8th EUREGEO Barcelona | Catalonia | Spain june 15th - 17th 2015
EUropean Congress on REgional GEOscientific Cartography and Information Systems

EROSION MODELING BY WEPP IN PLOTS TREATED WITH SOLAR-DRIED CITRUS PEEL

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INTRODUCTION

Steep and bare slopes of large areas of Southern Italy are often subject to intense runoff and erosion after heavy and flash rainstorms. In these contexts, the hydrologic response of soils could be improved by enhancing infiltration through addition of organic matter. A high organic matter content generally improves physical, chemical and biological properties of soil (in particular increasing its macro-porosity and infiltrability and decreasing aptitude to seal formation, Chaney and Swift, 1984; Cox *et al.*, 1996; Le Bissonais, 1996) and encourages establishment and development of the vegetal coverage.

In agricultural system characterized by the presence of citrus processing industries, the production of citrus peel is high (about 100.000 t year^{-1} of dry matter): this by-product has got a low commercial value on the markets due to the high water content, which makes expensive biomass storage and transportation (Tamburino and Zema, 2009).

In marginal zones, close to agro-industries, where wastewater and by-products (such as citrus peel) could be distributed on soils at low cost, citrus peel, because of its high content of organic matter (about 900 g per kg of dry matter, Tamburino and Zema, 2009), could be used as a soil organic conditioner: this use makes easy its disposal and allows also its valorisation in order to reduce soil erosion rates in Mediterranean environment (Bombino *et al.* 2010).

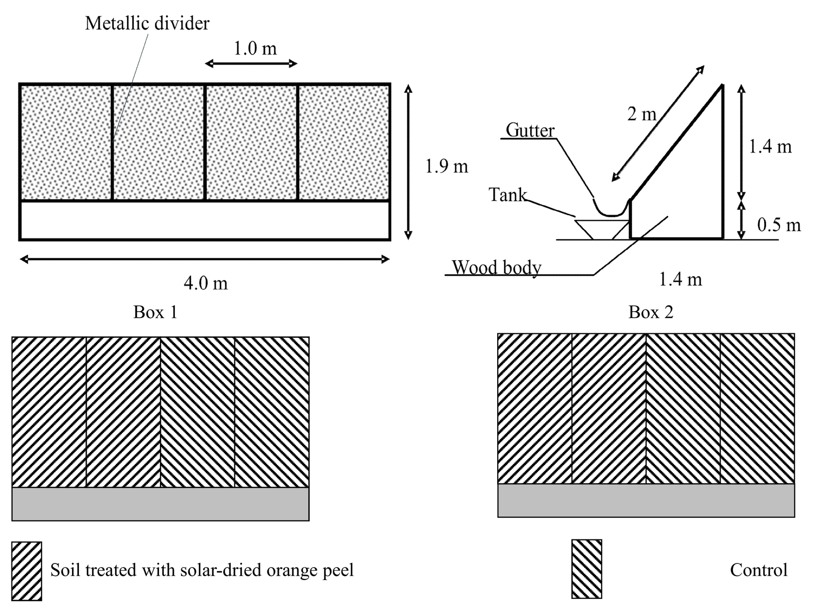
The hydrological benefits of citrus peel addition to soil can be easily evaluated also by a modelling approach. As well known, during the last decades, many prediction models was developed for prediction of hydrological variables under different environmental conditions and time/spatial scales. Among them, WEPP (Water Erosion Prediction Project), a physically-based, distributed parameters, continuous simulation (Nearing *et al.*, 1989), was widely applied under varying climatic and geomorphologic conditions. The model simulates at event scale surface runoff and soil loss in plots, hillslopes and watersheds.

AIM

WEPP prediction capability for surface runoff and soil loss in artificial steep slopes with bare soil and treated with solar-dried orange peel in semi-arid Mediterranean conditions; furthermore, model capability to quantify hydrological benefits of OM addition to soil is investigated.

METHODS

The investigation was carried out in the experimental farm of the Mediterranean University of Reggio Calabria (Southern Italy), located at 250 m a.s.l. Climatic characteristics of this area are typical of the Mediterranean basin, with mild rainy winters and warm dry summers; the experimental site falls within the phyto-climatic plan defined as "thermo-Mediterranean, dry sub-humid ombro-type" (Piussi, 1994).

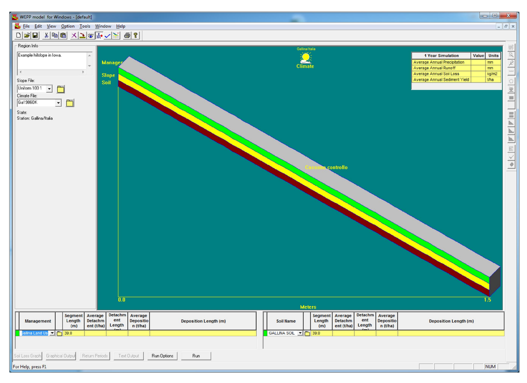


Eight plots, each one covering an area of 2 m^2, were remodelled (slope equal to 100%) in two wood boxes. The plots were hydraulically isolated by metal dividers (40-cm high and 20-cm deep in the soil) and a channel, located immediately below the bottom side of the box and linked to a tank, collected surface runoff volumes and sediment yields. In each plot a 40-cm deep layer of agricultural soil was overlain on a 10-cm layer of gravel. The agricultural soil was characterised by an average weight content of OM equal to 1.3% and the following grain size fractions (USDA soil classification): 59% sand, 29% silt and 12% clay. Solar-dried orange peel, previously shredded ($4 < \phi < 8$ mm), was incorporated at a dose of 3 kg/m^2 in the 3-cm deep surface layer of four plots (in the following indicated as "treated soils"). The remaining four plots (not treated) were considered as control. All plots were exposed to 15 natural rainfalls occurred between September and November 2004; as many events of runoff and soil loss were recorded. Runoff was collected in a tank and its volume measured after each event; soil loss was measured by weighing the eroded soil after oven drying (at 105 °C) the collected runoff. The measured volumes were referred to the projection of the plot surface on the horizontal plan (1.4 m^2).

The hydrological observations were visually compared to the corresponding predictions by WEPP. Model performance was evaluated by the coefficients of determination (r^2) and model efficiency (E, Nash and Sutcliffe, 1970), as usually done in modelling experiences.

WEPP MODEL DESCRIPTION

WEPP is a process-based model for simulating soil erosion by water along a hillslope or within a watershed (Laflen *et al.*, 1997; Flanagan and Nearing, 1995). The hillslope version of WEPP contains nine components: weather generation, winter processes, irrigation, surface hydrology and water balance, subsurface hydrology, soils, plant growth, residue decomposition, overland-flow hydraulics, and erosion. WEPP can divide a hillslope into multiple overland flow elements (OFE), within which soil properties and vegetation conditions are regarded uniform and unique. The erosion component estimates interrill and rill erosion, with the former treated as soil detachment by raindrop impact and subsequent sediment delivery to rills, and the latter a function of sediment detachment due to excess flow shear stress and transport capacity of concentrated flow as well as the load already in the flow (Pieri et al. 2006)



RESULTS AND DISCISSION

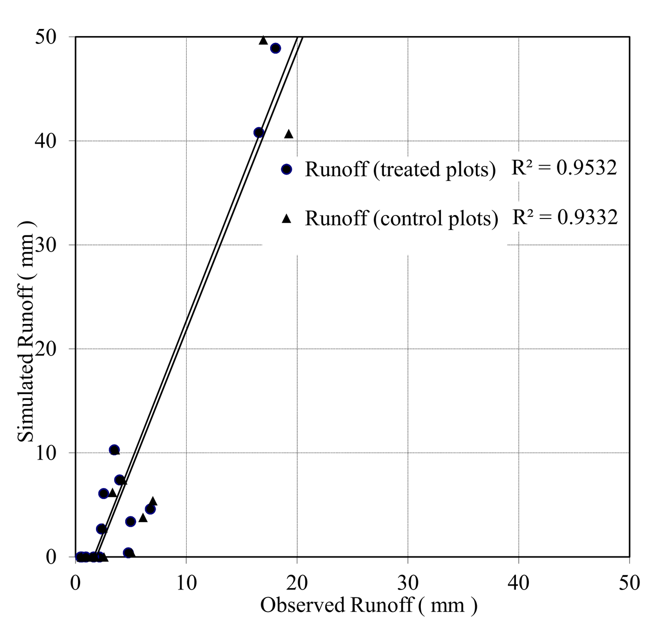
The table below reports the values of the observed events on control and treated soils. In both treated and control plots runoff volumes predicted by WEPP were correlated [r^2 = 0.95 in treated plots, 0.93 in control plots (chart a)] to the corresponding observations. Despite this correlation (Table beside), E was equal to -4.7, showing a poor model prediction capability, also after the setup of the most sensitive input soil parameters. A strong tendency to overestimation (on the average by 195%) was noticed in both control and treated plots (see charts c below) particularly for the largest rainfall events. This tendency was lower (+70%) for the events with intensity lower than 15 mm h^{-1} measured in treated plots.

WEPP performance (Table beside) was unsatisfactory also for erosion evaluations, being predicted soil losses far from the corresponding observed values in both control and treated plots (see charts d below); this was also confirmed by the low E (0.11). Anyway chart b shows a well correlation for treated plots (r^2 0.92), whereas in control plots it was very poor (r^2 0.56). However, WEPP model was able to catch the hydrological benefits linked to OM addition to soils; as a matter of fact, the observed reduction of soil loss between treated and control plots (on the average -78%) is very close to what simulated by the model (-75%).

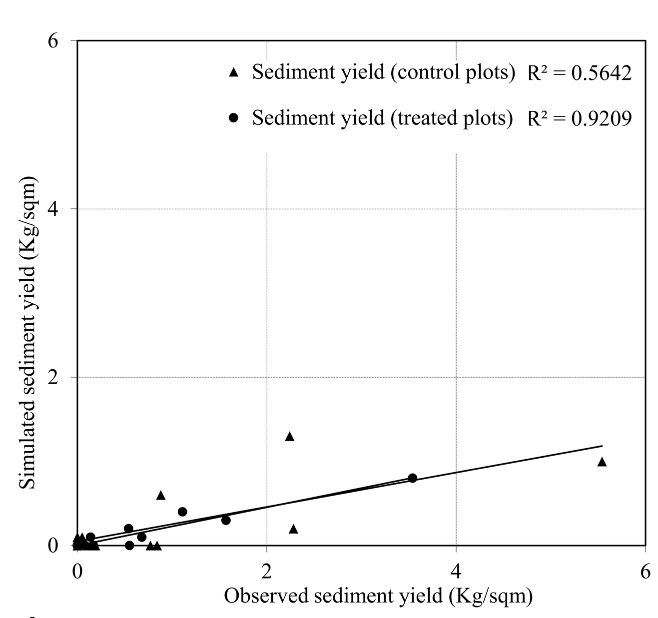
		Number of observations/ simulations	r^2	a	E	E_1	RMSE (mm)	CRM
Runoff	Treated plots	15	0.95	2.71	-4.76	-0.85	16.82	-0.99
	Control plots		0.93	2.68	-4.95	-0.90	17.27	0.22
Sediment yield	Treated plots	15	0.92	0.22	0.10	0.23	0.87	0.77
	Control plots		0.56	0.20	0.11	0.28	1.37	0.74

Event	Rainfall		Runoff volume (mm)		Soil loss (kg m^{-2})	
	Height (mm)	Mean intensity (mm h^{-1})	T	C	T	C
1	4.1	1	0.6	0.5	0	0.1
2	80	18.2	24.1	23.9	3.5	5.5
3	60	16.7	17	16.9	0.5	0.8
4	11.7	20.5	3.5	3.6	0	0
5	4.3	1.8	2.3	2.5	0	0
6	12.4	2.4	2.2	2.6	0	0
7	22.4	5.6	6.7	7	0.6	0.4
8	22.2	1.3	5	6.1	0.1	0.1
9	9.4	0.5	2.5	3.3	0	0
10	14.3	1.7	4	4.3	0	0
11	1.0	1.0	0.4	0.5	0	0
12	10.6	3	4.8	5	0.1	0.1
13	5.3	1.9	1.6	1.8	0	0
14	55	15.5	16.5	19.2	0.1	2.8
15	5	1.3	0.9	1.4	0	0

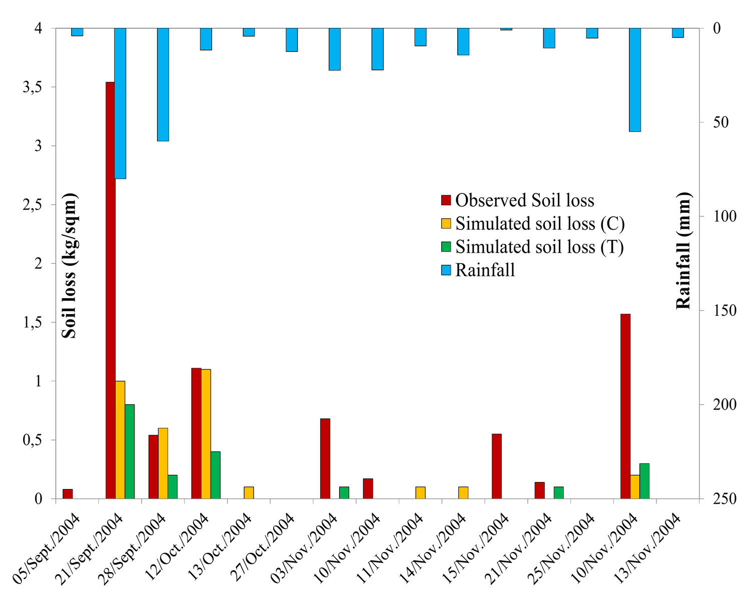
T = treated plot (added with citrus peel); C = control plot (without treatments).



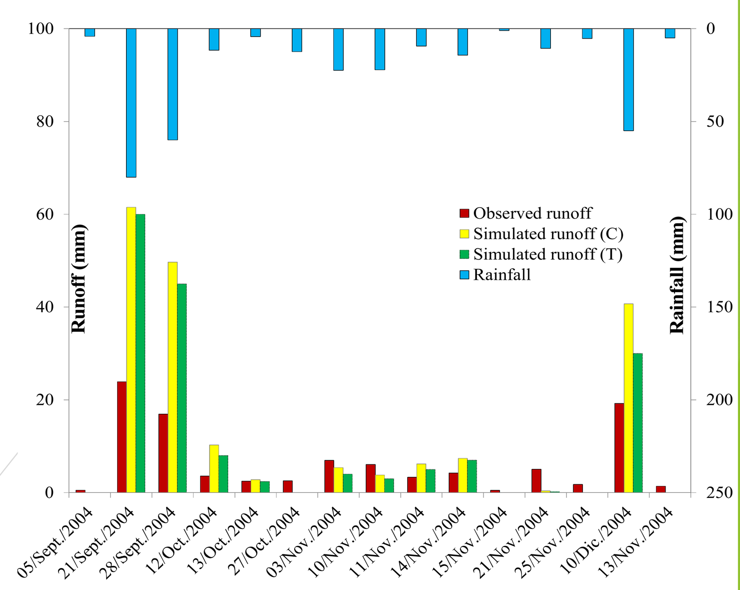
a



b



c



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CONCLUSION

Typical conditions of marginal areas of Southern Italy under semi-arid Mediterranean climate was simulated by WEPP. Surface runoff volumes and soil loss produced by 15 natural rainfalls were observed and compared to model simulations in four plots with soils treated with solar-dried orange peel and in four without any treatments.

A very poor model performance was detected (with a strong tendency to overestimation of the hydrological observations) both in control and treated plots. However, WEPP model was found to be able to simulate the lower hydrological response after addition of organic matter to soils. In fact, the soil input files were well populated by edaphic information so the model was able to feel the differences between plots. In the other hand, the land use input files were affected by the poor detailed data in consequence of experimantal plots lacking in crops and management information.

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