



Effects of soil management techniques on soil water erosion in apricot orchards



Saskia Keesstra^{a,*}, Paulo Pereira^{b,c}, Agata Novara^d, Eric C. Brevik^e, Cesar Azorin-Molina^f, Luis Parras-Alcántara^g, Antonio Jordán^h, Artemi Cerdàⁱ

^a Soil Physics and Land Management Group, Wageningen University, Droevendaalsesteeg 4, 6708PB Wageningen, The Netherlands

^b Environment Management Laboratory, Mykolas Romeris University, Ateities g. 20, LT-08303, Vilnius, Lithuania

^c Department of Forestry, Michigan State University, East Lansing, MI 48825, USA

^d Dipartimento dei Sistemi Agro-ambientali, University of Palermo, viale delle scienze, Italy

^e Department of Natural Sciences, Dickinson State University, Dickinson, ND, USA

^f Instituto Pirenaico de Ecología, Consejo Superior de Investigaciones Científicas (IPE-CSIC), Departamento de Procesos Geoambientales y Cambio Global, Zaragoza, Spain

^g Department of Agricultural Chemistry and Soil Science, Faculty of Science, Agrifood Campus of International Excellence - ceiA3, University of Cordoba, Cordoba, Spain

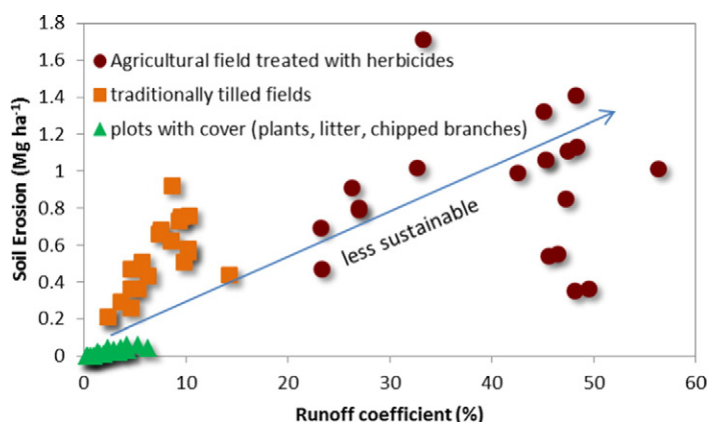
^h MED_Soil Research Group, Dep. of Crystallography, Mineralogy and Agricultural Chemistry, University of Seville, Spain

ⁱ Soil Erosion and Degradation Research Group, Department of Geography, University of Valencia, Valencia, Spain

HIGHLIGHTS

- Prevailing management (tillage and herbicide treatment) keeps soil bare and prone to erosion
- Assessment of runoff and erosion for three management types (tillage, herbicide and covered)
- Herbicide treatment causes 1.8 and 45.5 times more erosion than tillage and covered respectively
- 60 rainfall simulation experiments showed tenfold lower erosion rates with covered soil
- Soil erosion was extremely high in herbicide treated orchards, even higher than in tilled orchards

GRAPHICAL ABSTRACT



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ABSTRACT

Soil erosion is extreme in Mediterranean orchards due to management impact, high rainfall intensities, steep slopes and erodible parent material. Vall d'Albaida is a traditional fruit production area which, due to the Mediterranean climate and marly soils, produces sweet fruits. However, these highly productive soils are left bare under the prevailing land management and marly soils are vulnerable to soil water erosion when left bare. In this paper we study the impact of different agricultural land management strategies on soil properties (bulk density, soil organic matter, soil moisture), soil water erosion and runoff, by means of simulated rainfall experiments and soil analyses. Three representative land managements (tillage/herbicide/covered with vegetation) were selected, where 20 paired plots (60 plots) were established to determine soil losses and runoff. The simulated rainfall was carried out at 55 mm h^{-1} in the summer of 2013 (<8% soil moisture) for one hour on 0.25 m^2 circular plots. The results showed that vegetation cover, soil moisture and organic matter were significantly higher in covered plots than in tilled and herbicide treated plots. However, runoff coefficient, total runoff,

* Corresponding author.

E-mail addresses: saskia.keesstra@wur.nl (S. Keesstra), paulo@mruni.eu (P. Pereira), agatanovara@unipa.it (A. Novara), eric.brevik@dickinsonstate.edu (E.C. Brevik), cazorin@ipe.csic.es (C. Azorin-Molina), qe1paal@uco.es (L. Parras-Alcántara), ajordan@us.es (A. Jordán), artemio.cerda@uv.es (A. Cerdà).

sediment yield and soil erosion were significantly higher in herbicide treated plots compared to the others. Runoff sediment concentration was significantly higher in tilled plots. The lowest values were identified in covered plots. Overall, tillage, but especially herbicide treatment, decreased vegetation cover, soil moisture, soil organic matter, and increased bulk density, runoff coefficient, total runoff, sediment yield and soil erosion. Soil erosion was extremely high in herbicide plots with $0.91 \text{ Mg ha}^{-1} \text{ h}^{-1}$ of soil lost; in the tilled fields erosion rates were lower with $0.51 \text{ Mg ha}^{-1} \text{ h}^{-1}$. Covered soil showed an erosion rate of $0.02 \text{ Mg ha}^{-1} \text{ h}^{-1}$. These results showed that agricultural management influenced water and sediment dynamics and that tillage and herbicide treatment should be avoided.

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1. Introduction

Acceleration of soil erosion rates is the main cause of land degradation and, as a consequence, leads to loss of soil fertility and decrease in agricultural production and farmers income, which results in unsustainable agriculture (Colazo and Buschiazzi, 2015; Novara et al., 2015; Yan and Cai, 2015). Acceleration of soil erosion rates is the result of increased runoff on soil surfaces that are vulnerable to soil detachment (Van Oost et al., 2009). If a soil has characteristics (Stanchi et al., 2015) that prohibit infiltration of water (e.g. crusting, slacking, lack of macro pores) the runoff coefficient will be higher (Liu et al., 2014). However, if the soil has a rough surface (Gao et al., 2015), runoff will be delayed by ponding water, allowing water to infiltrate and reducing the soil erosion on such sites. But in the case where the soil is covered by vegetation infiltration rates are generally higher as a result of better soil structure, and the soil is protected against sediment detachment, which reduces the vulnerability to soil erosion (Seutloali and Beckedahl, 2015).

Agriculture is the main cause of soil losses and runoff (Cerdà et al., 2009a, 2009b; Novara et al., 2011; Laudicina et al., 2015) and orchards under rainfed agriculture have some of the highest soil erosion losses due to the lack of land levelling, terraces, intense tillage, compaction due to heavy machinery and herbicide application (Bisantino et al., 2015; Prosdocimi et al., 2016). Tillage has been part of the Mediterranean agricultural practices for millennia. Farmers have used this as a tool to avoid the competition for water with the crops, to enhance the infiltration by creating a rough and permeable surface. In addition the tillage breaks the capillary routes for the water to evaporate after a rain event. In Vall d'Albaida the tradition of an intense ploughing was used also to produce "dust" that protect the plant against insects

(farmers personal communication). Because of the long tradition of Mediterranean farmers to keep their fields clean of weeds, farmers continue to do this, even when from a sustainability or productivity point of view this is no longer necessary and this is now a key point in the education for a better soil management (Keesstra et al., 2016a, 2016b). In Vall d'Albaida the ploughing use to take place 3 to 4 times per year, but many farmers over-tillage because this tradition of produce "dust" and avoid any weed. In Fig. 1B can be seen how farmers plough already bare orchards.

High erosion rates have been observed in avocado (Atucha et al., 2013) and olive orchards (Gómez et al., 2003; Vanwallegem et al., 2010), new citrus plantations (Cerdà et al., 2009b; Li et al., 2015) and vineyards (Novara et al., 2013; Tarolli et al., 2015). Almond (Faulkner, 1995), persimmon (Cerdà et al., 2015), and apricot (Abrisqueta et al., 2007) orchards have also shown high erosion rates, but little research has been carried out comparing agriculture land management in fruit orchards. Also no research has been reported in other orchards such as apples, cherries or pears even though the worldwide land area devoted to fruit production is growing due to demand for fresh fruits and juices (Jackson et al., 2011). Until recently, most of the research in soil erosion has been done in areas occupied by cereals. These annual crops show high erosion rates due to intense tillage and a lack of vegetative cover (Cerdà et al., 2009a, 2009b; Stevens et al., 2009; Rodríguez-Blanco et al., 2013; Ligonja and Shrestha, 2015). High erosion rates result in the loss of soil, and with that the loss of services soils provide for society (Brevik, 2009; Keesstra et al., 2012; Berendse et al., 2015; Brevik et al., 2015; van Leeuwen et al., 2015).

Apricot (*Prunus armeniaca*) production in Spain was 119,400 Mg in 2013, which is 3% of the total world production (FAO, 2015). In Spain, 25 to 50% of the total apricot production is exported to European

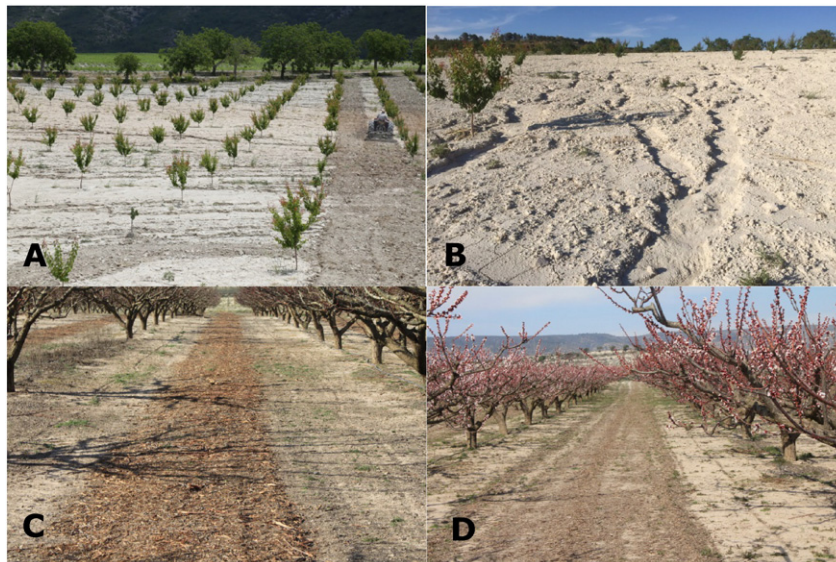


Fig. 1. Views of apricot orchards in the province of Valencia. Pictures A and B show evidence of high erosion rates after a thunderstorm that dropped 40 mm of rain in 30 min on 2-year old apricot orchards. Pictures C and D show chipped branches spread over the soil between the trees in mature apricot orchards in winter.

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