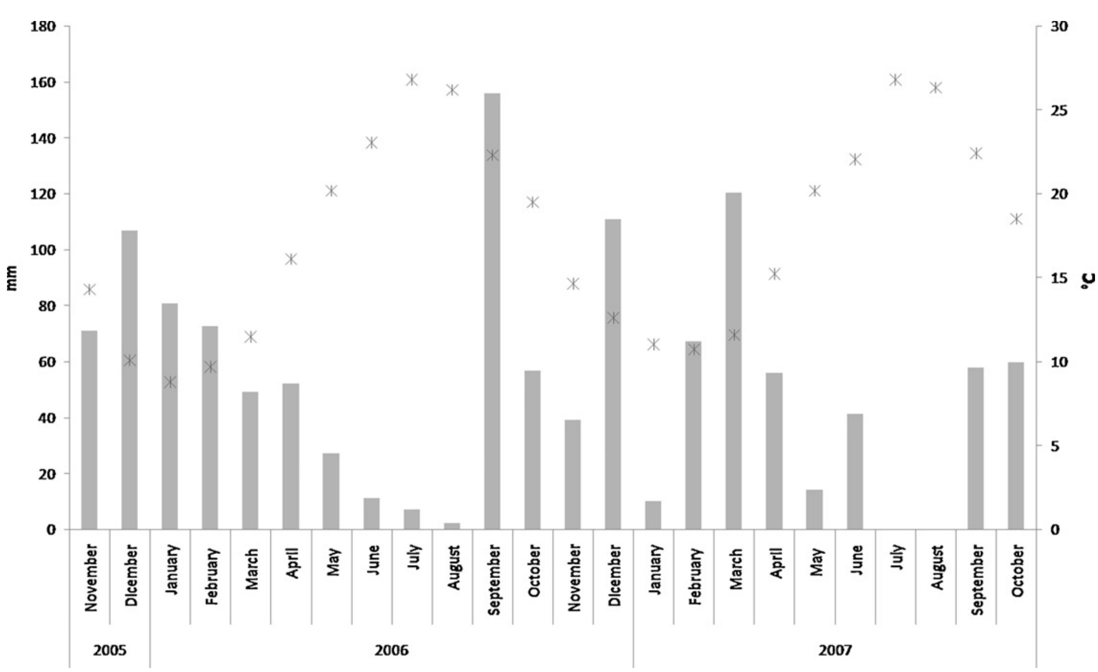

Fig. 1. Montlhy rainfall and mean temperature from November 2005 to October 2007.