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Agriculture, Ecosystems and Environment 113 (2006) 356–363
Agriculture Ecosystems & Environment
www.elsevier.com/locate/agee

Nutrient losses by runoff in vineyards of the Mediterranean Alt Penedès region (NE Spain)

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Received 16 March 2005; received in revised form 6 October 2005; accepted 25 October 2005
Available online 24 January 2006

Abstract

This paper deals with nutrient (N and P) losses by runoff in vineyards of the Penedès area (north-eastern Spain), and their relationship with rainfall erosivity. The study was carried out in a commercial vineyard, which was levelled previous to vineyard establishment in order to adapt fields to mechanised labours, leaving on top of the surface soils very low in organic matter content and very susceptible to erosion. After levelling, large inputs of organic wastes before and/or after planting were incorporated in order to improve soil properties. The analysis was done under natural rainfall during the period 2000–2001, in which 17 rainfall events were recorded. Runoff ratios varied from 2.9 to 28.6%, except for two extreme events in which by up to 55.8 and 80% of rainfall ran off, respectively. Sediment concentration in runoff was very variable ranging between 2.9 and 25.3 g L^{-1} depending on the rainfall erosivity, which also affected nutrient losses. Erosion processes exported significant amounts of nutrients, which represent about 8 kg ha^{-1} $year^{-1}$ of N and 6.5 kg ha^{-1} $year^{-1}$ of P, without taking into account losses in the extreme events. The results point out that most soil and nutrient losses are due to a small number of events recorded every year, which can contribute to more than 60% annual soil and nutrient losses.

Keywords: Nitrogen; Phosphorus; Soil losses; Vineyards; Runoff; Rainfall erosivity; Rainfall kinetic energy; Mediterranean climate

1. Introduction

The frequent high-intensity rainfall events characteristics of the Mediterranean climate (López-Bermúdez and Romero-Díaz, 1993; Martínez-Casasnovas et al., 2002; Ramos, 2002) affect the vulnerability of the Mediterranean region to erosion. In addition, erosion processes in this area are being accelerated by new land management practices applied in intensive agriculture. Social and economical constrains are forcing to mechanise most of the agricultural works, which very often has enabled significant alterations of the terrain slopes to adapt fields to mechanised labours. Vineyards are among the land uses that incur the highest soil losses (Tropeano, 1983; Wicherek, 1991; Wainwright, 1996), which increase after mechanisation due to the low water infiltration capacity of the resulting soils. The Alt Penedès vineyard region (north-eastern Spain), in which more than 80% of the cultivated area is occupied by vineyards, is an example of this situation. During the last decades, vineyard surface has increased significantly and about 50% of the old vineyards have been mechanised and adapted to the new systems. Most of the traditional soil conservation measures (planting following contour lines and in bench terraces) are then eliminated and the soil surface levelled, affecting their chemical and physical properties. The resulting soils have very low organic matter content and very weak structure. In most cases, vineyards are maintained bare soil during most of the year in order to avoid competition for water by weeds.

The most limiting factor of water intake into the soils is their high susceptibility to sealing (Ramos et al., 2000), which gets worse with land transformation. Soil losses by runoff have been evaluated at plot (Usón, 1998) and field scale (Ramos and Porta, 1997) reaching values of 22 Mg ha^{-1} during autumn, period in which rainfall are

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0167-8809/$ – see front matter
doi:10.1016/j.agee.2005.10.009

usually of high intensity. In extreme events, soil losses up to 217 Mg ha^{-1} have been recorded in the area (Martínez-Casasnovas et al., 2002). Some evaluations about the influence of these land transformations show the increase of erosion rates in land levelled versus the original soils (Nacci et al., 2002).

Nutrient movement from agricultural lands has been extensively studied during the last decades (Sims et al., 1998). Most of the studies have been focused on N and particularly on P associated with water quality, since already low P concentrations have dramatic effects on algae and aquatic microorganisms development. Portielje and Van der Molen (1999) point out that total P concentrations in water of 0.03–0.1 mg L^{-1} are the concentrations associated with the critical values (9–25 μg L^{-1}) to produce eutrophication.

García Rodeja and Gil-Sotres (1997) indicate that nutrient losses by runoff depend on different factors: topography, land use, soil properties and weather conditions, particularly rainfall intensity and duration, and in some cases it is also influenced by the depth of rainfall. In order to contribute to this knowledge, the aim of this paper is the analysis of nutrients (N and P) mobilised by runoff in rainfall events of different erosive potential, quantified by their intensity and kinetic energy. The research is carried out in a mechanised vineyard plot that was levelled and planted 12 years ago.

2. Materials and methods

2.1. Study area

The study area is located in the Alt Penedès region (north-eastern Spain), between the Anoia and Llobregat rivers (41°24′45″N, 1°48′22.69″E), where vineyards represent the main land use. The area has a Mediterranean climate with an annual average temperature of about 15 °C and an annual rainfall of about 550 mm, very irregularly distributed throughout the year.

2.2. Plot characteristics, sampling and analysis

The study was carried out in a 12-year-old vineyard, in which land levelling works were done before establishing the plantation (Fig. 1). Most soil profiles have been truncated and underlying horizons and parent materials are now at the surface. The plantation consists of trained vines, at 1.3 m × 3.1 m pattern, which run along the contour (perpendicular to the maximum slope degree direction). Every eight rows there is a hillside ditch or broadbase terrace (locally named ‘‘rasa’’). Their function is to intercept surface runoff and convey it out of the field. The slope of the plots is about 9%. Maintaining a bare soil is achieved in this vineyard by frequent tillage between the rows.

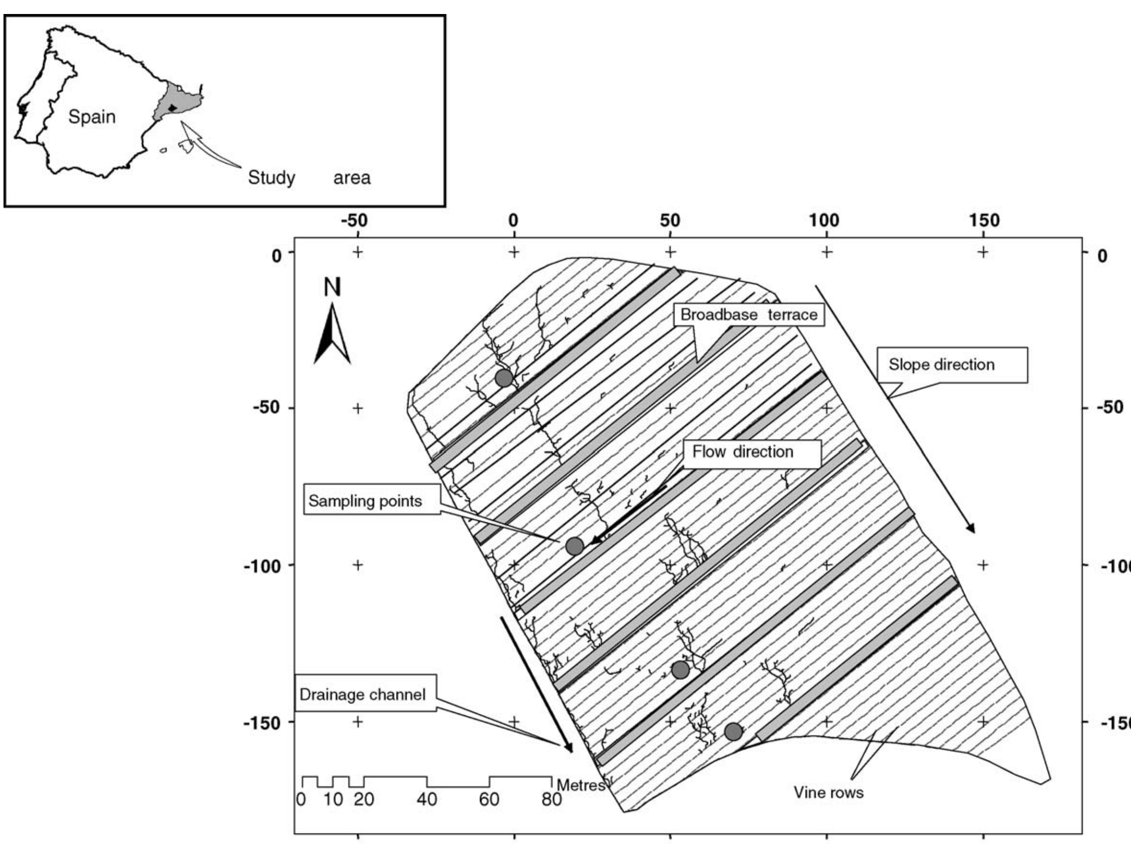

Fig. 1. Location of the study area and sampling points.