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Soil Erosion Aspects in Agricultural Ecosystem

Elena Comino, Paolo Marengo and Valentina Rolli
Land, Environment and Geoengineering Department Politecnico di Torino
C.so Duca degli Abruzzi, Torino
Italy

1. Introduction

Agricultural activities have an important role in the primary sector of Italian economy, favorable climate characteristics have guaranteed the developing of numerous agricultural products, along the whole national land.

Within the present work, vineyard cultivations have been studied with the aim to analyze the effects caused by the intense cultivation practices, evaluating the annual soil loss and the management methodologies causing an increase or decrease of the erosion phenomenon.

Traditional hillside viticulture uses deep and surface tillage, this technique, also due to increased mechanization, causes deterioration of soil physical characteristics, surface erosion, transport of sediment, nutrient leaching. Controlled grass covering of the inter-rows has proved to improve the stability of soil aggregation, to mitigate soil water erosion by reducing run-off.

Runoff and sediment transport were partially controlled when the vineyards had this structure and when the work was undertaken in the traditional manner with weeding and digging to maintain the soil. The use of tractor cultivation since the beginning of the 1950s has favored the creation of furrows which are able to collect water and to generate channels. The intensive use of chemical weed killers in the 1960s and the absence of cultivation under the plants have enhanced the erosion processes which threaten the long term sustainability of the soil.

Our studies have been focused on the North-West Italy, in Monferrato area, that is characterized by hills landscape and vineyard cultivations. In presence of agricultural activities on sloping lands, the erosion phenomena could be very dangerous in terms of soil loss from organic matter, of great importance for plants growth and landscape quality. Erosive phenomena can be determined by atmospheric agents, but the most important, in terms of generated effects is rain. The erosion caused by rainfall events can be expressed in different ways, referring to the intensity (mm/h), or the water height (mm) and the kinetic energy. The rainfall erosion determines an effect, both in consequence of the rain drop impact, both for water volume flowing along the slope, in case of high intensity. The effect caused by rain impact (splash erosion) is also dependent to the drop dimensions, the erosion effects could be higher if drops increase in size and in velocity. Velocity changes with the height rainfall, it increases and become constant in a distance of 20 m from the soil impact (terminal velocity), that is reached when the drop weight is balanced by the air resistance.

The rain impacts on soil, influences the soil erodibility that represents soil susceptibility to be eroded. The parameters involved in soil erodibility are soil aggregation, consistency and soil strength. Soil erodibility could be divided in two aspects, the first is the detachability and the second the transportability. In relation to the soil characteristics (i.e. texture), one aspects can be predominant on the others. The transportability of the soil is the most significant phenomenon, especially in presence of intense rainfall and considerable slope of the soil (hills cultivation). The effects of this common combination of factors is represented by channels/rills (that could reach deep dimension), representing the preferential roads causing soil removal. In consequence of the geometric characteristic of the soil (i.e. its slope), a first phase of transportability of the detached soil can be substituted by a deposit in a soil part with a minor slope degree.

The soil sediment transport phase, named runoff, is caused by numerous small channels that are known as rills and the phenomenon is the rills erosion. The soil parts between two or more rills are named interrill and also here erosion occurs, the interrill erosion. Rill and interrill erosion represent the overland flow and are considered diffuse erosion. In the interrill area the rain drop impact and superficial flow are the principle factors responsible of soil erosion, while in rills, soil detachability is caused by water flowing in channels. In presence of cultivated soil, rills have limited deep and length because the superficial morphology of the soil is frequently changed by the agricultural activities (mechanization), and soil micro-topography represents an important aspect influencing the rills characteristics. In Fig 1 has been possible to see as, in not cultivated soil, rills are more defined and deep and length can be interest the whole slope.

The soil loss and the rills formation represent a dangerous threat for vineyards, because determine the removal of a consistent part of organic matter useful for plant growth. Different methodologies are commonly used to reduce the erosion phenomena, as the vineyard arrangement along the contour line in order to break the water flow in the maximum slope lines. Another widespread alternative consists in the contribution provided by spontaneous vegetation growing in the vineyards inter-rows. Nevertheless in the first years (4-5 years) of the vineyard plantation, spontaneous vegetation is not present for the competition developed with vineyard plants, while is recommended after the start-up period. Vegetation provided a contribution against soil loss (De Baets et al. 2006) because limits the impact caused by water splash phenomenon on bared soil and the superficial runoff, increases the soil porosity and improves the water infiltration, reducing the soil compaction. In soil with high water content, vegetation can reduce the moisture level, avoiding also the roots asphyxia phenomenon. Vegetation represents also a source of organic matter for soil enrichment, but needs of management for growth control as the periodical cut or the weed-killer treatment around the plant trunks.

On the other side, vegetation can compromise the vineyard health in cases of water deficit or in areas characterized by limited water availability.

Numerous tests realized in situ on small soil plots (Arnaez et al., 2007) or bigger portion of vineyards (Tropeano, 1984; Cavallo et al. 2010), have demonstrated a reduction of soil loss during simulated or natural events, in presence of vegetated soil, because cover vegetation reduces the kinetic energy of drops impacting on soil and the consequence caused by rills formation.

Fig. 1. Rill erosion on bared soil

The natural erosion phenomenon has been reproduced by simulated events using an experimental equipment on a small soil portion and by the software modeling on slope scale adopting three models most widespread in literature, as showed in Fig.2.

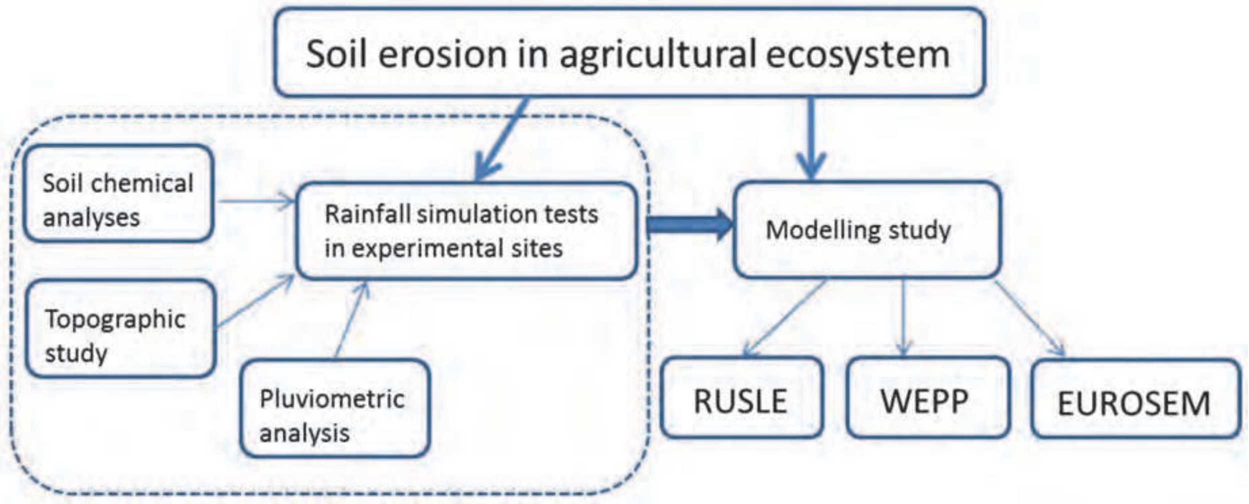

Fig. 2. Scheme of the experimental framework

2. Experimental device

The erosion effects caused by natural meteorological events have been studied through numerous tests simulating rainfall phenomena.

A simulator equipment has been built testing clods of 1 m^2 with different characteristics of moisture, soil topography, micro-topography and cover vegetation.

The simulator structure has been realized based on pre-existent models of previous research (Cerdà et al. 1997), Fig.3 represents the instrument used in situ for the rainfall tests. The simulator has a superior base of 0.40 x 0.40 cm where the nozzle (Spraying Systems 1/2HH-30WSQ and 1/4HH-14WSQ), was inserted (Fig.4). The rainfall simulator had four telescopic legs reaching a maximum height of 3.50 meters. In our tests the simulator height has been fixed to 2 m as suggested by previous research (Humphry et al. 2002; Arnaez et al. 2007).

Fig. 3. Experimental equipment

Fig. 4. Superior base and nozzle

Other important aspect is represented by the wind protection for simulated rainfall. A protection realized by plastic sheets, has been used as cover simulator to be sure that rain impacts on analysed soil. Through this system wind did not influence the rain direction and the general result of the tests (Fig.5).
The delimitation of the clod interested by the test has been realized by two thin metal sheets of 1m length for each of three sides and inserted within the soil to stop the water runoff in the tested clod (Fig.6).

Fig. 5. In situ rainfall test

Fig. 6. Wind protection

In the forth side, that is the downslope side, an iron gutter pipe has been positioned with the function to reach all the detached runoff from the tested clod. The gutter pipe is connected by a tube to the sample tank for the subsequent laboratory analyses for the sediment estimation. The rain drops have been simulated using nozzles already proposed in previous case studies (Covert and Jordan 2009)., A pressure gauge has been introduced to measure the pressure of the water before the nozzle exit, between the water tube and the nozzle. Water was available through a tank and a pump positioned near the tested clod.

A calibration of the simulator has been realized before the in situ tests, in order to establish the rain intensity. The chosen intensities present similar characteristics to the real natural values, obtained by a rainfall analysis realized in the meteorological stations nearer to the experimental sites.

The three different nozzle have been used reproducing three different intensity: 40, 80 and 130 mm/h. Last intensity (130 mm/h) is typical of short but very strong summer events. The length of the rainfall events has been set to 20 min, while for the stronger events only 10 min, because more representative.

During the simulation numerous samples (water and sediment), have been collected in order to monitor the runoff during the test. It was established that the first information was the starting runoff. The subsequent sampling was realized each 5 minutes and its sampling time was 1 min.

The collected samples (4 or 5 in consequence of the starting runoff time), have been analysed through laboratory tests by which the samples have been dried in oven at 105° C for 24 hours. The dried matter permits to know the runoff amount and sediment soil loss distribution during the whole test length.

3. Experimental site

The experimental sites, choose for the realization of the rainfall simulated tests, involve vineyards with different characteristics. In presence of slope, the methodology for plant cultivation can be adapted to the soil characteristic and agricultural management. The most widespread techniques, concern the row plants disposal along the contour line or perpendicular to them, following the maximum slope lines. The experimental site analysed during the following tests present the contour line configuration of plantation, is in Piedmont region (North-West Italy), in a typical hill area named *Monferrato*. The experimental site is located in Castel Boglione town (near to Nizza Monferrato and Acqui Terme towns). Castel Boglione is extended on 12 km^2 at 260m a.s.l. *Monferrato* area involves the provinces of Asti and Alessandria and is almost exclusively characterized by hills. *Monferrato* area can be divided in three parts, *Low Monferrato*, including Alessandria province between Po and Tanaro rivers; *Up Monferrato* in South direction Between Bormida valley and Ligurian Appennino and the *Monferrato Astigiano* including the Asti province, delimited by Belbo and Versa torrents.

The experimental site is located at 200 m a.s.l. (4 km far from Nizza Monferrato), between the *Monferrato Astigiano* and *Up Monferrato* areas (Fig.7, 8).

The studied vineyard presents a cultivation of *Barbera* grapevine (typical of Piedmont region) and a disposal on row following the natural contour lines. Soil has been analyzed through chemical and physical analysis. The soil has a fine texture with a plasticity index > 40 and classified by the USDA classification as clay-loam, with the following percentage (Fig.9).

The chemical-physical analysis showed the soil as alkaline, with mean calcareous content and low content of organic matter.

Fig. 7. Aerial image of experimental site

Fig. 8. Reference vineyard

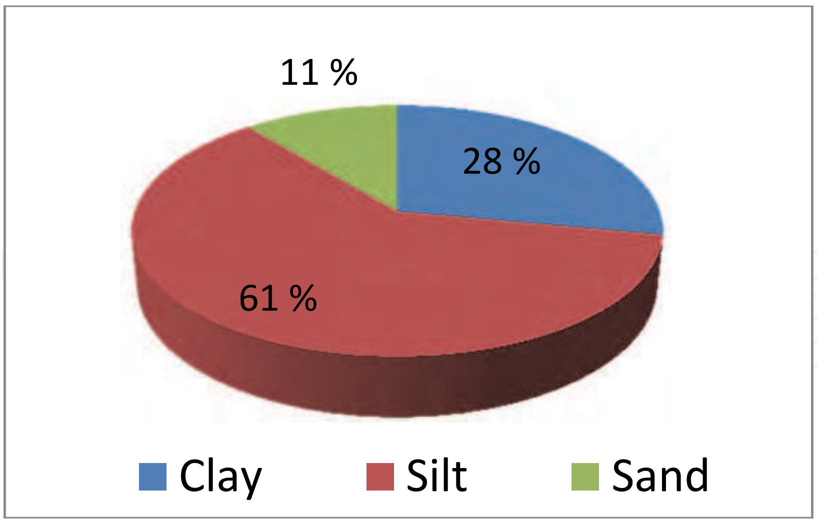

Fig. 9. Percentage of soil texture

Main soil parameters	
pH	*8.4*
Organic matter (%)	*1.87*
Carbonates (%)	*23.08*
Phosphorous (mg/Kg)	*52.1*
Potassium (mg/Kg)	*185.4*
Calcium (mg/Kg)	*3054.62*
Total Nitrogen (%)	*0.37*
Magnesium (mg/Kg)	*18.4*

Table 1. Main chemical parameters monitored in tested soil

Examined soil presents high cationic exchange with high Phosphorous, Potassium, Calcium and Nitrogen level, while content of Magnesium and Ammonium is low (Table 1).

4. Climatic and pluviometric analysis

Piedmont region is characterized by different climatic areas as consequence of co-existence of mountain, hill and plane areas. The North-West part of the region is surrounded by mountains reaching also 4000 m, characterized by cold climate and persistent snow. Hills and plane lands are not so far from mountain area, but present better climatic characteristics (temperate sub-continental), permitting numerous agricultural activities as vineyards cultivation. The rainfall events are more frequent in spring and autumn, especially in the mountain area, while are less consistent in the south plane part of the region. The rainfall events are also conditioned from the direction of the air masses: when they comes from South to North the presence of mountains create a limits and the rainfall events are more frequent on the hill and plane part of the region (Perosino and Zaccara, 2006).

The pluviometric analysis has been based on the data provided by the Hydrological Annals of the meteorological station of Nizza Monferrato and Acqui Terme in a period between 1915 and 2009. The monthly precipitation have been used for the definition of the mean values; the maximum annual values at 1, 2, 6, 12 and 24 hours, have been used for the definition of the pluviometric probability curves for maximum length of 1 day and return time of 5, 10, 15, 20, 25, 30, 40 and 50 years. Maximum values at 10, 20, 30 and 60 minutes have been used for the reconstruction of significant erosive events in a time period between 1994 and 2004.

The absence of pluviometric data in correspondence of 1915-1930, 1940-1949 determined an analysis realized on shorter period (not referred to the whole period 1915-2009), and the mean values have been subsequently compared.

MEAN MONTHLY AND ANNUAL PRECIPITATION (mm)									
	1915-1919	1920-1929	1930-1939	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009
January	71	54	40	35	26	71	44	54	31
February	49	50	39	49	47	57	39	23	35
March	113	79	52	47	53	81	98	31	40
April	91	69	60	80	74	38	69	72	82
May	148	46	90	74	34	69	65	70	79
June	57	25	43	40	34	29	38	47	34
July	43	37	41	42	25	25	15	23	35
August	26	31	49	36	31	49	70	35	72
September	140	78	76	51	57	46	34	106	70
October	110	69	57	80	84	129	100	87	73
November	78	101	114	107	90	51	65	71	102
December	79	58	56	75	43	60	29	40	54
Annual	**1005.0**	**694.7**	**716.2**	**716.7**	**589.7**	**705.6**	**666.9**	**658.8**	**704.7**

Table 2. Pluviometric analysis summary describing the monthly and annual mean precipitation

Table 2 represents the mean monthly and annual precipitation in the nearer meteorological stations to the experimental site. Referring to the annual precipitation values, it has been possible to see that except for the first value, the mean value for the subsequent decades is about 700 mm.

5. Topographic analysis

The experimental site present a vineyard cultivation following the contour lines. Topographic relief has been realized through a total station in order to obtain a planimetric image of the tested area and some transversal sections. The relief has been realized from the down slope point and represents a cultivated field with 22 rows of plant with a distance of 2.70m.

SECTION	MEAN SLOPE
1	28.9 %
2	25.8 %
3	23.4 %
4	23.9 %

Table 3. Main studied section for slope determination

Four transversal sections have been traced for the definition of the mean slope (Table 3).
Fig. 10 represents the plan design of the whole experimental site while the Fig. 11 is the second section with a slope of 25.8%.

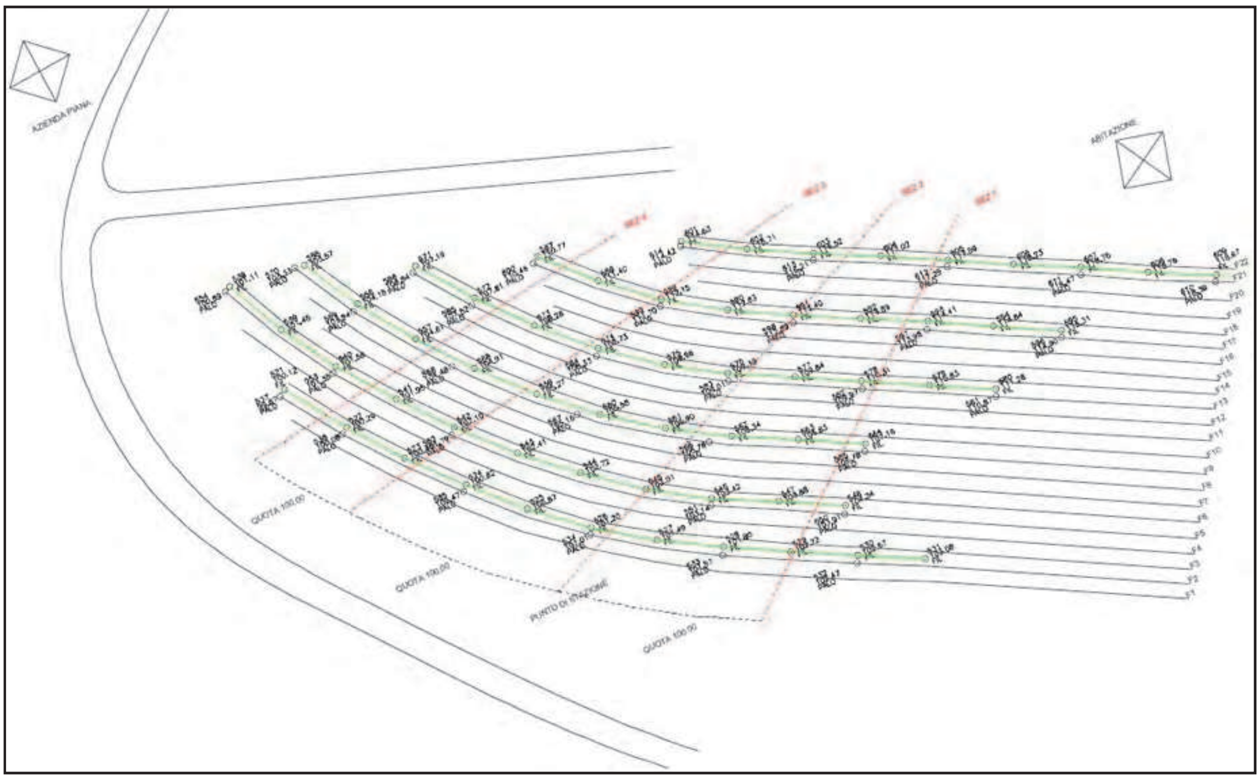

Fig. 10. Output of the topographic analysis on tested vineyard

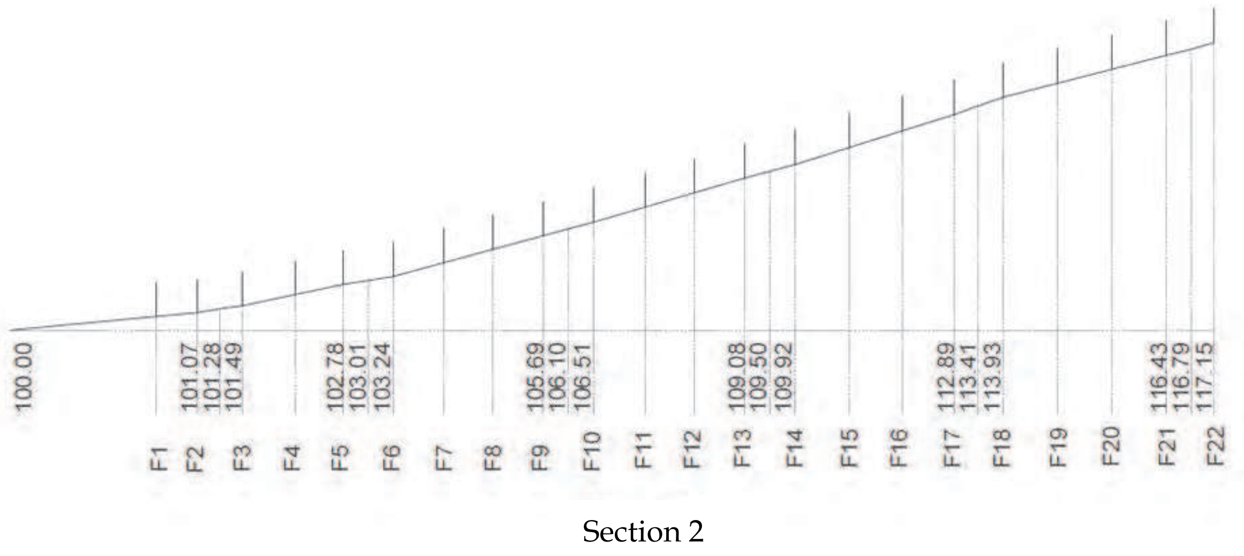

Fig. 11. Profile of section 2

6. Models description

Soil models tend to over-predict erosion for small measured values and under–predict erosion for large measured values. Risse at.al (1993) applied the empirically based USLE model, Universal Soil Loss Equation (Wischmeier and Smith, 1978) to simulate erosion from natural run-off (Nearing, 1998). Although the original USLE has been retained in RUSLE, the technology for factor evaluation has been altered and new data have been introduced with which to evaluate the terms for specified conditions.

The USDA - Water Erosion Prediction Project (WEPP) model represents a new erosion prediction technology based on fundamentals of stochastic weather generation, infiltration theory, hydrology, soil physics, plant science, hydraulics, and erosion mechanics. The hillslope or landscape profile application of the model provides major advantages over existing erosion prediction technology. The most notable advantages include capabilities for estimating spatial and temporal distributions of soil loss (net soil loss for an entire hillslope or for each point on a slope profile can be estimated on a daily, monthly, or average annual basis), and since the model is process-based it can be extrapolated to a broad range of conditions that may not be practical or economical to field test (Flanagan et al., 1995).

The European Soil Erosion Model (EUROSEM) is the result of European Commission funded research involving scientists from Europe and the USA. The model simulates erosion on an event basis for fields and small catchments. It uses physical descriptions to describe the process of soil erosion and is fully dynamic.

6.1 RUSLE

The Revised Universal Loss Equation (RUSLE) is an empiric soil erosion model, based on a multiplicative equation that predicts the amount of soil lost per hectare per year due to water erosion (sheet and rill erosion only). The RUSLE equation has been developed by the NRCS (Natural Resources and Conservation Services, a branch of the U.S. Department of Agriculture) over the course of the last 40 years.

The Universal Soil Loss Equation (USLE) model was based on the first concept of the separation and transport of particles from rainfall by Wischmeier and Smith (1965) in order to calculate the amount of soil erosion in agricultural becoming widely used and accepted empirical soil erosion model developed for sheet and rill erosion based on a large set of experimental data from agricultural plots.

The USLE has been enhanced during the past 30 years by a number of researchers. Modified Universal Soil Loss Equation (MUSLE) (Williams, 1975), Revised Universal Soil Loss Equation RUSLE (Renard et al., 1997), Areal Nonpoint Source Watershed Environmental Resources Simulation (ANSWERS) and Unit Stream Power Erosion Deposition (USPED) represent an improvement of the former USLE equation. In 1996, when the U.S. Department of Agriculture (USDA) developed a method for calculating the amount of soil erosion under soil conditions besides pilot sites such as pastures or forests, RUSLE was announced to add many factors such as the revision of the weather factor, the development of the soil erosion factor depending on seasonal changes, the development of a new calculation procedure to calculate the cover vegetation factor, and the revision of the length and gradient of slope. The equation (1) of the RUSLE model is formed by 5 factors involved in the water erosion phenomena.

$$A\ (t/ha/y) = R \times K \times LS \times C \times P \tag{1}$$

where:

A = the predicted average annual soil loss from interrill (sheet) and rill erosion from rainfall and associated overland flow. Units for factor values are usually selected so that "A" is expressed in tons per hectare per year.

R = Rainfall-Runoff Erosivity Factor. "R" is an indication of the two most important characteristics of storm
erosivity: (1) amount of rainfall and (2) peak intensity sustained over an extended period of time. Erosivity for a single storm is the product of the storm's energy **E** and its maximum 30 minute intensity **I30** for qualifying storms. There are many equations that estimate the R parameter.

K = Soil Erodibility Factor. "K" values represent the susceptibility of soil to erosion and the amount and rate of runoff, as measured under the standard unit plot condition.

LS = Slope Length and Steepness Factor. The slope length "L" and steepness "S" factors are combined into the "LS" factor in the RUSLE equation. A "LS" value represents the relationship of the actual field slope condition to the unit plot.

C = Cover-Management Factor. "C" represents the effect of plants, soil cover, soil biomass, and soil disturbing activities on soil erosion. RUSLE uses a subfactor method to compute soil loss ratios, which are the ratios of soil loss at any given time in a cover-management sequence to soil loss from the unit plot. Soil loss ratios vary with time as canopy, ground cover, soil biomass and consolidation change. A "C" factor value is an average soil loss ratio weighted according to the distribution of "R" during the year. The subfactors used to compute a soil loss ratio value are canopy, surface cover, surface roughness, and prior land use.

P = Support Practices Factor. "P" represents the impact of support practices on erosion rates. "P" is the ratio of soil loss from an area with supporting practices in place to that from an identical area without any supporting practices. Most support practices affect erosion by redirecting runoff or reducing its transport capacity. Support practices include contour farming, cross-slope farming, buffer strips, stripcropping, and terraces.

6.2 EUROSEM model

EUROSEM model (European soil Erosion Model) has been created by a European group of researchers at the end of '90 and has been based on the KINEROS program developed by Wollhsier et al (1990). EUROSEM model provided an erosion estimation due to rainfall and superficial runoff.

EUROSEM considers different aspects of the erosive phenomenon as

- drop interception due to the vegetative cover,
- volume and the kinetic energy of the rain drops,
- stagnation of water on soil for the micro-topography,
- runoff and sediment deposit.

The hydrographic basin has been represented by skew plains and channels that are respectively slopes and the hydrographic network (Fig.11).

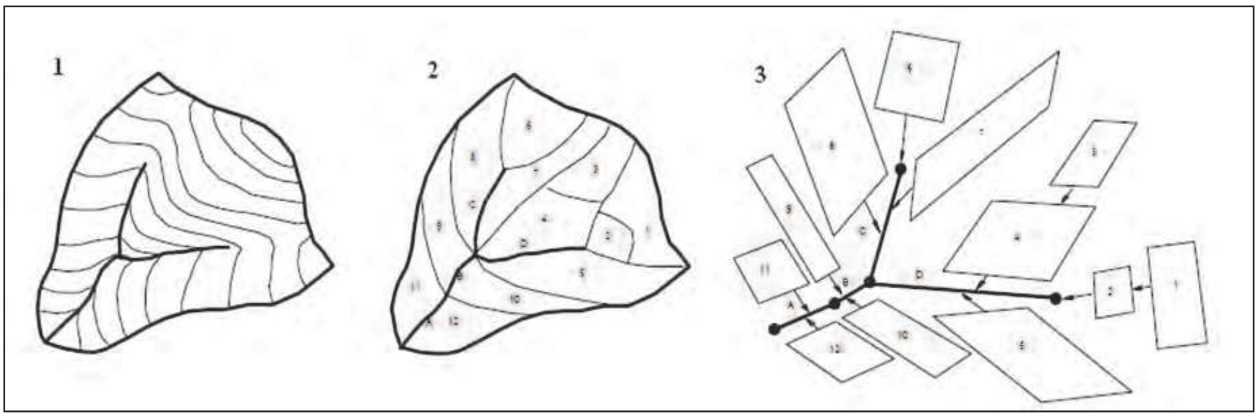

Fig. 12. EUROSEM plain and channels representation

EUROSEM model is based on the following mass transport equation (2):

$$\frac{\partial(AC)}{\partial t}+\frac{\partial(QC)}{\partial x}-e(t,x)=q_S(x,t) \tag{2}$$

Where:

- C (m^3 *m^{-3}) is the sediment concentration in the flow
- A (m^2) is the flow transversal area
- Q (m^3*s^{-1}) is the water flood
- q_s (m^2*s^{-1}) is the sediment removal for unit length flow
- *e* (m^2*s^{-1}) is the superficial erosion
- *x* (m) is the longitudinal coordinate
- *t* (s) is the time

The slope can be also represented by a interril-rill scheme considering an overland flow running on soil surface.

EUROSEM can model the slope in two different versions, the first does not consider the presence of rills but only a superficial irregularity of soil, the second considers the rills as channels for the transport of the water flow coming from the interril. In the first case the soil surface is considered as interril area and the flow direction is the maximum slope. In the second case the overland flow is directed to the rills channels with a slope (decided by EUROSEM), that is 1.4 time that of the plain element.

6.3 WEPP model

WEPP model (Water Erosion Prediction Project), has been created in the U.S.A. and represents one of the most advanced mechanistic model. WEPP could be applied to the temporal scale of the single event or to a multi-year events. The erosion estimation, by *profile* version, can be calculated on the slope scale or on a smaller surface (few square meters), while the *watershed* version permits the estimation for a small catchment. The *grid* model version guarantees a better results because the analyzed soil can be sub-divided and the mesh gives an higher precision in the results.

WEPP model has been based on seven different aspect concerning climate, water infiltration, hydric balance, vegetation, runoff, erosion and water transport in the hydrographic network; the model needs of numerous input data.

WEPP model permits to solve the lack of numerous detailed information. For example, inserting information about a short climatic period, the model compares them with other information present in the software libraries. In relation to the probability of a precipitation each day can be classified as wet (in presence of a precipitation), or dry (in absence of precipitation). The precipitation is considered water if the air temperature is higher than 0°C, otherwise is considered snow. Thanks to this approach is possible to obtain the hyetograph, knowing the total precipitation height. The water intensity is also important for the definition of the water infiltration percentage and the superficial runoff. The infiltration phenomenon is based on the Green and Ampt equation (1911), modified by Mein and Larson (1973) for constant intensity event and by Chu (1978), for variable intensity. The water partitioning between infiltration and runoff depends on hydraulic conductivity and saturation. If no detailed information are available the soil texture and cationic exchange are sufficient, and can be considered constant or variable i.e. for the presence of vegetation or soil management practices.

The water balance permits the estimation of the evapotranspiration rate, deep infiltration and interception by root systems. Vegetation is considered both in the alive part and in the decomposition part that can contribute to the runoff and the solid sediment transported.

WEPP model uses a geometric scheme based on a rill-interrill configuration dividing the slope in a sequences of homogenous areas (homogeneous in relation on the model parameters), in order to transfer all the results about the runoff and erosion values to the subsequent surface in the motion direction. The erosion component of the model calculates the soil detachment and the deposition along the profile that is subdivided in small parts. In the interrill the detachment is consequence of the rain impact. This portion of sediment is transported by the overland flow originated during the event reaching rills where can be transported within them or remain as deposit.

7. Results

The application of RUSLE model in the experimental vineyard gave as outputs the data set in table 4 and showed in Fig.13, that correspond to different percentage of cover vegetation.

MEAN ANNUAL SOIL LOSS (t ha^{-1} y^{-1})				
Parameters	**20%**	**40%**	**60%**	**80%**
R	101,19	101,19	101,19	101,19
K	0,40	0,40	0,40	0,40
L	1,90	1,90	1,90	1,90
S	1,81	1,81	1,81	1,81
C	0,20	0,10	0,04	0,01
P	1,00	1,00	1,00	1,00
A	**27,84**	**13,92**	**5,85**	**1,81**

Table 4. RUSLE model results in terms of soil loss varying the cover vegetation

Increasing the cover vegetation from 20 to 80%, the soil loss values significantly decrease from 28 to 2 t/ha*y.

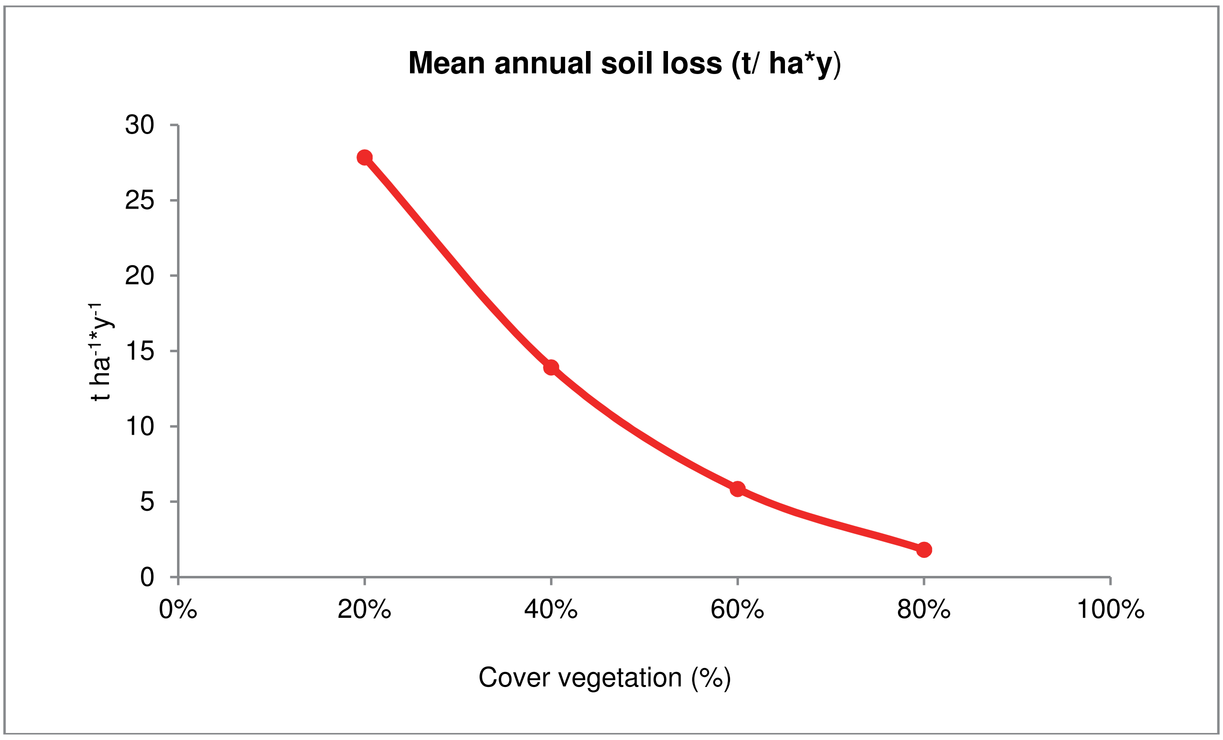

Fig. 13. Mean annual soil loss by WEPP simulation

Fig. 14, 15 represent the WEPP outputs for rain intensities of 40 and 80 mm/h in correspondence of two percentages of cover vegetation (70 and 10%). The rainfall events have variable duration from 10 to 40 minutes.

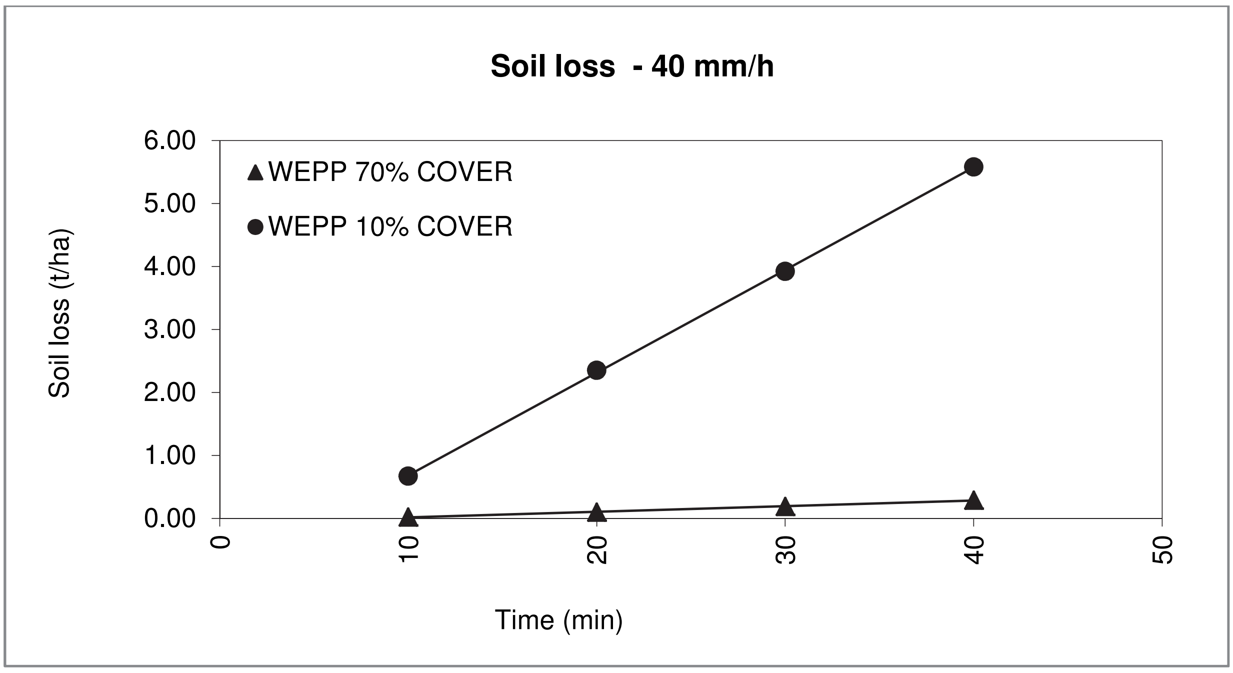

Fig. 14. WEPP soil loss simulation for different cover vegetation at 40mm/h

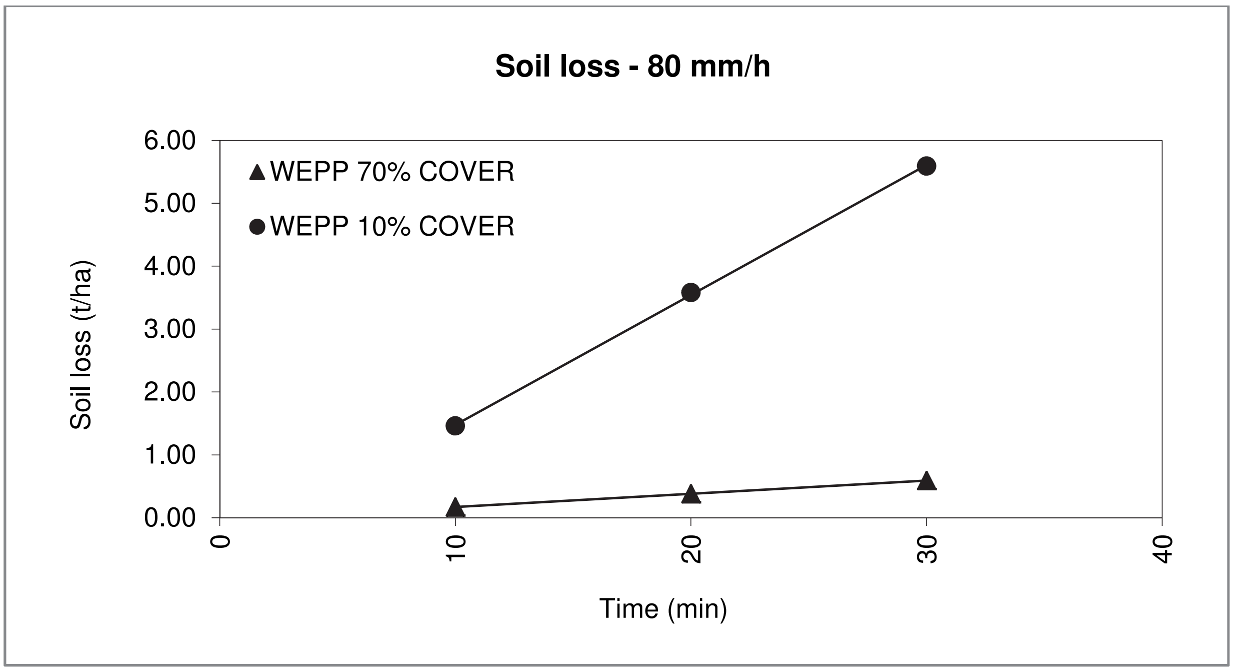

Fig. 15. WEPP soil loss simulation for different cover vegetation at 80mm/h

For both intensities (Fig.14, 15), soil with a low cover vegetation is much more threated by erosion phenomenon. This trend is more evident increasing the rainfall event duration.

Another sensible studied factor is the soil slope percentage. In the study case has been demonstrated that the increase of soil slope causes an higher soil loss. This trend is much more visible for stronger events characterized by an higher intensity and long duration (Fig.16, 17), where at 30 minutes the soil loss on 20% of soil slope is about 0.35 t/ha*y and on 29% of soil slope the soil loss is 0.6 t/ha*y.

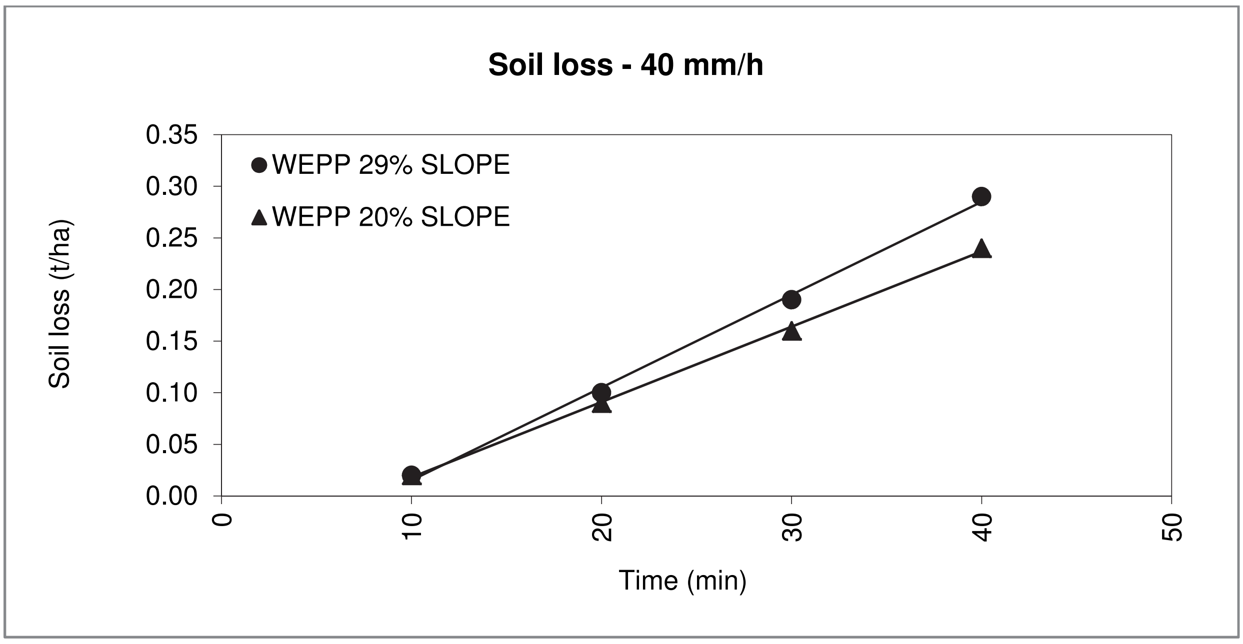

Fig. 16. WEPP soil loss simulation for different soil slope at 40 mm/h

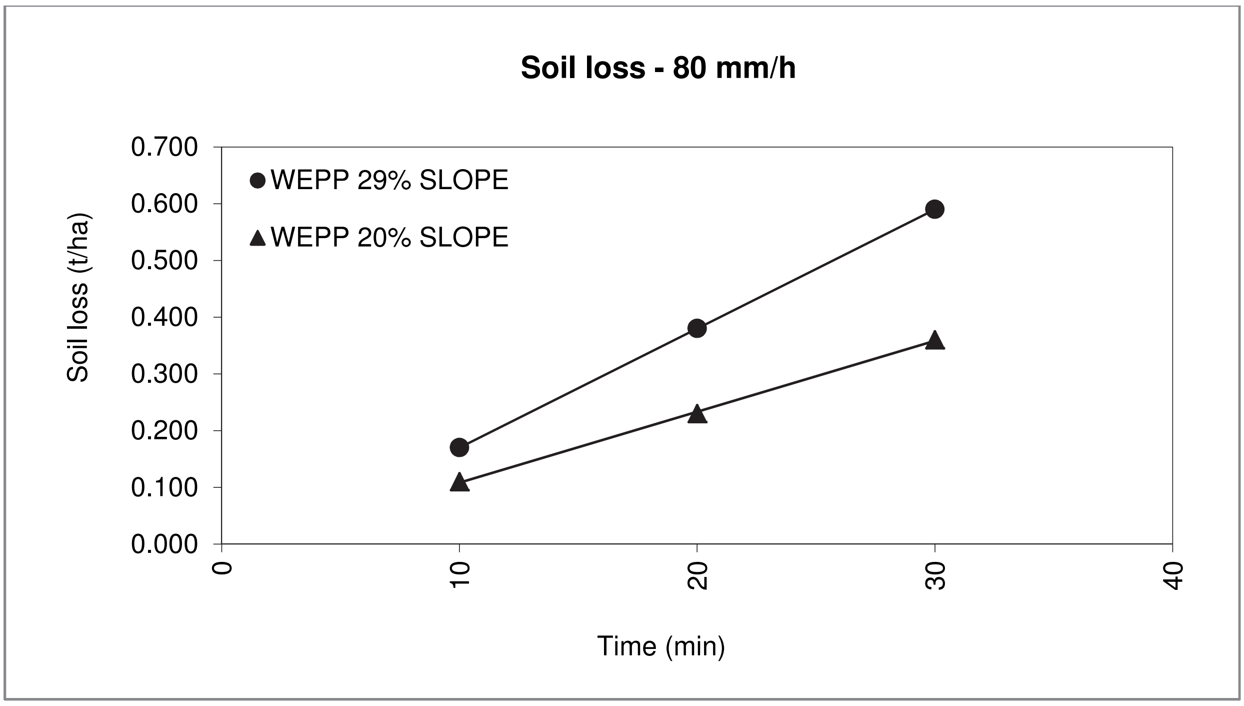

Fig. 17. WEPP soil loss simulation for different soil slope at 80 mm/h

EUROSEM model can be useful for the definition of the erosive effects caused by single events characterized by steps of intensity. Fig. 18, 19 below represent the estimation in terms of tons per year of soil loss for a single event with intensity characterized as follow.

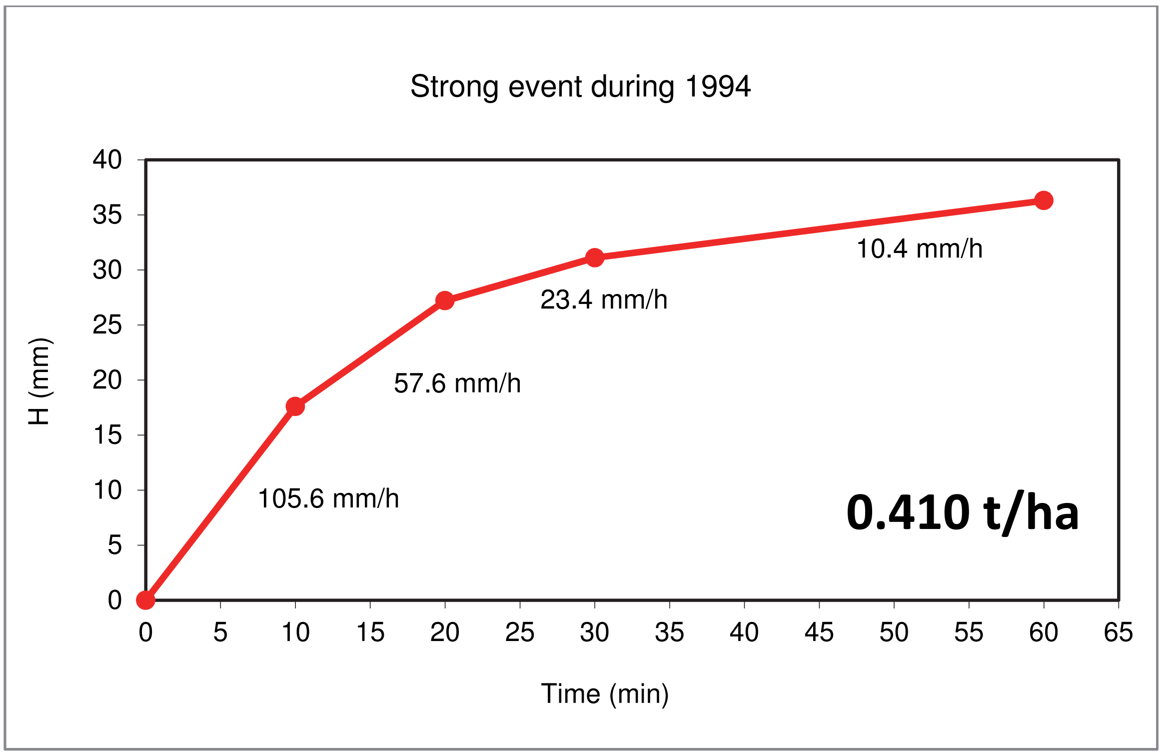

Fig. 18. EUROSEM simulation for event with variable intensities (1994)

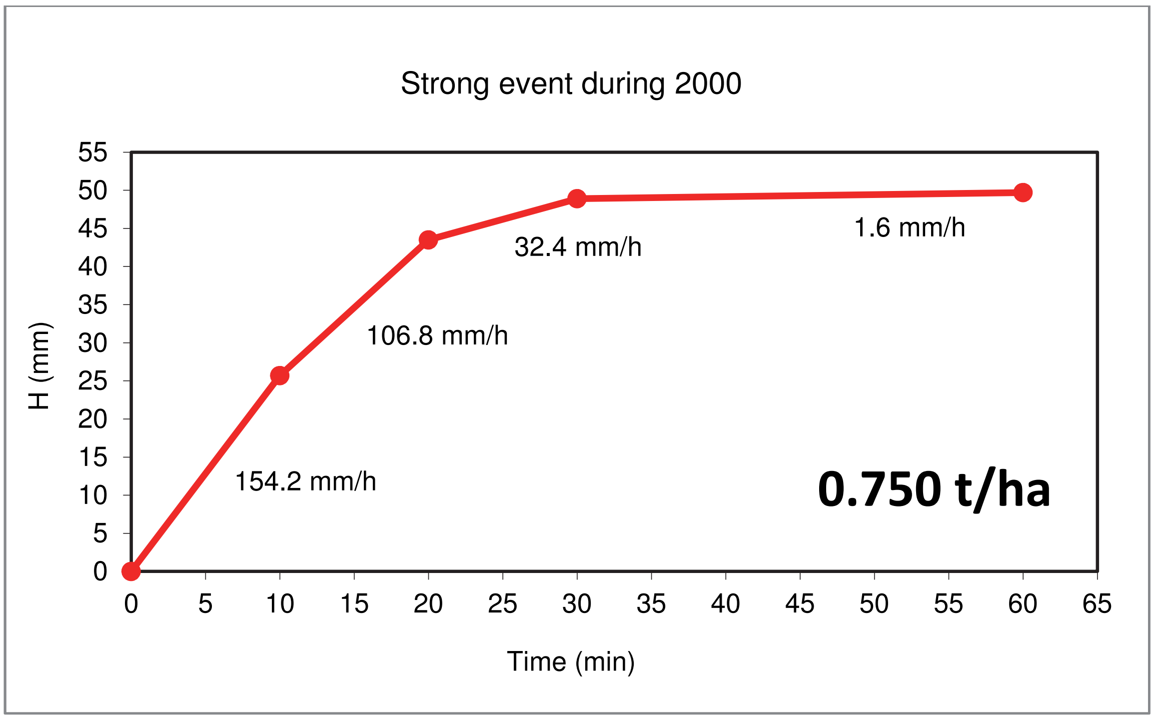

Fig. 19. EUROSEM simulation for event with variable intensities (2000)

The implementation of input parameters in WEPP (Flanagan anf Frankerberger, 2002) and EUROSEM (Morgan et al. 1998) models showed different trends of soil loss for different rainfall intensities and percentage of soil slope. In Fig.20, 21 the slope percentage is a mean value (29%) measured by the topographic analysis.

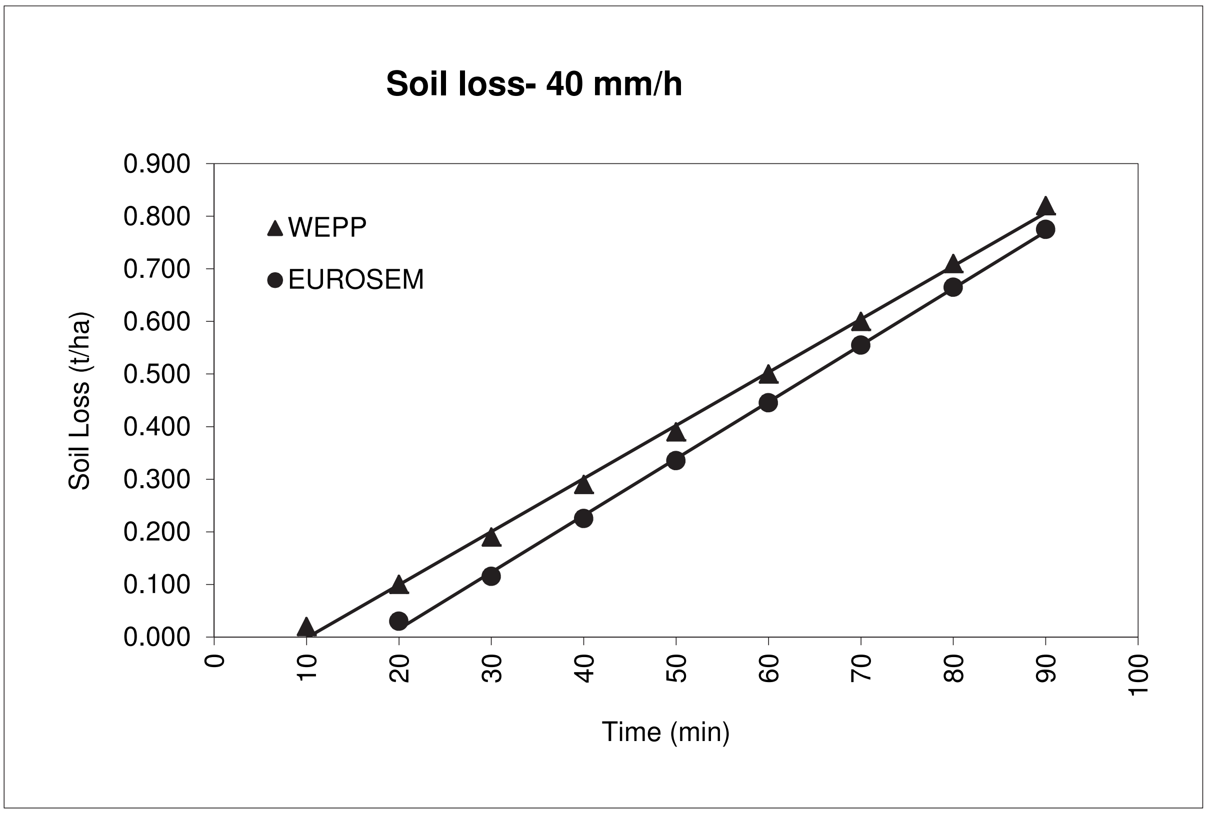

Fig. 20. WEPP and EUROSEM results for rainfall events of 40 mm/h

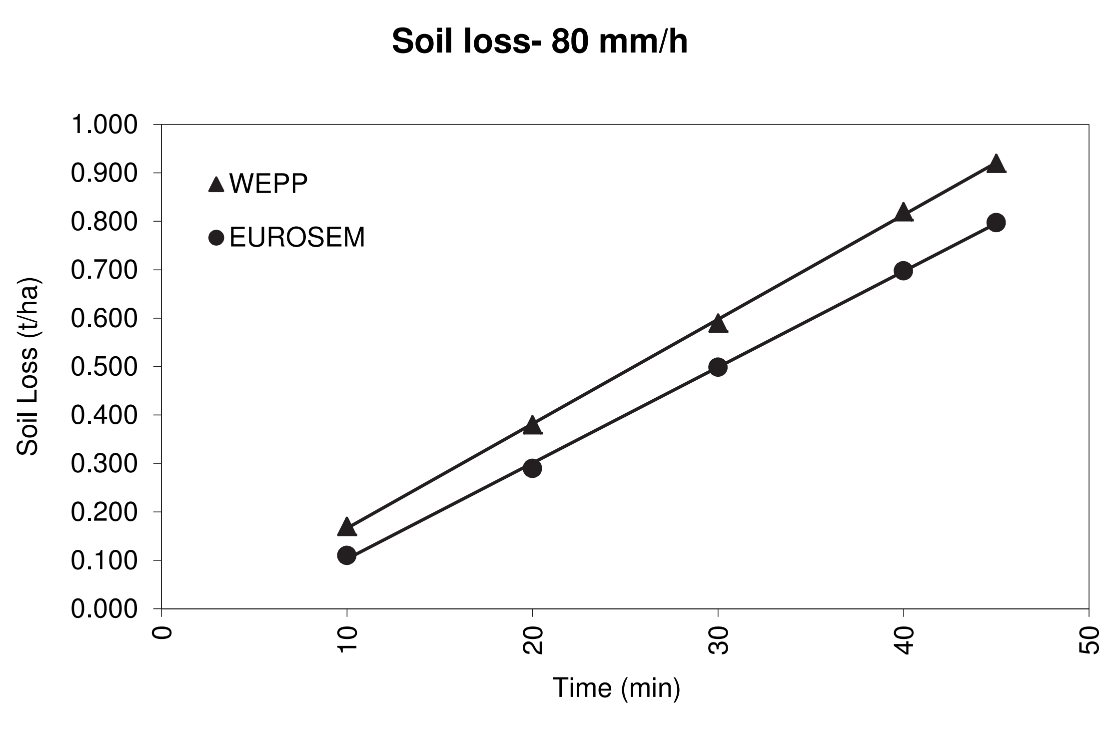

Fig. 21. WEPP and EUROSEM results for rainfall events of 80 mm/h

WEEP and EUROSEM could be applied to the vineyard scale for the annual erosion estimation but for their different characteristics the model outputs present some discrepancies. WEPP, in its *profile* version, is appropriate for the modeling of a single slope. EUROSEM model has been thinking for the erosion estimation at a basin scale and the output computational errors, if referred to a vineyard scale, is higher. The input data required for WEPP model are specific for the analyzed vineyard and concern the agricultural management practices. EUROSEM needs or more general parameters and has no differences between cultivated soil or hydrographic network basin, for this reason the same results could be associated to more than one configuration (slopes or hydrographic basin).

Soil loss results obtained for stronger events (Fig.22), have been compared with RUSLE model output. RUSLE output is equal to 3.83 t/ha*y considering a cover vegetation in the inter-row of 70%. Analyzing Fig.21 has been possible to see that in some cases (as for the stronger events occurred in 2000), a single event can be responsible of the major part of the soil loss during the whole year.

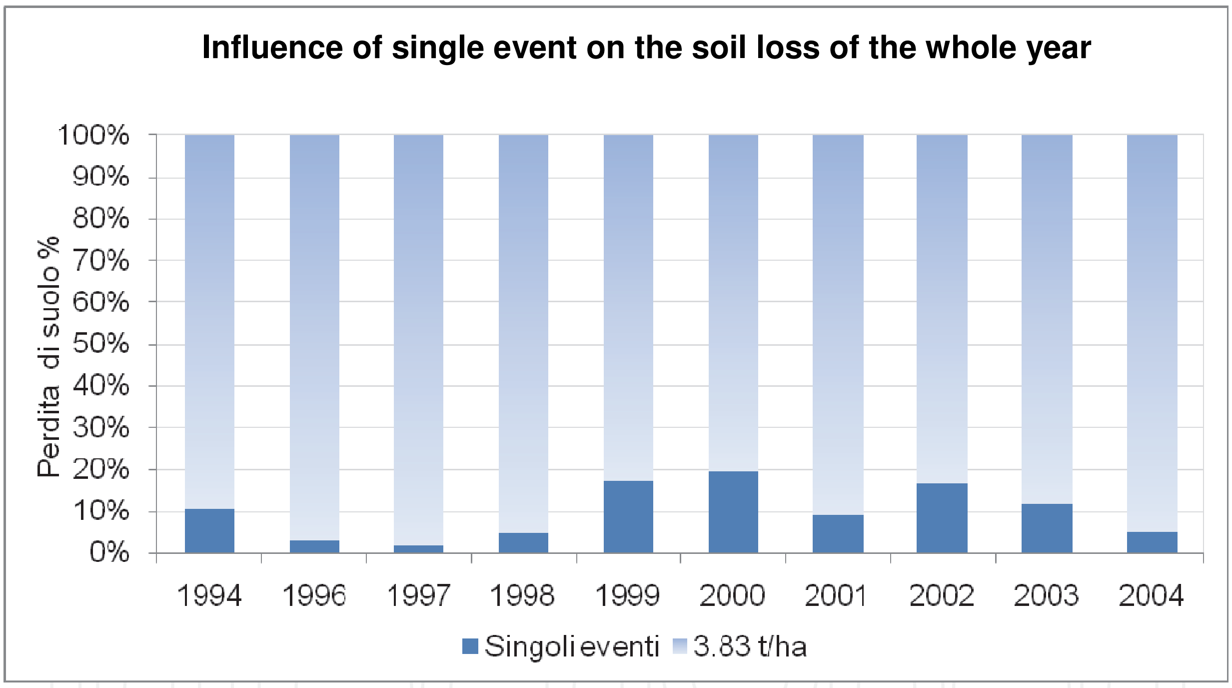

Fig. 22. Analysis of the influence of a single event on the total annual soil loss

Table presents some data concerning the experimental tests realized in situ describing main characteristics of the tested plots. In table 5 plots present variable slope with the same intensity, different percentage of vegetation cover and experimental soil loss. The soil loss is influenced by different parameters, especially by vegetation cover (where soil is bared the soil loss reaches higher value).

In table 6 have been compared experimental soil loss obtained by tests realized in situ and calculated soil loss obtained using WEPP model with the same input parameters. The compared results showed a difference in experimental and calculated results, in particular in tests 2 and 3, Fig.23 is the graphic representation of this difference measured in percentage.

Tests	Slope (%)	Intensity (mm/h)	Vegetation cover (%)	Moisture (%)	Experimental Soil loss (g)
1	16	85	69 (4)	26.5	11.16 (3.66)
2	25	85	0	31.6	42.84 (12.38)
3	30	85	93 (5)	31.0	5.61 (1.91)

Table 5. Main results provided by experimental tests

Tests	Experimental soil loss (t/ha)	Calculated soil loss (t/ha)
1	0.112	0.210
2	0.428	3.850
3	0.056	0.270

Table 6. Comparison between experimental and calculated (by WEPP) soil loss

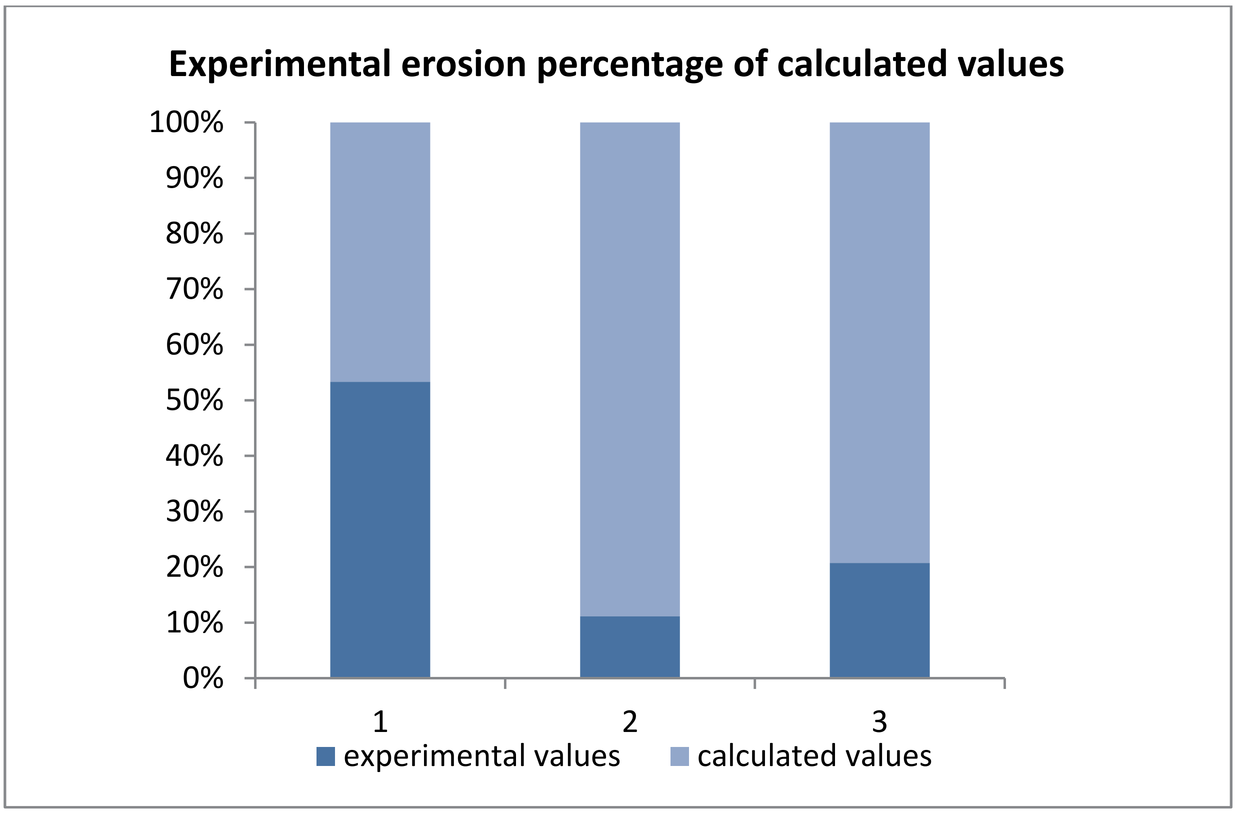

Fig. 23. Percentage of incidence of interrill erosion of the whole phenomenon

It is possible to assume that the event simulated by the experimental equipment, represents only the interill rate excluding the rill erosion phenomenon, in consequence of the small dimensions of the plot. Comparing the output provided by WEPP model (light blue in Fig.23), and the experimental results (dark blue in Fig. 23), it is possible to appreciate the incidence of the interrill rate on the whole phenomena.

The incidence of the interrill erosion, as showed in Fig.23, decreases with the increases of the slope gradient. The vegetated plot (test 3), characterized by higher slope, presents an interrill rate more evident if compared with the bared soil. The susceptibility of bared soil to the rills erosion is higher because soil is not protected by vegetation. In vegetated soil the predominant factor is represented by interrill erosion.

8. Conclusion

In the present research had been evaluated the applicability of three different models for the soil erosion estimation in Italian hills vineyards. The tested models, RUSLE, EUROSEM and WEPP are widespread in typical of different part of the world and have been proposed in numerous previous researches.

Models have been applied on an existent experimental site, located in the North-West Italy and validated by data obtained through experimental tests realized on near sites (Tropeano, 1984; Cavallo et al., 2010). RUSLE model gave results useful for a general estimation of the erosion phenomena, however the outputs are strictly dependent to the single parameters estimation and the model does not permit the simulation of the erosive rainfall events.

Concerning the two mechanistic models considered, WEPP has demonstrated the most reliable results in the erosion estimation, if compared with EUROSEM. Although WEPP requires a significant number of input parameters, generally not easily available. Another criticalities for both models is the non-automatically generation of rills, where the most important part of the erosion occurs. Both models need of the pre-definition of mean spatial definition of rills.

WEPP, even if showed some criticalities, can be considered a reliable instruments for soil erosion prevision in vineyard cultivation, useful in the agro-ecosystem management and the prevision of the best practices for the future agricultural activities.

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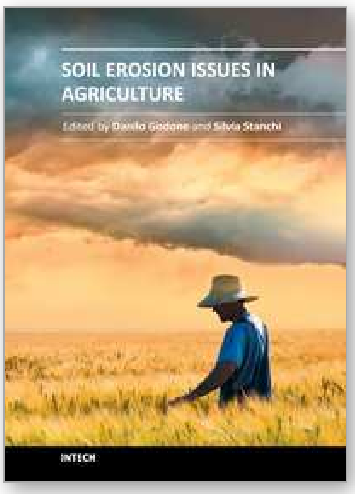

Soil Erosion Issues in Agriculture
Edited by Dr. Danilo Godone

ISBN 978-953-307-435-1
Hard cover, 334 pages
Publisher InTech

Published in print edition October, 2011

The book deals with several aspects of soil erosion, focusing on its connection with the agricultural world. Chaptersâ€™ topics are various, ranging from irrigation practices to soil nutrient, land use changes or tillage methodologies. The book is subdivided into fourteen chapters, sorted in four sections, grouping different facets of the topic: introductive case studies, erosion management in vineyards, soil erosion issue in dry environments, and erosion control practices. Certainly, due to the extent of the subject, the book is not a comprehensive collection of soil erosion studies, but it aims to supply a sound set of scientific works, concerning the topic. It analyzes different facets of the issue, with various methodologies, and offers a wide series of case studies, solutions, practices, or suggestions to properly face soil erosion and, moreover, may provide new ideas and starting points for future researches.

How to reference

Elena Comino, Paolo Marengo and Valentina Rolli (2011). Soil Erosion Aspects in Agricultural Ecosystem, Soil Erosion Issues in Agriculture, Dr. Danilo Godone (Ed.), ISBN: 978-953-307-435-1, InTech, Available from: http://www.intechopen.com/books/soil-erosion-issues-in-agriculture/soil-erosion-aspects-in-agricultural-ecosystem

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51000 Rijeka, Croatia
Phone: +385 (51) 770 447
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Unit 405, Office Block, Hotel Equatorial Shanghai
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中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821