The effects of mulching on soil erosion by water. A review based on published data

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MED Soil

RECARE Preventing and Remediating degradation of soils in Europe through Land Care

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ABSTRACT

Among the soil conservation practices that have been recently implemented, mulching has been successfully applied in different contexts (Jordán et al., 2011), such as agricultural lands (García-Orenes et al. 2009; Prosdocimi et al., 2016), fire-affected areas (Prats et al., 2014; Robichaud et al., 2013a,b) and anthropic sites (Hayes et al., 2005), to reduce water and soil losses rates. In these contexts, soil erosion by water is a serious problem, especially in semi-arid and semi-humid areas of the world (Cerdà et al., 2009; Cerdan et al., 2010; Sadeghi et al., 2015a,b). Although soil erosion by water consists of physical processes that vary significantly in severity and frequency according to when and where they occur, they are also strongly influenced by anthropic factors such as unsustainable farming practices and land-use changes on large scales (Cerdà, 1994; Montgomery, 2007). Although the beneficial effects of mulching are known, their quantification needs further research, especially in those areas where soil erosion by water represents a severe threat. In literature, there are still some uncertainties about how to maximize the effectiveness of mulching in the reduction of soil and water loss rates. First, the type of choice of the vegetative residues is fundamental and drives the application rate, cost, and consequently, its effectiveness. Second, it is important to assess application rates suitable for site-specific soil and environment conditions. The percentage of area covered by mulch is another important aspect to take into account, because it has proven to influence the reduction of soil loss. And third, the role played by mulching at catchment scale, where it plays a key role as barrier for breaking sediment and runoff connectivity. Given the seriousness of soil erosion by water and the uncertainties that still concern the correct use of mulching, this work aims to evaluate the effects of mulching on soil erosion rates and water losses in agricultural lands, post-fire affected areas and anthropic sites. Data published in literature have been collected. The results proved the beneficial effects of mulching on soil erosion by water in all the contexts considered, with reduction rates in average sediment concentration, soil loss and runoff volume that, in some cases, exceeded 90%. Furthermore, in most cases, mulching confirmed to be a relatively inexpensive soil conservation practice that allowed to reduce soil erodibility and surface immediately after its application.

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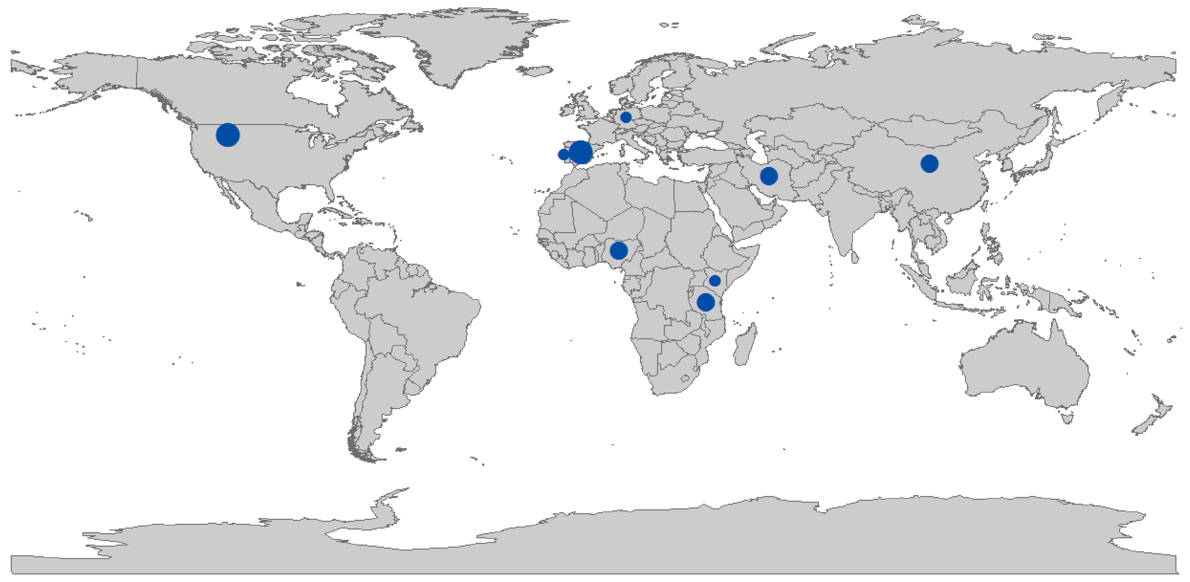
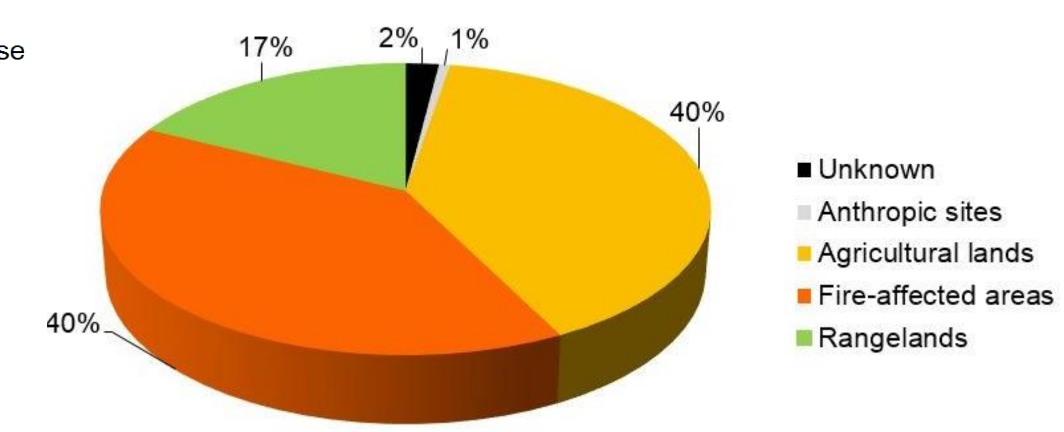
DESCRIPTION OF DATABASE

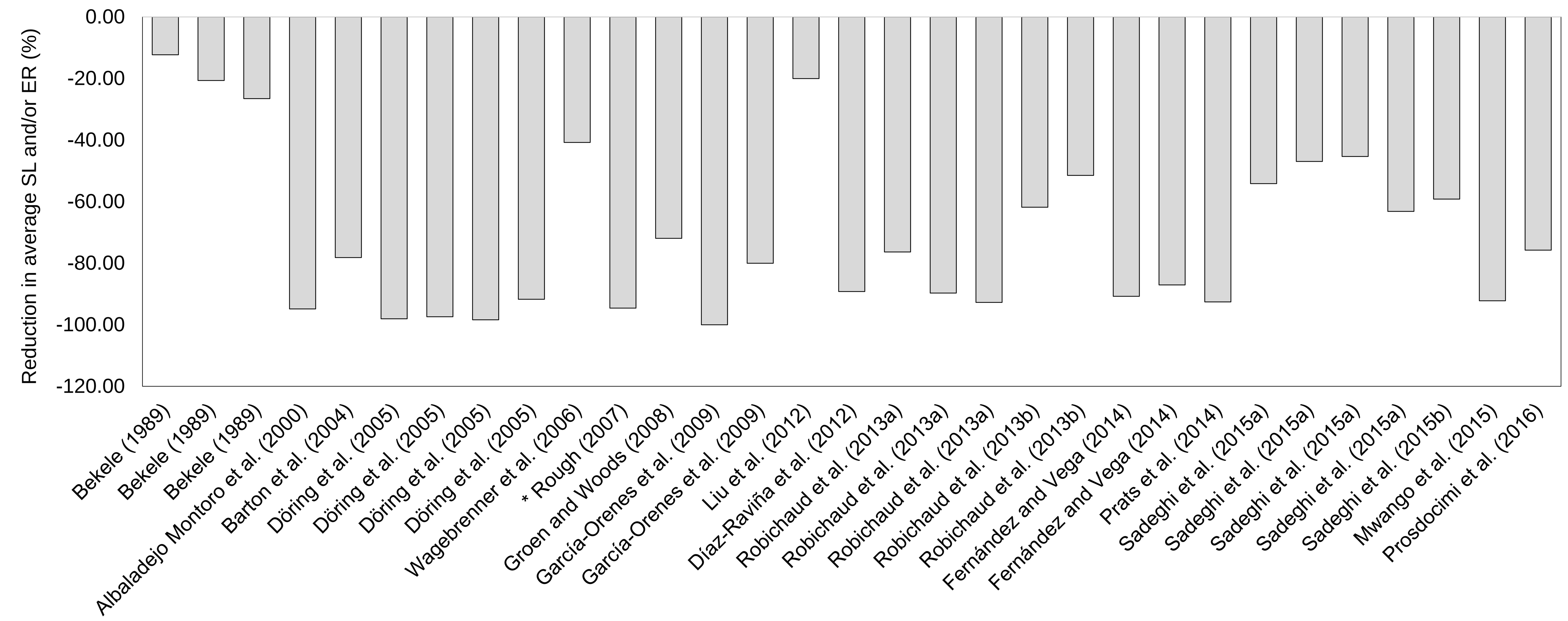


Spatial distribution across the world of the records of the database collected. USA, Spain, Iran and Nigeria results to be the countries where most of the studies were carried out (Prosdocimi et al. *under review*).



Relative frequency, expressed as percentages, of the environments where the study collected in our database, were carried out (Prosdocimi et al. *under review*).

MULCHING VS. CONTROL



Reduction percentages in average soil loss (SL) and/or erosion rate (ER). Articles are reported in chronological order (Prosdocimi et al. *under review*).

Average (avg) and standard deviation (SD) values computed for sediment concentration (Sc), soil loss (SL) and/or erosion rate (ER), runoff volume (R (L)) and height (R (mm)), by grouping data according to the soil conservation techniques, control (C) and mulching (M), and the measurement methods (RS = rainfall simulation; RP = runoff plot; SF = silt fence; SD = sediment trap). The average reduction (%) induced by mulching for each variable has been computed too. No distinction has been made among the different types of mulch at this point (Prosdocimi et al. *under review*).

	Sc ($g\ L^{-1}$)		SL (g)		ER ($Mg\ ha^{-1}\ yr^{-1}$)						R (L)		R (mm)		RC (%)	
	RS		RS		RP		SF		SD		RS		SD		RS	
	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M
Avg	12.06	3.75	433.25	107.62	53.62	22.71	2.73	0.98	12.00	8.71	21.62	15.84	19.80	21.27	56.67	35.97
SD	20.22	3.48	1516.18	152.03	75.21	52.15	5.21	3.06	14.89	9.56	22.86	19.66	28.84	31.13	19.87	20.05
Reduction (%)	-68.9		-75.2		-57.6		-64.5		-27.4		-26.7		+7.4*		-36.5	

* Increase, instead of reduction, in average runoff height (R (mm)).

APPLICATION RATE AND COVER OF MULCHES

Average (avg) and standard deviation (SD) values of the application rate (Ar) and cover mulch (Cm) computed for each measurement method (RS = rainfall simulation; RP = runoff plot; SF = silt fence; SD = sediment trap) (Prosdocimi et al. *under review*).

	RS		RP		SF		SD	
	Ar ($g\ m^{-2}$)	Cm (%)	Ar ($g\ m^{-2}$)	Cm (%)	Ar ($g\ m^{-2}$)	Cm (%)	Ar ($g\ m^{-2}$)	Cm (%)
Avg	326.04	69.9	431.19	-	401.20	60.0	186.67	-
SD	257.34	22.0	322.53	-	399.19	12.3	46.03	-

DISCUSSION AND FUTURE GUIDELINES

• This literature review confirmed the worldwide importance of using mulching to reduce soil and water losses in agricultural lands, rangelands, fire-affected areas and anthropic sites.

• The monitoring of the mulched plots over longer periods is, in our opinion, essential to enrich the understanding about the persistence of the beneficial effects of mulching.

• Further research should be carried out to develop appropriate methods to procure adequate amounts of residue mulch, and prove that the optimum mulch rate entails reasonable expenses that farmers and land managers can afford. Science must be of help to both farmers and land managers by providing them evidence-based means for implementing more sustainable soil management practices.

(a) Transport of bales of straw mulch, (b) unloading of the bales in the vineyard, (c) transport of the bales in the inter-rows and consequent application of the straw mulch along the inter-rows. Pictures are taken at Celler del Roure in Les Alcusses de Moixent (Province of Valencia, Spain) (photos by A. Cerdà).

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