Catena 157 (2017) 58–66

Contents lists available at ScienceDirect

Catena

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

Spatial and temporal variability of spontaneous grass cover and its influence on sediment losses in an extensive olive orchard catchment

Encarnación V. Taguas[a,*], Karl Vanderlinden[b], Aura Pedrera-Parrilla[b], Juan V. Giráldez[a], José A. Gómez[c]

[a] School of Agronomy and Forestry Engineering, University of Cordoba, Campus Rabanales, Leonardo Da Vinci building, 14071 Córdoba, Spain
[b] IFAPA, Centro Las Torres-Tomejil-Ctra. Sevilla-Cazalla, km 12.2, 41200 Alcalá del Río Seville, Spain
[c] Institute of Sustainable Agriculture (CSIC), Avda. Alameda del Obispo s/n, 14004 Córdoba, Spain

ARTICLE INFO

Keywords:
Olive crop
Spontaneous grass cover
Spatial patterns
Temporal patterns
Soil losses

ABSTRACT

Vegetal covers protect the soil against erosion in agricultural systems. In marginal olive farms, spontaneous grass covers are preferred due to their low cost, despite their high spatial and temporal heterogeneity which limits their efficiency. Although the impact of different managements, soil conditions or cover crops species has been evaluated and compared, there is currently insufficient information available on the spatial and temporal patterns of spontaneous grass covers in olive groves. This work focuses on the analysis of the spatial distribution patterns, temporal stability and protection capacity of spontaneous grass covers in olive orchards. First, the temporal variability of spontaneous grass cover was explored in relation to the meteorological conditions and the management system. Second, spatial analysis by distance indices (SADIE) was applied to explore the spatial patterns and persistence of the spontaneous cover. Finally, a descriptive analysis of events was made to illustrate the degree of influence of the cover on the hydrological response of the catchment.

A total 12 surveys were carried out on a seasonal scale over 3 years (2011 – 2013) to measure the cover percentage of spontaneous grass through surface photograph analyses. A regular, permanent grid of 37 points (6 samples/ha) was used to define each sample-location. In order to evaluate the relations between the cover percentage and meteorological variables, multiple linear regressions were adjusted while the SADIE approach and correlation analysis were used to describe possible spatial aggregation patterns and its dependence on topographical and soil attributes such as aspect, slope, drainage area, height, richness of grass species and apparent electrical conductivity.

The average annual percentage of cover ranged from 23% to 36%, with a coefficient of variation of 57% and 6%, respectively. On the seasonal scale, the cover varied between 0.2% and 50%. Accumulated precipitation during the precedent 15 days, the average of minimum temperature of the previous 60 days and the cumulated potential evapotranspiration of the same period showed a significant correlation with the mean cover percentage in the catchment. A simple multiple linear regression adjustment between the cumulated precipitation for the 15 previous days and the number of months since the vegetation was removed using herbicide or by summer conditions gave a determination coefficient of 77%. Moreover, a permanent spatial pattern was observed for periods characterized by abundant preceding rainfall. Only the apparent electrical conductivity of the topsoil (50 cm in depth) showed significant correlations with the spatial patterns of spontaneous grass. Finally, similar rainfall events taking place with different degrees of soil cover presented very different hydrological responses, which allowed us to quantify the contribution of spontaneous vegetation to sediment dynamics during humid periods.

1. Introduction

Thirty-three percent of the world's soils present a moderate or high risk of degradation as a result of threats such as erosion, salinization, compaction, acidification and contamination by chemicals (FAO, 2015). Sustainable management of agricultural soils and sustainable production are crucial to reverse the trend of degradation and ensure current and future food security for the world's population.

Traditional Mediterranean land-uses such as olive cultivation have been associated with soil degradation (i.e. Gómez et al., 2014a), mainly

* Corresponding author.
E-mail address: evtaguas@uco.es (E.V. Taguas).

http://dx.doi.org/10.1016/j.catena.2017.05.017
Received 25 October 2016; Received in revised form 11 May 2017; Accepted 16 May 2017
0341-8162/ © 2017 Elsevier B.V. All rights reserved.

as a result of the combined effects of periodic high-energy rainfall events, a hilly topography and the implementation of soil management strategies that minimize water competition by weeds, but which also keep a large part of the soil bare throughout the year (i.e. Gómez and Giráldez, 2009; Gómez et al., 2014a). Currently, Spain is the leading country in the world in terms of surface area dedicated to olive cultivation (approximately 2.5 Mha) and olive yield (MAGRAMA, 2016), and over 1.5 Mha of the production area is concentrated in Andalusia, the southernmost region, (Andalusian Government, 2016). Yet the nature of the farms that comprise this area is heterogeneous in terms of size, olive varieties, planting densities, irrigation and plant and soil management systems. This illustrates the complexity of the economic and environmental management, which is constrained by different factors in each particular farm. The Andalusian Council of Agriculture, Fisheries and Rural Development (2015) recently classified the olive farms in Andalusia in underperforming groves (6.3% of the area), steep slope (> 15%) groves (23.3% of surface area), extensive groves with planting densities of below 150 trees ha^{-1} (47.5% of the area), extensive groves with medium density (7.5% of the area) and intensive and super-intensive olive groves (15.4% of the area). With approximately 68% of the olive groves on terrain with slopes > 10%, it is mandatory to maintain a vegetation cover of at least 1 m in width between the tree rows, according to cross-compliance regulations and to counter the high risk of soil erosion (Spanish Agricultural Guarantee Fund-MAGRAMA, 2015).

The benefits derived from grass covers for sustainable agriculture, such as soil conservation and reduction in ground water contamination, increased organic matter, improvements in structure and other quality indicators, moisture maintenance and effective control of diseases, are widely recognized (e.g. Moreno et al., 2009; Gómez et al., 2009; Alcántara et al., 2011; González-Sánchez et al., 2012). A suitable vegetation cover in olive orchards should grow fast, compete with undesired weeds - but not with the crop, reach a medium height and show low combustibility. It should also be well-adapted to the annual and intra-annual variability of rainfall and temperature, and to poor and shallow soils, while it should not host harmful insects or pests. In addition, it should be able to attract or mobilize nutrients and be capable of self-seeding to save the costs of re-sowing (Saavedra-Saavedra et al., 2015). Finally, it should also tolerate compaction by machinery traffic and different herbivore species.

There are different types of vegetation covers, ranging from spontaneous grass covers to sown mono- or multispecific covers. Monospecific and selected covers behave more homogeneously, despite their higher sensitivity to adverse weather conditions than spontaneous covers, with a greater variability including more rustic species (Soler et al., 2004). Spontaneous grass covers must be used in steep areas where seeding treatments and movements of earth are difficult, and this is the most common type of vegetation cover in Andalusia (González-Sánchez et al., 2007) due to its low or zero cost. High water competition during critical periods of the olive growing cycle and an irregular spatial and temporal distribution are attributed to spontaneous grass covers (González-Sánchez et al., 2007; Alcántara et al., 2011).

Spatial and temporal patterns of vegetal communities are responsible for degree of soil protection against the force of the rainfall, as well as the flow velocity and infiltration rates determining sediment dynamics and the connectivity of hydrological and ecological processes (Maestre et al., 2008). López-Vicente et al. (2016) used the model DR2-2013© SAGA v1.1 to describe runoff generation processes in olive plots with conventional tillage and cover crop. These authors concluded that the lowest temporal variability of run-on in olive orchard plots was found in the cover crop plots and highlighted that there was a clear gap in the spatial patterns of the hydrological processes in olive orchards with cover crops despite its importance in explaining the connectivity and dynamics of water and sediment. Its impact must be particularly significant at spatial scales different to plots (Taguas et al., 2015a), where most studies carried out in catchments were aimed at evaluating soil water content distribution and soil properties in the context of precision agriculture (e.g. Pedrera-Parrilla et al., 2014; Espejo et al., 2014) or the analysis of natural vegetation patterns (e.g. Robinson et al., 2012).

Numerous studies have compared the impact of different managements, soil conditions or species characteristics linked with cover crops in olive groves (e.g. Martínez-Raya et al., 2007; Gómez et al., 2009; Alcántara et al., 2011; Correia et al., 2015; Parras-Alcántara et al., 2016). To the best of our knowledge, we do not know of any studies that have characterized the spatial and temporal patterns of spontaneous grass covers in olive groves. The objective of this work was to describe spatial patterns in spontaneous grass covers and their hypothetical temporal stability, as well as their role in soil protection. In order to achieve this objective, the temporal variability of spontaneous grass cover was assessed and linked to meteorological observations and with management characteristics. In addition, a spatial analysis was performed to evaluate the existence of spatial patterns and their temporal persistence, and a descriptive analysis of events was carried out to analyze the influence of the degree of cover on the hydrological response of the catchment.

2. Material and methods

2.1. Study site

The study catchment is situated in the southwest of the province of Córdoba, southern Spain (37.4°N, − 4.8°W; Fig. 1), in the upper reaches of the Guadalquivir Valley, characterized by a hilly terrain with a long tradition of olive cultivation (Taguas et al., 2013). The soil in the catchment is Calcareous Cambisol (FAO, 2006), with a sandy-loam texture in the top-horizon (− 20 cm). The drainage area is 6.1 ha, with a mean elevation of 239 m and a mean slope of 15%. The annual precipitation is 400 mm, and the average temperature in the hottest month (July) is 26.5 °C, whereas in the coldest month (January) it is 8.4 °C. The olive trees in the catchment were planted in 1995 on a 7 × 7-m grid. The yield of this olive grove is low (~1.3 Mg/ha) and consequently, in order to limit production costs, only a few management operations are performed. The soil management system is no-tillage with spontaneous grass cover growing from winter to spring. Grass is removed once (in spring), or twice a year (September or October and March, April or May) if the autumn is very wet, either mechanically or using herbicides under the canopies. Table 1 provides a detailed overview of the management operations performed during the study period (2011–2013).

2.2. Cover degree sampling of spontaneous grass cover

Twelve spontaneous grass cover surveys were performed during 2011, 2012 and 2013 (4 per year, 1 per season). The sample dates were selected according to the variations of meteorological conditions throughout the year, which are directly responsible for differences in the development of the spontaneous grass cover: 30-Jan-2011 (*C_Meas_1_1*); 25-Mar-2011 (*C_Meas_1_2*); 5-May-2011 (*C_Meas_1_3*); 12-Nov-2011 (*C_Meas_1_4*); 13-Jan-2012 (*C_Meas_2_1*); 13-May-2012 (*C_Meas_2_2*); 5-Jul-2012 (*C_Meas_2_3*); 24-Nov-2012 (*C_Meas_2_4*); 31-Jan-2013 (*C_Meas_3_1*); 19-Apr-2013 (*C_Meas_3_2*); 19-Jun-2013 (*C_Meas_3_3*); 29-Nov-2013 (*C_Meas_3_4*). Observations were performed on a regular grid, with a density of 6 points/ha (n = 37) and oriented NE-SW, along the direction of the maximum soil variability as detected through a soil apparent electrical conductivity (ECa) survey, which was carried out in the study catchment using EM38DD equipment in March 2010. Grass cover surveys were performed in the lanes between the tree lines, away from the olive canopies. At each grid point, a 0.5 × 0.5-m^2 frame was used to delimit the sample area and a georeferenced photograph was taken (Reflex Olympus E-420, ED 14–42 mm) on each survey date at a height ranging from 1.4 to 1.7 m (Fig. 1). The

Download English Version:

https://daneshyari.com/en/article/5769846

Download Persian Version:

https://daneshyari.com/article/5769846

Daneshyari.com