Session GM4.3: Land cover dynamics and geomorphic processes in hillslope environments: from data acquisition to modelling and management practices
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Impact of land use changes and of agricultural management in vineyards to shallow landslides susceptibility in a representative area of northern Italian Apennines

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1. THE PROBLEM

Increase in wine production worldwide

different management techniques (inter-row management)

important effects in soil system:

- physical,
- hydrological,
- chemical
- biological properties

Shallow landslide triggered by intense rainfall events

WHICH PRACTICES MIGHT PROMOTE THE STABILITY OF SLOPING VINEYARDS?

2. AIMS

Assessing and monitoring the effects of inter-rows management in vineyards on

- ❑ soil physical properties;
- ❑ soil hydrological properties;
- ❑ root density;
- ❑ root mechanical properties and root reinforcement;
- ❑ biodiversity.

Landslide Prevention through land use management

Protocol for correct agricultural practices

Farmer formation

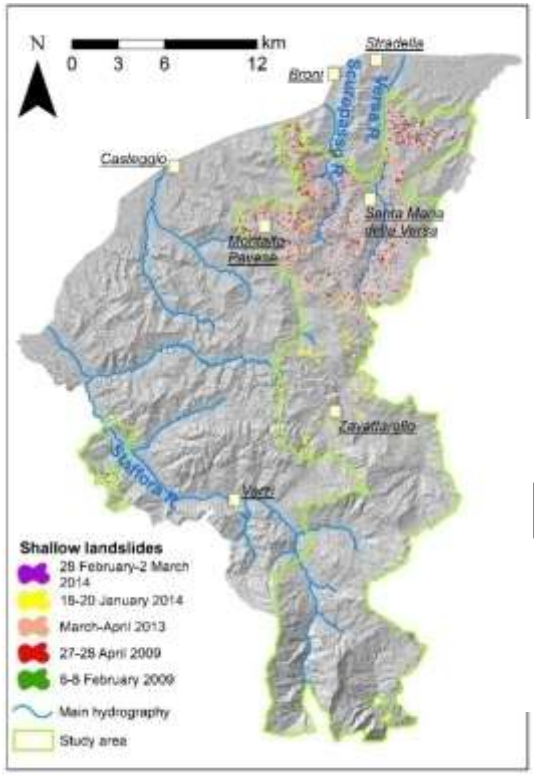
Biodiversity and ecosystem protection.

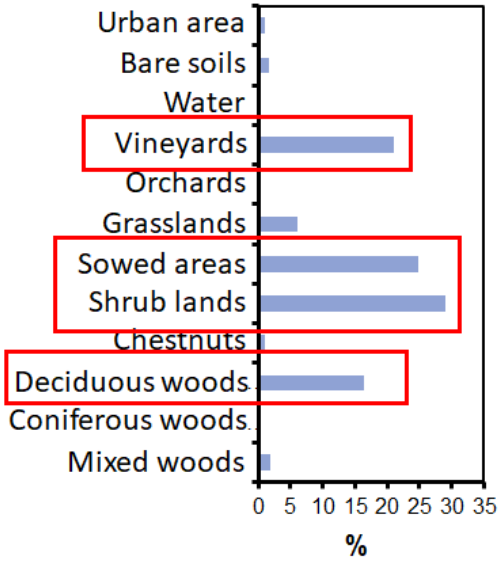
Improvement of the land form and of tourism

3. THE STUDY AREA

Oltrepò Pavese is among the top ten areas for wine production in Italy.

Shallow landslides and soil erosions are the cause of several damages to agriculture, in particular to the precious slope vineyards.





More than 2000 shallow landslides and soil erosions since 2009 (8.1 km^2, 2.5% of the area)

3. THE STUDY AREA

Total tillage (TT)

Permanent grass cover (PGC)

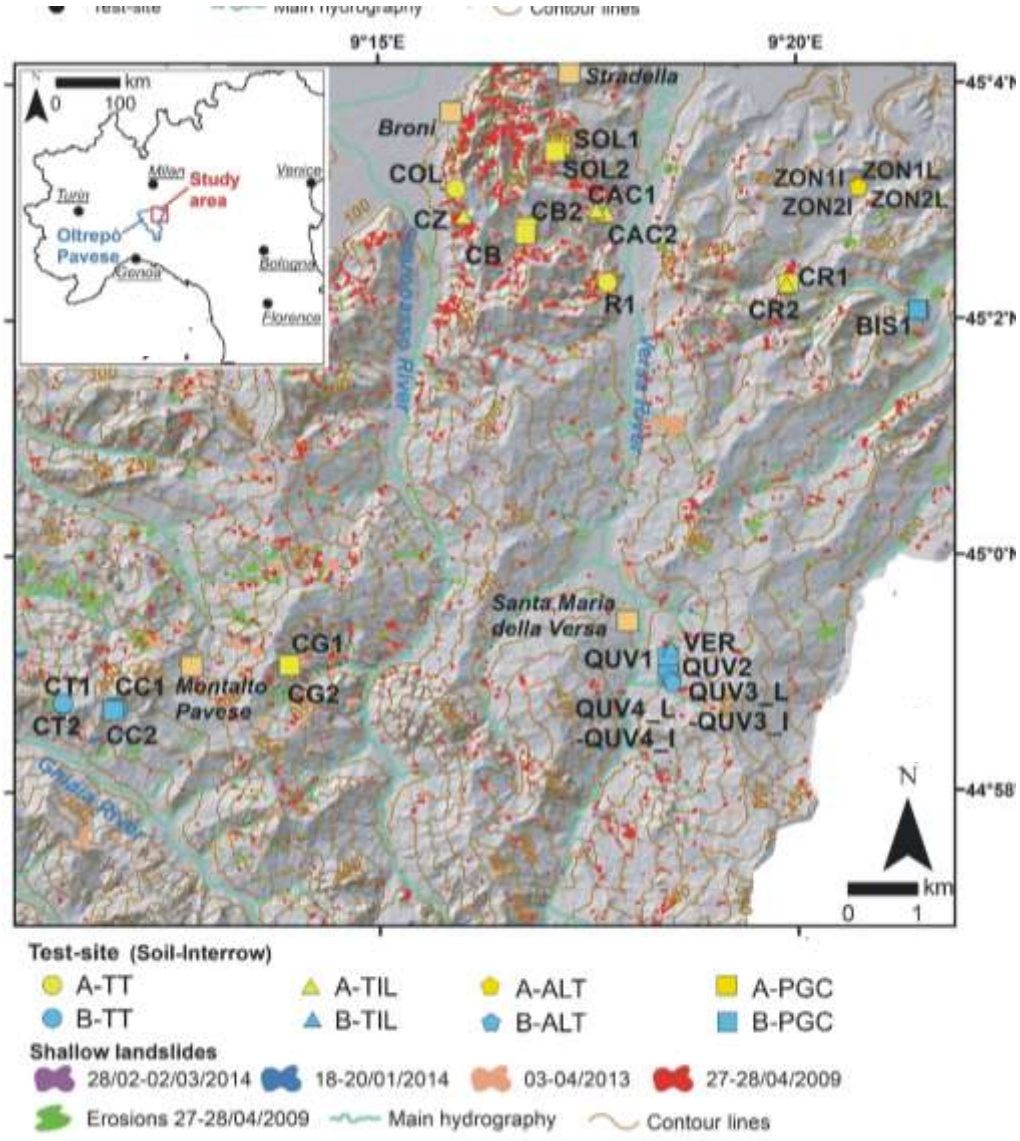
DIFFERENT AGRICULTURAL MANAGEMENT OF INTER ROW VINEYARDS

Tillage (TIL)

Alternating tillage-grass (ALT)

3. THE STUDY AREA

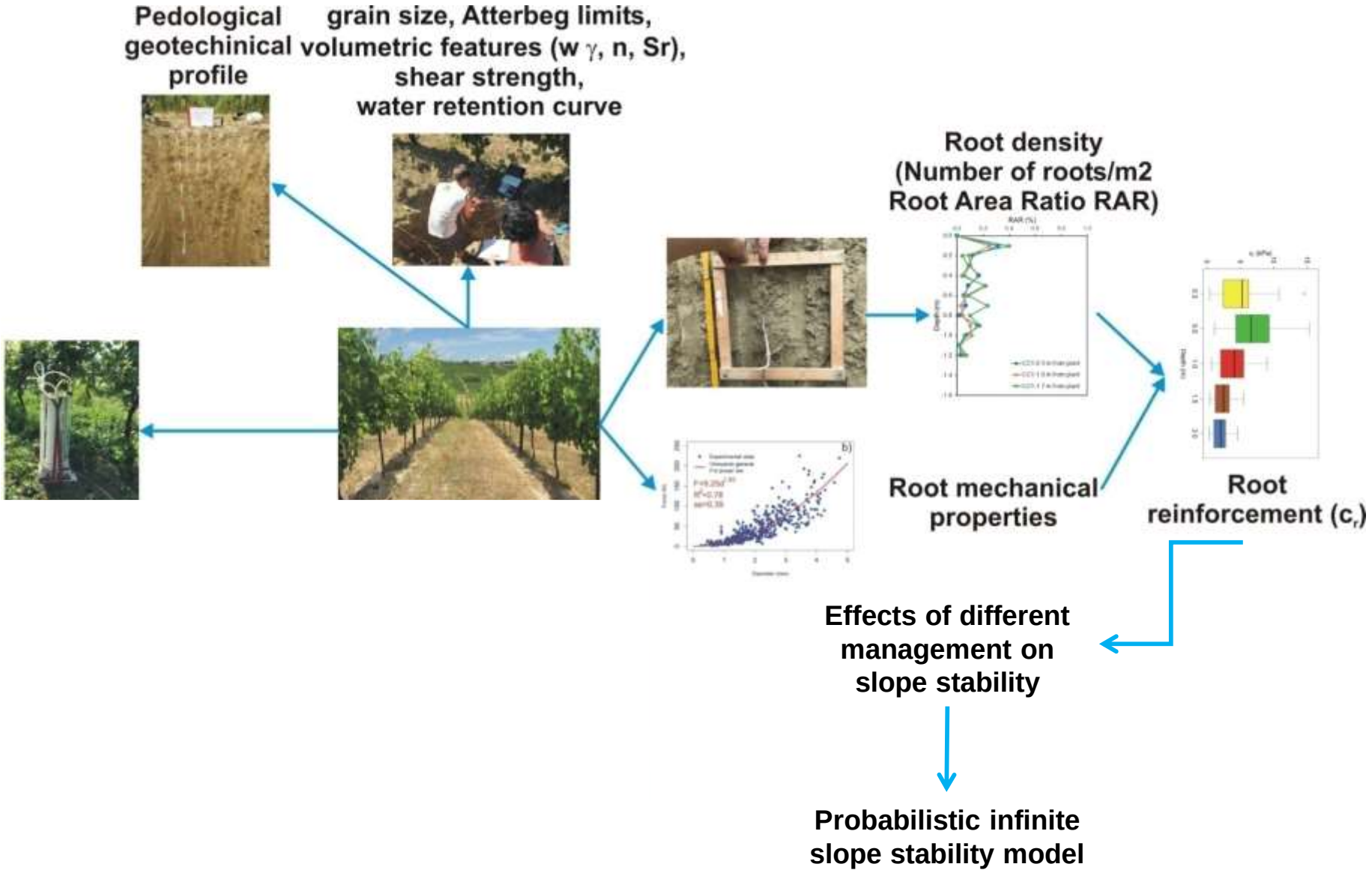
24 trenches in 29 sites of different geological and geomorphological



Site	Inter-row	Representativity
R1-COL	TT	A. Clayey silts of medium-low plasticity; short and steep slopes (9-25°)
CZ-CAC1-CAC2-CR2	T	
CG1-CG2-SOL1-SOL2-BIS1*-CB-CB2	PGC	
CT1-CT2	TT	B. Silt with clay/Clay with silt of high plasticity; long slopes with medium slope angle (4-17°)
VER	T	
CC1*-CC2*-QUV1-QUV2	PGC	
QUV3-QUV4	AL, PGC	

*Biological regulation

4. METHODS


Pedological geotechinical profile
grain size, Atterbeg limits, volumetric features (w γ, n, Sr), shear strength, water retention curve
Root density (Number of roots/m2 Root Area Ratio RAR)
Root mechanical properties
Root reinforcement (c,)
Effects of different management on slope stability
Probabilistic infinite slope stability model

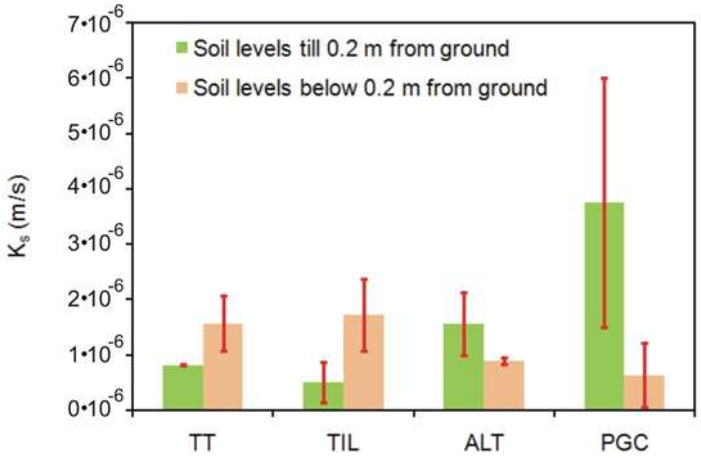
5. RESULTS

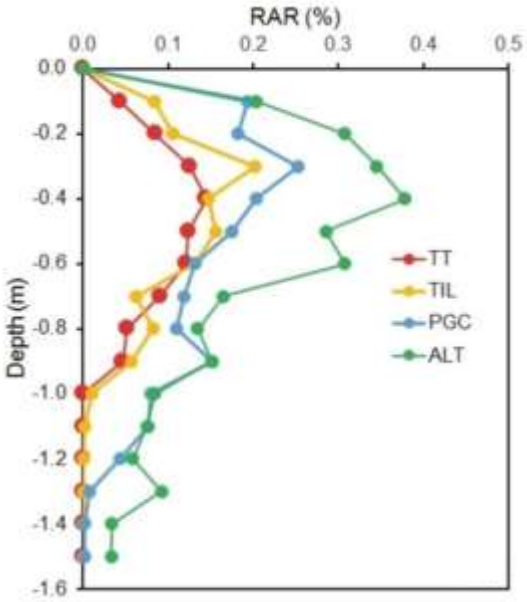
Inter-row management has effects on:

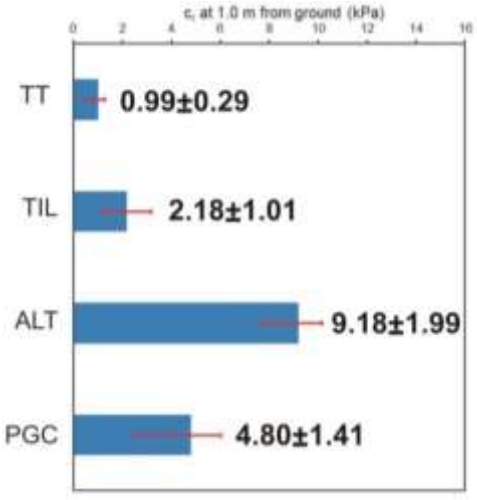
•**Saturated hydraulic conductivity (K_s)**: in shallow layers, K_s is higher in grass cover and alternating inter-rows; in deep layers, K_s is higher in tilled inter-rows

•**Root density (RAR)**: RAR is higher in grass cover and alternating inter-rows, all along the soil profile

•**Root reinforcement (c_r)**: following the root density trend, c_r is higher in grass cover and alternating inter-rows, all along the soil profile







5. RESULTS

Slope stability analysis

- **Infinite slope model** (**Lu and Godt, 2008**)

$$F_s = \frac{\tan\varphi'}{\tan\beta} + \frac{2c'}{\gamma z \sin 2\beta} - \frac{\sigma^s}{\gamma z}\left[(\tan\beta + \cot\beta)\tan\varphi'\right].$$

- **Input data**
  - DEM (1x1m – LIDAR 2012)
  - Z?
  - φ' (friction angle);
  - c' (soil cohesion c_s + **root reinforcement c_r**);

  Normal distribution of parameters

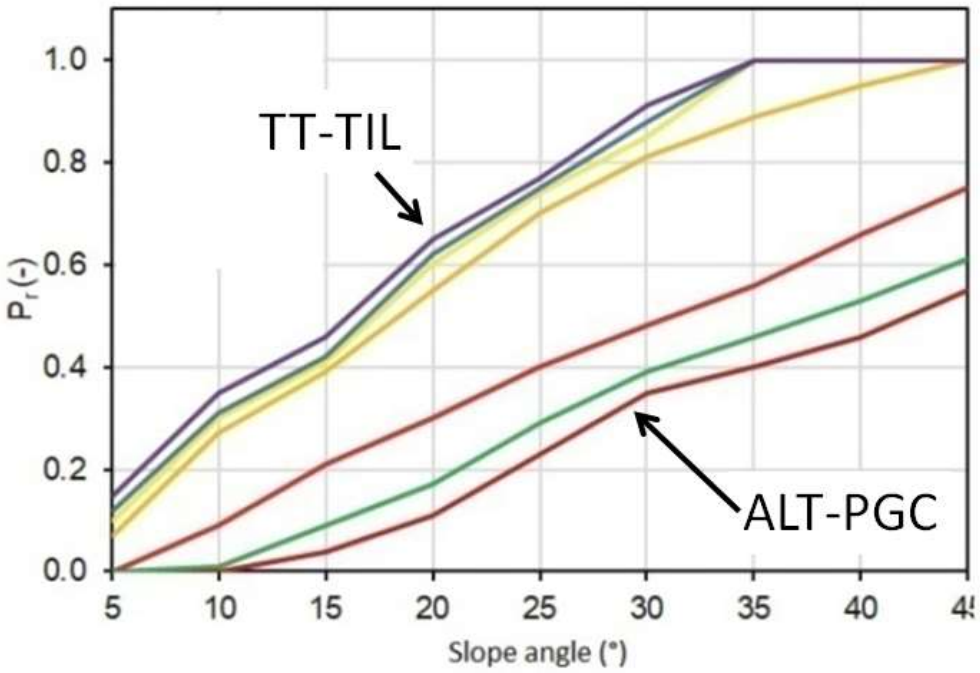
  - σ^s (suction stress)

  Uniform distribution
  $0<\sigma^s>10$ kPa (triggering conditions; Bordoni et al. 2015)

- **1000 Monte Carlo simulations**

5. RESULTS

Slope stability analysis (probability of rupture) in relation to different managements



- **c_r of alternating vineyards ≃ woodlands; cr of tilled vineyards ≃ sowed areas, shrublands**
- For the same slope angle, **probability of rupture is significantly higher in sowed areas, shurb lands and tilled vieneyards**
- **Vineyards with permanent grass cover** allow to promote the stability of **medium-steep slopes (> 20-25°); alternating vineyards** increase the stability also of **very steep slopes (> 30-35°)**

6. CONCLUSIONS

- **Effect of vineyards management on saturated hydraulic conductivity**

- **Significant effects of of vineyards management on root density and root reinforcement** → Root density and reinforcement are higher in vineyards with permament grass cover or alternation

- Slopes cultivated with vineyards seem **more stable if permanent grass cover or alternation** are present as inter-row management

- The results of this study provide **important indications for planning effective management practices** of vineyard inter-row soils in order to guarantee an improved amount of root density, which promotes a better development of the plants and might reduce the proneness to slope instabilities of sloping vineyards. Therefore, vineyards with alternating management of the inter-rows represent an agronomical practice that might be applied widely, guaranteeing an improvement of territory resilience

THANKS FOR THE ATTENTION

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