Agricultural Water Management 191 (2017) 67–76

Contents lists available at ScienceDirect

Agricultural Water Management

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

Effects of compost amendment on the available soil water and grape yield in vineyards planted after land levelling

M.C. Ramos

Department of Environment and Soil Science-Agrotecnio, University of Lleida, Alcalde Rovira Roure 191, E25198-Lleida, Spain

ARTICLE INFO

Article history:
Received 20 January 2017
Received in revised form 24 May 2017
Accepted 30 May 2017

Keywords:
Levelled soils
Rainfall distribution
Soil hydrological properties
Vines
Water availability

ABSTRACT

The aim of this research was to compare the effect of compost amendment on soil water and on the available water for vines planted in levelled soils in comparison to those planted in undisturbed soils. Two vineyards, one levelled before vineyard establishment and one planted in the original soil, were compared. In each of them, the effect of compost application on the surface was compared with a control (without compost application). Soil characteristics such as soil texture, organic matter content, hydraulic conductivity and soil sealing were evaluated in each area. In addition, soil water was monitored at different soil depths in each treatment. Available soil water was evaluated along the growing cycle in two years with different rainfall distributions. Soil hydrological properties improved with compost amendment, in particular soil water holding capacity at different pressures. Soil water distribution within the soil profile and available water varied between the years depending on rainfall characteristics. For a given year, it varied significantly between levelled and unlevelled plots and between treated and untreated areas. In dry years, the available soil water reached very low values within the growing cycle, being lower in the levelled plot and higher in compost-amended areas in both plots. Compost amendment increased yield to a lesser proportion in the levelled soils but more in the dry than in the wet years. The results indicate the need to use different management strategies within the plots to optimize the use of water due to the differences in the final soil characteristics after land levelling operations.

1. Introduction

The intensification of agriculture has been accompanied by the mechanization of most of the work carried out in the fields. This, in many cases, has required levelling operations to prepare the fields to facilitate the circulation of machinery within the fields and most of the traditional soil and water conservation measures have been eliminated. Land levelling operations generate changes in soil properties (Aquino et al., 2015) and greatly disturb soil profiles, in some cases leaving deeper horizons on top of the surface, which usually have poorer soil properties (Brye et al., 2005; Brye et al., 2006; Capolongo and Pennetta, 2008; Sharifi et al., 2014; Aquino et al., 2015). In particular most hydrological properties that control water infiltration and water retention capacity are negatively affected (Misopolinos and Zalidis, 2002; Ramos and Martínez-Casasnovas, 2010), associated to changes in soil texture and porosity. In most cases, levelling operations favour sealing (Ramos et al., 2000), reducing infiltration and as a consequence the amount of water accumulated in the soil profile. This is particularly important in areas where high intensity rainfall events are recorded. In these cases, a significant amount of water is lost through runoff (Ramos and Martínez-Casasnovas, 2009).This is the case of the Mediterranean area, in which crops like vines, olive trees or almonds, which are usually cultivated with bare soil during almost the entire year, are among the land uses that suffer the highest runoff and erosion rates (García-Ruiz, 2010). These land uses are among those that have undergone the biggest transformations during the last decades, and in which the effects of greater sealing and crust formation produced under land levelling even increase such water losses. In addition under the future scenario of climatic change, in which more intense events are expected, the negative effect may be even higher.

In some cases, farmers, aware of poor soil properties, try to improve soil conditions by adding organic residuals, which on the other hand act as organic fertilization. Soil organic matter content, as well as other properties such as aggregate stability, porosity, infiltration and soil water-holding capacity, improved

E-mail address: cramos@macs.udl.es

http://dx.doi.org/10.1016/j.agwat.2017.05.013
0378-3774/

after application (Aggelides and Londra, 2000; Ingelmo et al., 2003; Weindorf et al., 2006; Fares et al., 2008; Morlat and Chaussod, 2008; Rasoulzadeh and Yaghoubi, 2010; Zare et al., 2010; Logsdon and Malone, 2014; Brown and Cotton, 2011; Jha et al., 2015; Dougherty and Chan, 2014; Yazdanpanah et al., 2016) and reduced runoff and soil losses (Bean and Dukes, 2015; Sadeghi et al., 2015). However, the effects in the long term may be only observed under high application doses, and repeated applications should be performed in order to maintain soil property improvement. In this respect, Aranyos et al. (2016) in an experiment using different compost doses between 9 and 27 Mg·ha^{-1} of dry matter every three years, only found variations in some years, in the plots treated with the highest doses.

The effect of compost amendment on vine health and grape quality parameters has also been analysed (Pinamonti, 1998; Chan and Fahey, 2011; Schmidt et al., 2014). Pinamonti (1998) found some beneficial effects by reducing chemical weed control and allowing the substitution of chemical fertilizers with no loss in the vigour, yield or quality of musts. Schmidt et al. (2014) concluded, however, that those treatments induced only small and mostly non-significant effects in poor fertility, alkaline, temperate soil. In addition, Chan and Fahey (2011) indicated that the application of mulch to grape vines may increase K supply and an increase in berry K and pH.

However, some potential risk has been associated to compost application in vineyards. In this respect, Korboulewsky et al. (2002) indicated the risk of increasing phosphorus in the soil when sewage sludge compost was applied, which may reach concentrations that will pose a risk to surface waters and ground water. Morlat and Chaussod, (2008) indicated that, under high rates of organic amendments in vines, mineralized N exceeded the vine requirements implying a risk of N leaching.

An example of these land uses and types of management is the viticultural area located in the Anoia-Penedès region, NE Spain. This area has been dedicated to vine cultivation for centuries, and it has experienced major transformations since the 1990s, with land levelling operations to establish new plantations adapted to the mechanization of almost of labour. Soil properties have been altered creating variability within the plots (Ramos and Martinez-Casasnovas, 2006). The effects of land levelling on soil water and yield has already confirmed with differences in yield of about 28% between levelled and unlevelled plots (Ramos and Martínez-Casasnovas, 2010). However, the variability in yield between years could be up to 50% depending on climatic conditions (Ramos and Martínez-Casasnovas, 2010, 2014).

Under the scenario of climate change, in which higher variability on climate and more extreme conditions may be recorded, the need of adopting strategies for water conservation and efficient use seems necessary. In this context, this research tries to analyse the effect of compost amendment on soil water and its further repercussion. The aim of this paper was to analyse the improvement that some amendments may bring about on soil water content and on the available water for the vines in an area with a Mediterranean climate and in which vines are cultivated under rainfed conditions. Soils treated with compost in both levelled and unlevelled situations were compared, and the available water in each situation was evaluated under different rainfall regimes.

2. Material and methods

2.1. Study area

The study area is located in the Catalan Prelitoral Depression (NE Spain), about 35 km west of Barcelona (lat: 41.48°, long: 1.81°, elev.a.s.l.: 320m). The most representative soils in the study area are *Typic Xerorthents* and *Typic Calcixerepts*. Most plots have been heavily transformed by land levelling to facilitate agricultural activity. Two vineyard plots were considered in this research. In one plot, important land levelling operations were carried out before vineyard stablishing, cutting more than 3 m of soil in the upper part of the slope and filling the areas downslope. Despite having preserved some soil from the upper layer and added to the surface after levelling, significant changes were produced in soil properties. The results shown in this research make reference to the upper part of the slope where cutting operations were done. The other plot maintained the original soil profile. The average slope of the plots was about 9 and 6%, respectively in the levelled and unlevelled plot. The plantation consists of trained vines, with a 1.3 m × 3.1 m pattern. The vine rows are perpendicular to the maximum slope gradient.

2.2. Control parameters and evaluations

The two vineyards selected within the same area were planted with *Vitis vinifera* L. Chardonnay. Composted manure was applied to the fields at a rate of 40 Mg·ha^{-1} in alternate rows and incorporated in the upper 25 cm of soil. Compost was applied the year prior to years 1 and 2, and 2 years before year 3 included in this study. The characteristics of the applied compost are shown in Table 1. Within each plot, soil properties including soil particle distribution (Gee and Bauder, 1986) organic matter content (Allison, 1965) and water content at saturation, and −33 kPa and −1500 kPa soil matric potentials, using Richard plates, were evaluated in both treated and untreated areas. In addition, infiltration rates were evaluated in each vineyard plot and treatment using rainfall simulation in small plots of 0.30 × 0.20 m delimited in the field. Rainfall composed of 2.5 mm diameter drops of deionized water falling freely from droppers 2.5 m above the soil surface was simulated until reaching contact runoff (about for 40 min) with an intensity of 60–80 mm h^{-1}. This intensity is usually recorded every year in summer and autumn rainstorms, which are the events that produce the highest erosion losses. Runoff samples were collected every 10 min. Infiltration rates were estimated from the difference between water applied and runoff. The probe was maintained until reaching constant runoff rates (Ramos et al., 2000). With this information the steady infiltration rate was calculated. Three replications were carried out at each location.

The research included in this work refers to three years with different rainfall characteristics. Rainfall characteristics during the study period were evaluated with data recorded in the same fields using a tipping bucket pluviometer connected to a data-logger, which recorded information every minute. The minimum amount

Table 1
Characteristics of the composted cattle manure applied in the study (mean and standard deviation).

Parameter	Concentration (referred to dry weight)	Parameter	Concentration (referred to dry weight)
Moisture content (%)	49 ± 3	Organic N (mg g^{-1})	12.2 ± 0.8
Organic matter (g kg^{-1})	630 ± 40	N-NH_4 (mg g^{-1})	2.2 ± 0.5
EC (1:5)$_{25\,°C}$ (dS m^{-1})	16.3 ± 0.6	N-NO_3 (mg g^{-1})	1.5 ± 0.2
P (g kg^{-1})	10.9 ± 0.2	C/N ratio	12.5