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SOIL LOSS IN OLIVE ORCHARD USING OIL PRESS REMAINS

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Olive groves in the Mediterranean Basin have often occupied marginal soil and hills, where other crops proved to be unsustainable. Despite a recent trend towards intensive cultivation and new plantations on better soils, many olive groves in Andalusia are rain-fed and located on steep slopes. Limited research has shown that soil management in olive orchards has important effects on runoff and soil losses. Due to its limited rainfall, traditional orchard management in the Mediterranean region is based on reduced tree density, canopy size control by pruning, and intensive weed control to avoid competition for stored soil water. Alternative methods have been adopted by us including: conventional tillage combined with olive leaves and conventional tillage with product of the two-step olive oil will process (oil press remains). Two scenarios are remaining; adding 27 kg m^{-2} of product of the two-step olive oil will process and 23 kg m^{-2} of olive leave separately. We have these managements three years ago. This effect of soil management on soil losses from olive plantations in southern Spain were evaluated using the Revised Universal Soil Loss Equation (RUSLE). Our results showed that conventional tillage caused the greatest soil loss, while using oil press remain the least. In both scenarios (conventional tillage with olive leaves and product of the two-step olive oil will process) the annual soil loss was reduced a 65 % and 90 % respectively.

Keywords: RUSLE, Soil erosion, Management, Tillage.

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ИСПОЛЬЗОВАНИЕ ОСТАТКОВ МАСЛА С ЦЕЛЬЮ УМЕНЬШЕНИЯ ЭРОЗИИ ПОЧВ ОЛИВКОВЫХ САДОВ

Оливковые рощи в Средиземноморье, как правило, располагаются на территориях, где не могут произрастать другие культуры. Несмотря на то что под интенсивное культивирование и молодые плантации принято отводить самые лучшие почвы, в Андалусии многие оливковые рощи питаются дождем и расположены на крутых склонах. Проведенные исследования показали, что уход за почвой в оливковых садах значительно влияет на поверхностный сток воды и само состояние почвы. Из-за небольшого количества осадков основными принципами выращивания фруктовых садов в Средиземноморской области является высаживание небольшого количества деревьев на единицу площади, контролирование площади кроны (подрезая ее) и постоянное пропалывание сорняков с целью снижения конкуренции за доступную воду. Были применены альтернативные методы, такие как традиционное культивирование с применением оливковых листьев и культивирование с применением остатков масла из маслоотжимного пресса. Рассматривались два сценария: добавление 27 кг/м^2 остаточного продукта в ходе получения оливкового масла и добавление 23 кг/м^2 оливковых листьев. Данные сценарии применялись на отдельных участках на протяжении трех лет. Степень эффективности применения подобных методов в южной Испании был оценен с помощью модифицированного универсального уравнения потери почвы (RUSLE). Результаты показали, что традиционное культивирование привело к наиболее значительному ухудшению почвы, в то время как использование остаточного продукта маслоотжимного пресса – к наименьшему. В обоих сценариях ежегодный ущерб почвы уменьшился на 65 % при возделывании земли с использованием оливковых листьев и на 90 % при возделывании земли с использованием остаточного продукта маслоотжима.

Ключевые слова: RUSLE, эрозия почвы, управление, культивирование.

Spain has over two millions hectares dedicated to olive orchards (Civantos, 1999), and about 75 % of the production is located in Andalusia. Limited research has shown that soil management in olive orchards has important effects on runoff and soil losses (Pastor *et al.*, 1999; Raglione *et al.*, 1999; Francia *et al.*, 2000).

Soil erosion is a major environmental threat to the sustainability and productive capacity of agriculture. During the last 40 years, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year (Pimentel *et al.*, 1995).

Average rates for soil loss have been estimated at 17 t ha^{-1} yr^{-1} in the United States and Europe, and 30-40 t ha^{-1} yr^{-1} in Asia, Africa and South America, mainly due to inadequate agricultural land use (Pimentel *et al.*, 1995). The soils found in the Mediterranean climate are highly variable, but do have in common properties that make them susceptible to water erosion. These include low organic matter content, poor structure and weak aggregate stability (Singer, 1991; Singer *et al.,* 1996). These areas become vulnerable to erosion because of decreased protection by vegetation cover in reducing effective rainfall intensity at the ground surface (Faulkner, 1990), the reduction of infiltration rate due to compaction from farm machinery (Fullen, 1985) and the formation of a soil surface crust (Morin & Benyamini, 1977; Casenave & Valentin, 1992). These characteristics lead to surface sealing during rainfall or irrigation, slow water infiltration, ponding and runoff with subsequent soil erosion. Without a clear understanding of how sealing influences soil hydrology, it isn't possible to accurately predict soil erosion.

Soil erosion is a primary environmental concern for agricultural land in many parts of southern Europe (Morgan, 1987; Arrúe & López, 1991; Lasanta *et al.*, 2000; López-Bellido & López-Bellido, 2001).

Erosion represents a serious hazard for land degradation and desertification in the Mediterranean region, bringing about large reductions in vegetation growth, siltation of water courses, filling of valleys and reservoirs, and the formation of deltas along coastal areas. In most Mediterranean land, the rates of erosion have been influenced by man since early prehistoric times (Inbar, 1992).

Therefore, study of soil erosion and sediment transport in an agricultural catchment's is essential for the protection of the environment and ecosystems (Jordan *et al.*, 2005).

The limited information that exists does not allow evaluation of the impact of soil management on soil losses across the diverse set of conditions that exist in the olive orchards of Andalusia (Gómez *et al.*, 2003). Simulation models are useful tools for decision-making in engineering and environmental planning (Engel *et al.*, 1993). Erosion models are either process-bassed or empirical (Morgan & Nearing 2000). While the potential of process-based models is greater, their complexity means larger data requirements, potentially greater problems of error propagation, and increased difficulty in understanding the way the model simulates the erosion processes (Favis-Mortlock *et al.*, 2001).

In the Iberian Albaladejo & Stocking (1989) found that USLE over-predicted soil losses, although it predicted soil losses within the same order of magnitude of the observed losses, for a soil with natural vegetation cover. Their use of only eight rainfall events is clearly insufficient to validate a model designed to estimate long-term, average annual soil losses.

The objective of the present work is to compare and evaluate the effect of soil management on soil loss in the olive orchards with traditional orchard management in the Southern Spain, Mediterranean region, using olive leaves and product of the two-step olive oil will process, using the empirical model RUSLE (Renard *et al.*, 1997).

STUDY AREA

This study has been realized in Torredelcampo – Jaen, Southern Spain, (Figure 1) the litologies are clays and loams Miocene. The topography is gently undulating. The majority of the soils are Calcisols, after FAO classification (1998). The surface horizons are minor in sand content (12.1 %), have comparable amounts of silt and clay (approximately 42 %). Many zones of the exposed calcareous C horizon are evident in areas of steep slope, where erosion has been the greatest. The Mediterranean aridic climate is characterized by cool winter (-5.2 ºC) and hot summer (40.6 ºC). The average annual rainfall is 646.3 mm distributed with interannual variability.

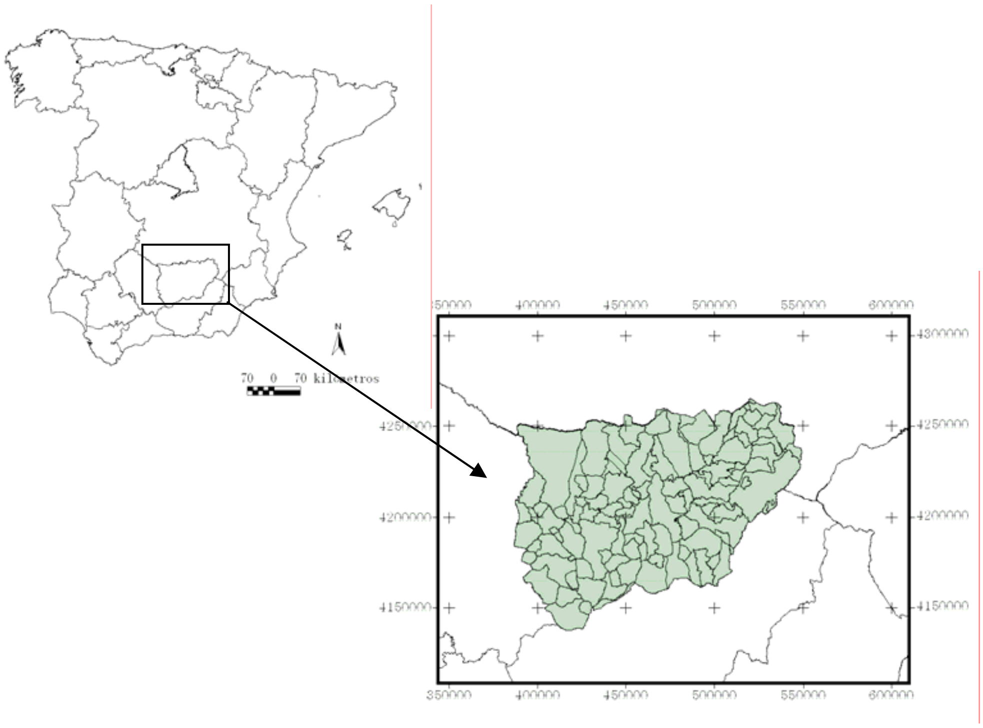


Figure 1. **Sampling locality**

METHODS

The experience was consisted to increasing oil press remainders (olive leaves and product of the two-step olive oil will process) to olive orchard under conventional tillage, a uniform tree spacing of 10 m × 10 m, and tree sizes (3 m height × 5 m in canopy diameter), was analyzed the physical-chemical properties influence, and the impact of soil management on soil losses in olive orchards. This experiences became three years ago, addicting 270 t ha^{-1} of product of the two-step olive oil will process and 230 t ha^{-1} of olive leaves.

The universal soil loss equation (USLE) was developed by Wischmeier and Smith (1965) and modified by Renard *et al.* (1997). The USLE framework has been widely used since original development in the 1960s to predict soil erosion in many parts of the world (Risse *et al.*, 1993; Renschler *et al.*, 1999). The RUSLE is an adapted of the USLE with the original equation for the USLE as the foundation for the revised version. The main difference between the two equations is the increased level of complexity in the RUSLE computation for individual factors and their combined interaction. RUSLE is an erosion model designed to predict the long-time average annual soil loss, *A*, carried by runoff from specific field slopes in specific crop and management systems, computed as:

$$A = RKLSCP \qquad (1)$$

where A is the mean annual soil erosion rate (t ha^{-1} yr^{-1}), R the rainfall erosivity factor (MJ mm ha^{-1} h^{-1} yr^{-1}), K the soil erodibility factor (t ha h ha^{-1} MJ^{-1} mm^{-1}), L the slope length factor, S the slope gradient factor, C the cover and management factor, P the supporting conservation practices. The last four factors are dimensionless, with values that represent ratios of loss from experimental plots 22.13 m in length with a uniform 9 % slope under continuously clean-tilled fallow management (Wischmeier & Smith, 1965; Renard *et al.*, 1997). What follows is our assessment of those factors in equation 1 that would be affected by soil management in olive orchards under our conditions.

1. R factor

We used a daily rainfall record to Torredelcampo, Jaén (1963-2002) (Parras A, personal communication) to calculate rainfall erosivity (*FMI*) following the approach of Arnoldus (1978), the rainfall erosivity in Torredelcampo was calculated, since this index considers the precipitation of every month (Arnoldus, 1978). The Fournier index (Equation 2) and the other factor that consider only the rainiest month in the years are suitable for those types of climate where only exists one maximum of precipitation and where the rain period is short. Whence:

$$\mathrm{FMI} = \sum_{i=1}^{12} \frac{p_i^2}{p_t} \tag{2}$$

where *FMI* is the modified index of Fournier, p_i is the monthly half precipitation, and p_t is the annual average rainfall. During that period, average annual rainfall was 646 mm, with a maximum of 1198 mm and minimum of 372 mm.

The average annual *R*-value was 69 MJ mm ha^{-1} h^{-1}, similar to estimate by ICONA (1988) also for Torredelcampo, using a different regression approach (Correlation 0.95, Renschler *et al*, 1999).

2. K factor

The soil erodibility was calculated using the following expression (Wischmeier & Smith, 1978; Renard *et al*., 1997):

$$K = [(2.1 \times 10^{-4}\,(12 - OM)M^{1.14} + 3.25(S - 2) + 2.5(P - 3)) / 7.59 \times 100] \tag{3}$$

where *OM*, is the soil organic matter content, *M* is (%silt + %very fine sand) × (100 - %clay), *S* is soil structure code, and *P* is permeability class (Table 1). If soil organic matter content was greater or equal to 4 %, *OM* was considered constant at 4 %. Moreover, the influence of rock fragments on soil loss was accounted for by a subsurface component in the soil erodibility *K* factor (Renard *et al*., 1997). Gómez *et al*., (2003) in Cordoba, Andalusia obtained similar values for *K*-factor.

3. Slope length factor (L)

Plot data used to derive the slope length factor (*L*) have shown that average erosion for the slope length *λ* (in ft) varies as:

$$L = (\lambda / 72.6)^m \tag{4}$$

where 72.6 = the RUSLE unit plot length in ft and *m* = a variable slope-length exponent (Wischmeier & Smith 1978). The slope length *λ* is the horizontal projection, not distance parallel to the soil surface. The slope-length exponent m is related to the ratio *β* of rill erosion (caused by flow) to interrill erosion (principally caused by raindrop impact) by the following equation (Foster *et al*., 1977):

$$m = \beta / (1 + \beta) \tag{5}$$

Values for the ratio *β* of rill to interrill erosion for conditions when the soil is moderately susceptible to both rill and interrill erosion were computed from (McCool *et al*., 1989)

$$\beta = (\sin\theta / 0.0896) / (3.0 (\sin\theta)^{0.8} + 0.56) \tag{6}$$

where *θ* = slope angle. Given a value for *β*, a value for the slope-length exponent *m* is calculated from equation 5.

4. Slope steepness factor (S)

Soil loss increases more rapidly with slope steepness than it does with slope length. The slope steepness factor (*S*) is evaluated from (McCool *et al*., 1987).

$$S = 10.8 \sin\theta + 0.03 \quad s < 9\ \% \tag{7}$$

$$S = 16.8 \sin\theta - 0.50 \quad s \geq 9\ \% \tag{8}$$

where *θ* is the slope angle, the equation 8, is based on the assumption that runoff is not a function of slope steepness, which is strongly supported by experimental data for steepness greater than about 9 %.

The extent of the effect of slope on runoff is highly variable on cultivated soils. Runoff is assumed to be unaffected by slope steepness on rangelands not recently treated with mechanical practices such as ripping.

Table 1

Properties and K factor values corresponding to soil used in this study

Soil	OM %	Permeability	Structure	Silt %	Clay %	Fine sand %	K (t ha h ha^{-1} MJ^{-1} mm^{-1})
Reference	1.53	Moderately slow-4	Medium granular-3	45.4	42.5	4.03	0.0326
Alpeorujo	3.18	Moderately slow-4	Fine granular-3	43.8	40.1	5.42	0.0296
Olive leaves	14.43	Moderately-3	Fine granular-2	43.3	31.2	8.56	0.0249

OM – organic matter; Alpeorujo – product of the two-step olive oil will process.

Table 2

Selected properties corresponding to soil in this study

Soil	Sand %	Fine sand %	Silt %	Clay %	Density gr cm^{-3}	pF 1/3 %	pF 15 %	pH	CO_3^{2-} %	CEC cmol + kg^{-1}	V %	OM %	OC %	N %
Reference	12.1	4.03	45.4	42.5	1.36	33.02	20.48	8.4	68.79	16.17	100	1.5	0.9	0.09
Alpeorujo	16.2	5.42	43.8	40.0	1.26	31.74	23.43	8.3	66.67	18.02	100	3.2	1.8	0.14
Olive leaves	25.7	8.56	43.3	31.0	0.49	45.44	31.73	8.2	48.48	28.04	100	14.4	8.4	0.57

OM – organic matter; CEC – cation exchange capacity; V – base saturation; OC – organic carbon.

Table 3

Decomposition C factor

Soil	PLU	CC	SC	SR	SM	C
Reference	1.0	1.0	1.0	0.708	1.0	0.708
Alpeorujo	0.95	1.0	0.4	0.708	1.0	0.27
Olive leaves	0.5	1.0	0.28	0.708	1.0	0.1

Alpeorujo – product of the two-step olive oil will process.

McIsaac *et al*., (1987) examined soil-loss data from several experiments on disturbed lands at slopes of up to 84 %. They recommended an equation of a form similar to that of equations *7* and *8*. Their coefficient of $\sin\theta$ was a range that encompassed equations *7* and *8*. Thus these equations should also be valid for disturbed-land applications.

Equations *7* and *8* are not applicable to slopes shorter than 15 ft (5 m) (Renard *et al*., 1997).

5. C factor-Cropping and management factor

Like many of the RUSLE factors, *C*-factor values are based on the concept of deviation from a standard plot under clean-tilled continuous fallow (Wischmeier & Smith, 1978; Renard *et al*., 1997). The annual cover management factor was computed according to Renard *et al*., (1997):

$$\mathrm{SLR} = \mathrm{PLU} \times \mathrm{CC} \times \mathrm{SC} \times \mathrm{SR} \times \mathrm{SM} \quad (9)$$

where *SLR* is the soil-loss ratio for the given conditions, *PLU* is the prior land-use sub-factor, *CC* is the canopy-cover sub-factor, *SC* is the surface-cover sub-factor, *SR* is the surface-roughness sub-factor, and *SM* is the soil-moisture sub-factor. All these factors are dimensionless. For the calculation of the sub-factors, a uniform tree spacing of 10 m ×10 m, and 3 m height × 5 m in canopy diameter (Table 3).

5.1. Prior Land-Use sub-factor, PLU

The prior-land-use sub-factor (*PLU*) expresses the influence on soil erosion of subsurface residual effects from previous crops and the effect of previous tillage practices on soil consolidation. The relationship is of the form (Renard *et al.,* 1997):

$$\mathrm{PLU} = \mathrm{C_f} \times \mathrm{C_b} \times \exp((-\mathrm{c_{ur}} \times \mathrm{B_{ur}}) + (\mathrm{c_{us}} \times \mathrm{B_{us}} / \mathrm{C_f}^{\mathrm{Cuf}})) \quad (10)$$

where *PLU* is the prior-land-use sub-factor (which ranges from 0 to l), C_f is a surface-soil-consolidation factor, C_b represents the relative effectiveness of subsurface residue in consolidation, B_{ur} is mass density of live and dead roots found in the upper inch of soil, B_{us} is mass density of incorporated surface residue in the upper inch of soil, c_{uf} represents the impact of soil consolidation on the effectiveness of incorporated residue, and c_{ur} and c_{us}, are calibration coefficients indicating the impacts of the subsurface residues. According to our observations, the *PLU* sub-factor for the conventional tillage is 1.0, for the soil with oil press remains this sub-factor was 0.951, and for the tree scenario using olive leaves this valour was 0.5 (Table 3).

5.2. Canopy-Cover sub-factor, CC

The canopy-cover sub-factor expresses the effectiveness of vegetative canopy in reducing the energy of rainfall striking the soil surface. Although most rainfall intercepted by crop canopy eventually reaches the soil surface, it usually does so with much less energy than does rainfall that strikes the ground without having been intercepted. The intercepted raindrops fracture into smaller drops with less energy, or drip from leaf edges, or travel down crop stems to the ground. The canopy-cover effect is given as:

$$\mathrm{CC} = 1 - \mathrm{F_c} \times \exp(-0.1 \times \mathrm{H}) \quad (11)$$

where *CC* is the canopy-cover sub-factor ranging from 0 to 1, *F* is fraction of land surface covered by canopy, and *H* is distance that raindrops fall after striking the canopy. The valour for the tree scenarios, was computed similar because the conditions are identical, this sub-factor, is 1 (Table 3).

5.3. Surface-Cover sub-factor, SC

Surface cover affects erosion by reducing the transport capacity of runoff water, by ausing deposition in ponded areas, and by decreasing the surface area susceptible to raindrop impact. Surface cover includes crop residue, rocks, cryptogams, and other nonerodible material that is in direct contact with the soil surface. The effect of surface cover on soil erosion is given by:

$$\mathrm{SC} = \exp((-\mathrm{b} \times \mathrm{S_p} \times (0.24 / \mathrm{R_u})^{0.0.8}) \quad (12)$$

where *SC* is the surface-cover sub-factor, *b* is an empirical coefficient, *S*, is percentage of land area covered by surface cover, and *R* is surface roughness. We used the parameters recommended for Renard *et al*., (1997) for row crops, and a surface roughness value of 0.0127 m taken from Renard *et al*., (1997).

5.4. Surface-Roughness sub-factor, SR

Surface roughness has been shown to directly affect soil erosion, and to indirectly affect it through the impact on residue effectiveness. In either case, this is a function of the surface's random roughness, which is defined as the standard deviation of the surface elevations when changes due to land slope or non-random tillage marks (such as dead furrows, traffic marks, and disk marks) are removed from consideration. A rough surface has many depressions and barriers. During a rainfall event, these trap water and sediment, causing rough surfaces to erode at lower rates than do smooth surfaces under similar conditions. Increasing the surface roughness decreases the transport capacity and runoff detachment by reducing the flow velocity. The surface roughness sub-factor is then

$$SR = \exp(-0.66 \times (R_u - 0.24)) \quad (13)$$

5.5. Soil-Moisture sub-factor, SM

Following Renard *et al.*, (1997), we used a soil moisture sub-factor to account for seasonal variations in soil moisture content (0 = permanent wilting point, 1 = Field Capacity).

6. Support practice factor, P factor

The support practice factor (*P*) is the ratio of soil loss for a field under a support practice to the corresponding loss unit plot (Renard *et al.*, 1997). Support practices include contour tillage, strip-cropping, use of terraces, and subsurface drainage. P factor values do not take into account conservation tillage and other improved tillage practices considered in the C factor contribution. The small size and inconsistent dimensions of individual fields make these traditional conservation structures and support practices unworkable in Torredelcampo. For this study, the *P* factor applied to the area was 1.

RESTRICTIONS TO RUSLE MODEL

The RUSLE equation does not estimate deposition, sediment yield at downstream locations, ephemeral gully erosion, or provide information on sediment characteristic. The erosion estimates using RUSLE represent soil loss by sheet and rill erosion only on portions of the landscape where erosion, but not deposition (Renard *et al.*, 1991).

A potential source of error in erosion estimated is the selection of factor values that introduce parameter uncertainty (Risse *et al.*, 1993). Both the *C* factor and the *R* factor values used in the model reflect annual averages for land management contribution to erosion and do not take into account different contributions to erosion of the various stages of plant growth cycles.

It has been shown that the RUSLE and USLE tend to over predict soil loss on plots with lower erosion rates and under predict soil loss on plots with higher erosion rates (Risse *et al.*, 1993; Nearing, 1998).

RESULTS

1. Analytical characteristics

The soil is a Calcisol (FAO, 1998) with traditional orchard management in Jaen, Andalusia region (greatest olive grove of the world), in loam-limestone loam, the soil have a highly content of clay and silt (Table 2), the permeability is moderately slow and structure medium granular (Table 1), slow density (1.36 gr cm^{-3}), basic ph (8.4) slow nitrogen and organic matter are the principal characteristics. Gil (2003) found similar soil in olive orchard in Cordoba, Andalusia.

The increasing of olive leave and product of the two-step olive oil will process to soil cause alteration of the physical-chemical properties of soil, this alteration is greater in olive leave soil, the principal modifications are the clay losses (45.5 % to 31 %), and improving permeability, improving field capacity and available water reduced the effect on runoff and soil losses.

2. Comparison of climate variability

The xeric regime Mediterranean is characterized by low precipitations and the great variability of these. The calculation of the *FMI* (Equation 2), to calculate rainfall erosivity, shows two different scenes.

First from them it's obtained considering the precipitation's average values throughout the series of data, in this case the value of R is 69 MJ mm ha^{-1} h^{-1}.

The second scene, is made calculating the FMI for the rainiest year of the data series, obtaining itself a value of R of 165 MJ mm ha^{-1} h^{-1}. This difference between values of R is of 96 MJ mm ha^{-1} h^{-1}, this is 139 % more, this implies that the analysis of A (t ha^{-1} yr^{-1}) (Equation 1, Graphic 7) will vary very significantly depending that the years are dry or dunked.

3. Easing calculate LS components

The RUSLE manual equations (Equations 4, 5, 6, 7, 8) (Renard *et al.,* 1997), we can verify that calculate is long and sometimes complicated.

The equations before described for lengths of 100 m with the different values from slope (degrees), were calculated, in the following polynomial equation $y = -0.0128x^2 + 1.2035x$; $r^2 = 0.9678$ (Figure 2).

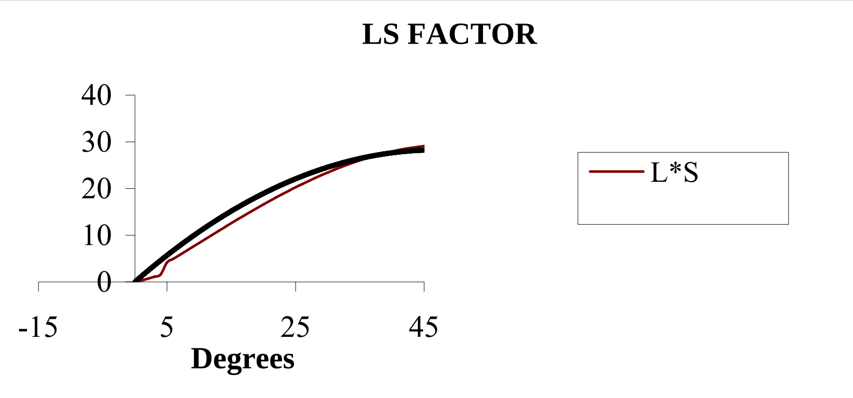


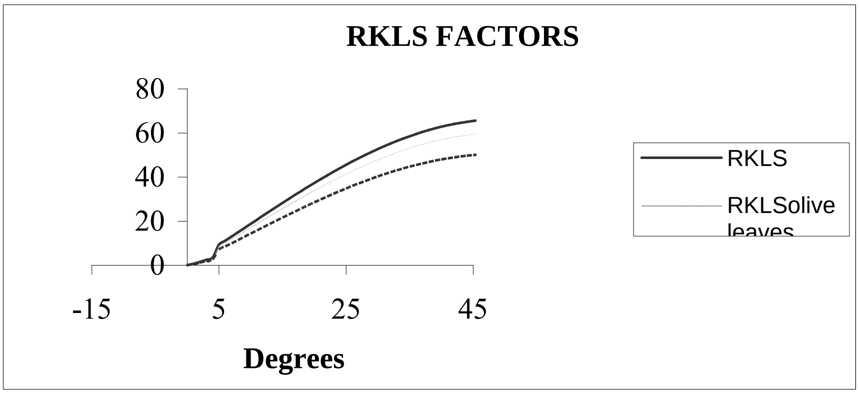
Figure 2. **Calculate LS factor**

The application of this equation accelerates the calculation of LS factors, from the values of the slope (S in degrees).

4. Analysis of different scenarios RKLS

The K calculated values (Equation 3, Table 1), indicate that the greater erodibility takes place in the reference ground; the different management handlings in olive orchards reduce the K values.

Adding 27 kg m^{-2} with product of the two-step olive oil will process, the erodibility is reduced 9.2 % (Table 1, Figure 3), remaining constant the permeability and becoming the structure but fine, this reduction of K value to constant RLS will cause that $RKLS$ is reduced 9.2 %.



Alpeorujo – product of the two-step olive oil will process.

Figure 3. **Values to RKLS factors**

The second scenario, sample that to additing 23 kg m^{-2} of olive leave to soil the erodibility was reduced a 23.6 %, this addition improves the permeability and the structure significantly, being reduced the percentage of clays, this reduction accelerates the soil's water incorporation, and therefore, its field capacity. As in the previous case, if *RKLS* studies jointly, we can observe that indeed a reduction of the 23.6 % in absolute terms exists.

5. Comparison of different soil management practices

When RUSLE is applied to a particular soil, the *R, K, L, S,* of equation 1 become fixed, and soil management effects are proportional to the different in the products of the *C* and *P* factors. Applying equation 9 and its sub-indices (Equation 10, 11, 12, 13), we can verify that the value maximum of cropping and management is the conventional tillage soil (Table 3, Figure 4), being reduced east value in 62 % and 85 % in product of the two-step olive oil will process and olive leaves respectively.

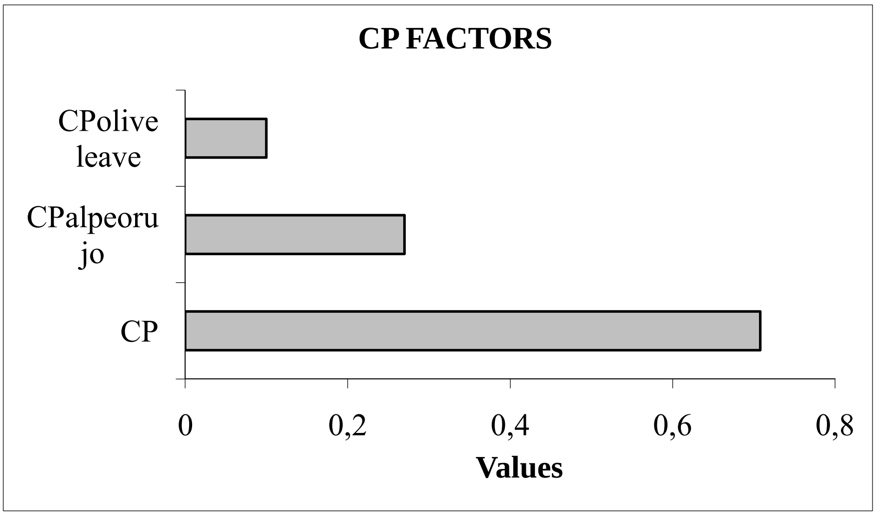


Figure 4. **Values to CP factors**

The main factors that take part in this reduction are the prior-land-use, the surface cover, and de surface-roughness, being this last constant in both cases.

The principal factor that affect is mass density of incorporated surface residue in the upper inch of soil.

P factor values do not take into account conservation tillage and other improved tillage practices considered in the *C* factor contribution. The small size and inconsistent dimensions of individual fields make these traditional conservation structures and support practices unworkable in Torredelcampo. For this study, a *P* factor of 1 was applied to the area. None of the studies cited included de *P* factor in their analyses, assuming a value of 1 in all cases.

6. Evaluation of risks in olive orchards under different conditions of slope-management

To illustrate affected the use of our parameterized RUSLE for evaluating erosion risks in olive orchards three cases were analysed.

The first scenario (Conventional tillage), were estimated soil losses in different slope conditions and 100 m long, typical olive orchards in hilly areas around Jaen. The Torredelcampo soil used in the simulation is described in Table 1 and 2. The model predictions shown in Figure 5, this result are similar that Moreira-Madueño (1991) for Montoro, and slow that the estimation realized for Gomez *et. al.,* (2003) in Cordoba. Although, in both cases are lightly slow. The soil losses values range to range between 0 t ha^{-1} yr^{-1} and 46.6 t ha^{-1} yr^{-1}, for slope between 0 – 45 degrees respectively.

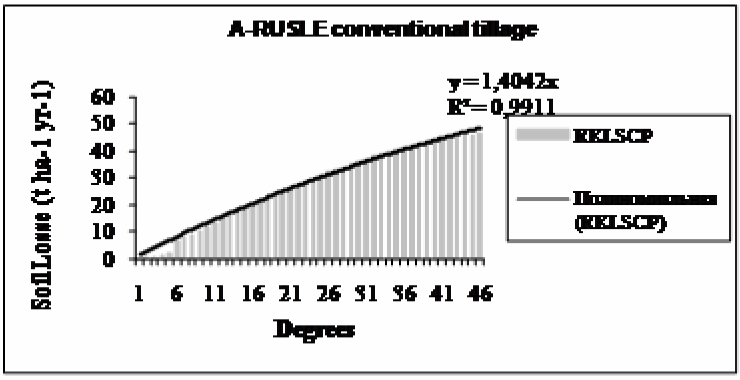


Figure 5. **Soil Loss – convencional tillage**

The second scenario illustrates the additing of product of the two-step olive oil will process to soil, the conditions were similar to conventional tillage. The soil losses values range between 0 t ha^{-1} yr^{-1} and 16 t ha^{-1} yr^{-1}, for slope between 0 – 45 degrees respectively (Figure 6).

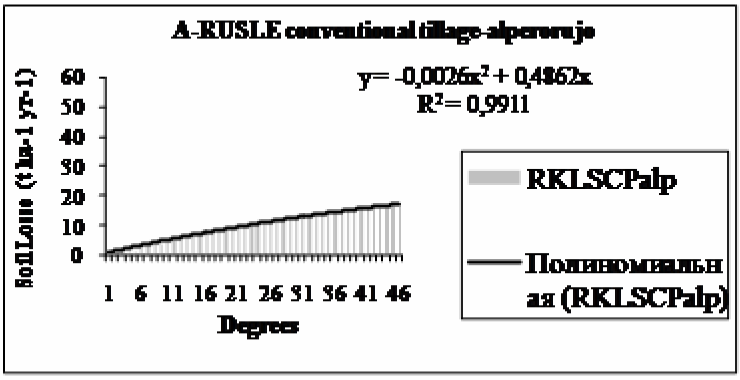


Figure 6. **Soil Loss- conventional tillage- alpeorujo**

The third scenario show the additing of olive leaves to soil, in the similars soils conditions. The soil losses values range between 0 t ha^{-1} yr^{-1} and 5 t ha^{-1} yr^{-1}, for slope between 0 – 45 degrees respectively (Figure 7).

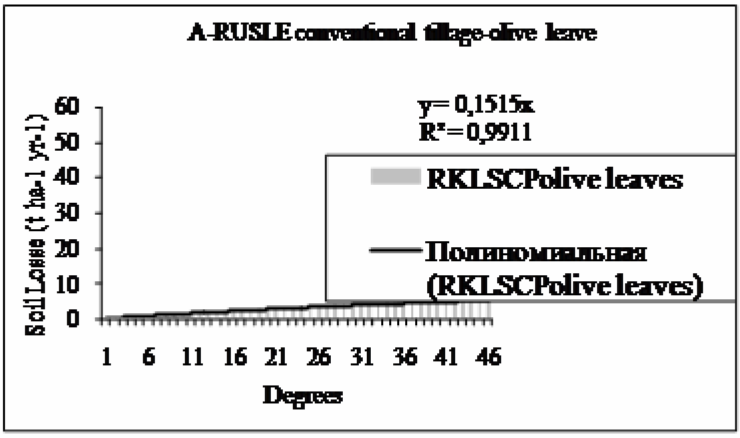


Figure 7. **Soil convencional tillage-olive leaves**

DISCUSSION

Olive groves addicted olive leaves and product of the two-step olive oil will process affect to chemical-physical properties, being very important to studying on soil loss in olive orchards. The consequence of this is the organic mater highly, the soils in the Mediterranean climate have a low organic matter content, poor structure and weak aggregate stability (Singer, 1991; Singer & Bissonnais 1996), the permeability is the best, low clay, every this make to low density, increasing the permeability to soil (Table 2), this analysis is similar to Gil (2003) and Moreira-Madueño (2001).

The impact of soil management doing highly permeability (Table 1), and low erodibility, can be 89 % low, in hills. The *R*-factor in the study area is 69 MJ mm ha^{-1} h^{-1}, can be 165 MJ mm ha^{-1} h^{-1} every years, when intensive rain, this effect cause a 220 % soil loss more, we can evaluated the impact of *R* values on soil loss in olive orchard (Figure 8). According to RUSLE manual (Renard, 1997), *S*-factor, have been made with more and less 9 % slope (Equation 7, 8). This quantification isn't lineal and it is long and sometimes complicated, we have calculated polynomial estimation (Figure 2), with R^2 = 0.9678, for 100 meters lengths (frequently in Mediterranean areas).

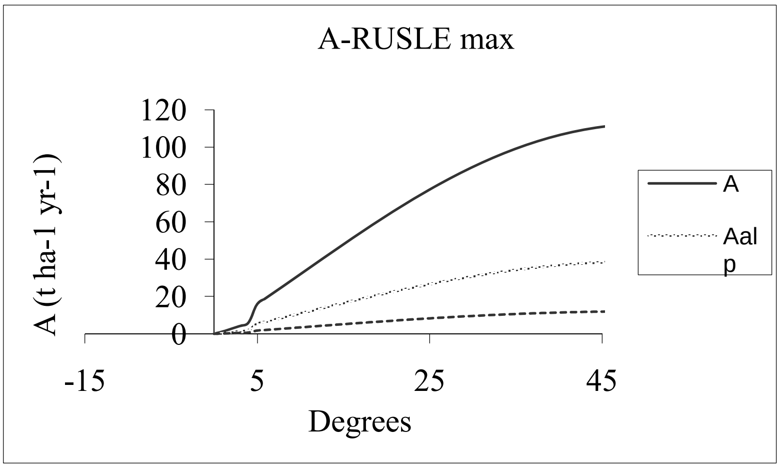


Figure 8. **Soil convencional tillage- Rmax**

With regard to the *C*-factor, values were reduced with addicted to oil leaves and product of the two-step olive oil will process, due to organic matter principally. All respect *P*-factor values do not take into account conservation tillage and other improved tillage practices considered in the *C* factor contribution. The small size and inconsistent dimensions of individual fields make these traditional conservation structures and support practices unworkable in Torredelcampo.

The impact of soil management in olive orchard with oil press remain is good, because limited the effect on runoff and soil losses.

CONCLUSION

The scarcity of experimental results on the rate of soil losses in olive orchard as affected by soil management have led us adopt the RUSLE model for evaluating the impact of various soil management methods on erosion in olive orchard. We conclude that addict oil press remain to be a good effective method for erosion control. The on-going studies should include an evaluation of the effects of soil management on soil conditions, with are not considered by the RUSLE, to improve our understanding of the system and to predict its change with time.

Our study offers the possibility of simulating the whole range of soil management techniques used in southern Spain to make a systematic comparison, so that future research is focused on issues relevant to the management methods that are most promising.

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