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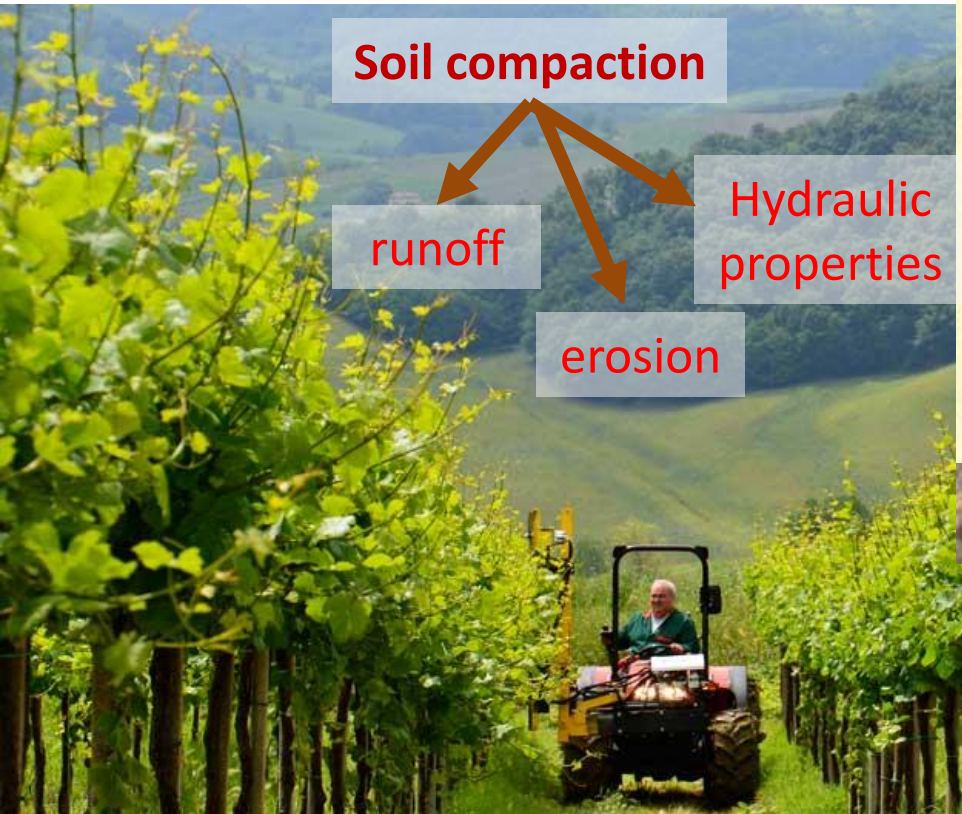
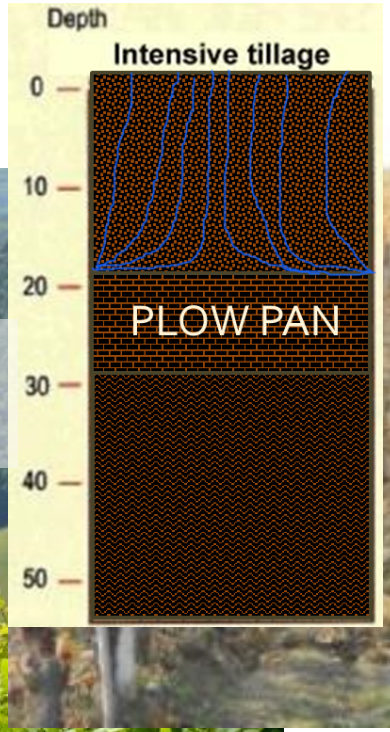
Effects of tractor traffic on soil compaction, water infiltration and soil erosion in tilled and grassed vineyards

Marcella Biddoccu, **Giorgio Capello**, and Eugenio Cavallo

National Research Council of Italy, IMAMOTER, Torino, Italy

Soil erosion is affected by rainfall temporal pattern and intensity variability. In vineyards, **machines traffic** is implemented with particular intensity from late spring to harvest, and it is responsible of **soil compaction**, that likely affects soil **hydraulic properties**, **runoff**, and **soil erosion**. Additionally, hydraulic and physical properties of soil are highly influenced by vineyards' **inter-rows soil management**.

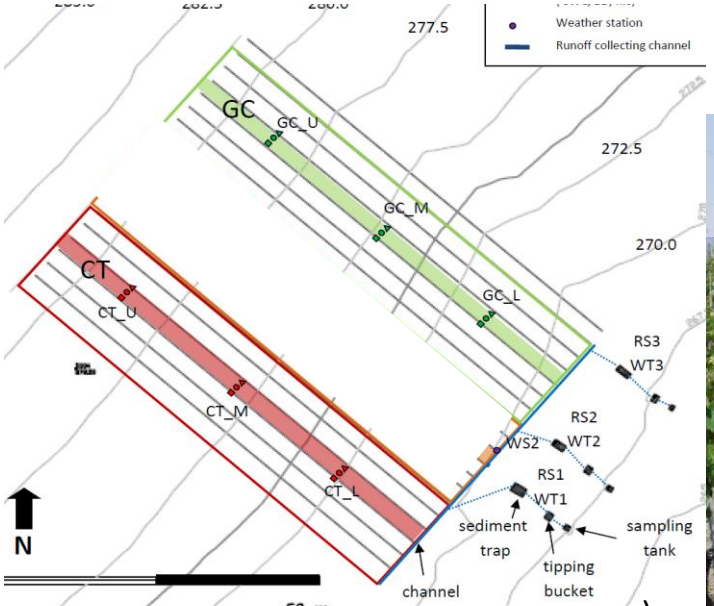




Soil management

The effect of machines traffic on soil compaction, hydrological and erosional processes has been investigated on a **sloping vineyards** with different inter-row soil managements (**tillage** and **permanent grass cover**) in the Alto Monferrato area (Piedmont, NW Italy).

Conventional Tillage (CT): chisel, 0.25 m depth twice a year



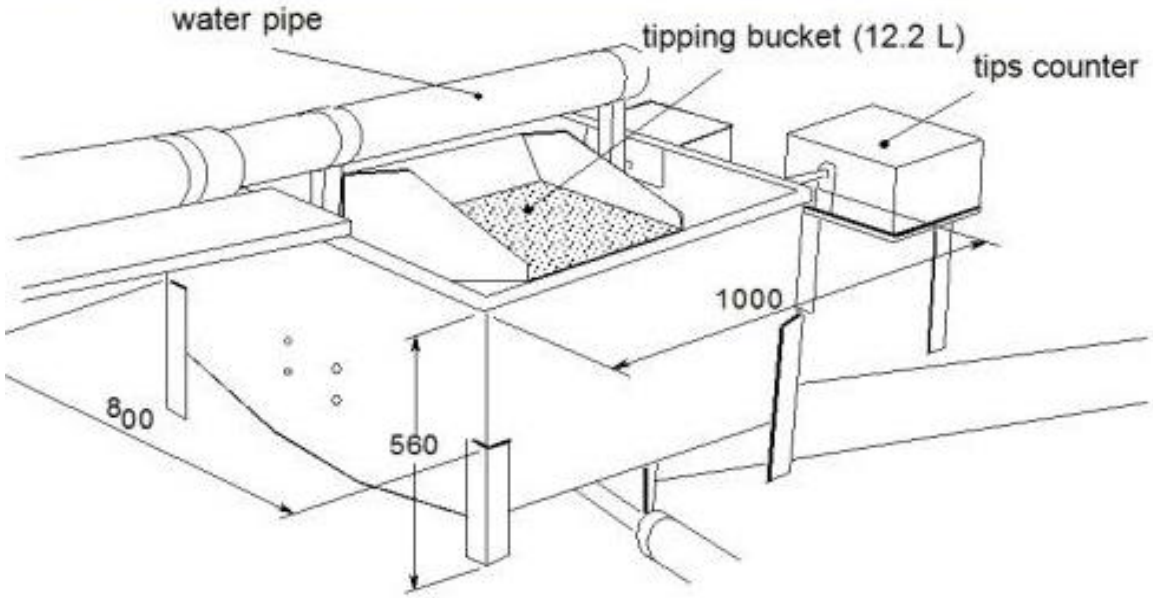
Experimental plots (modified from Biddoccu et al., 2016)

Grass Cover (GC): grass, mech. controlled twice a year

Vines up and down the slope

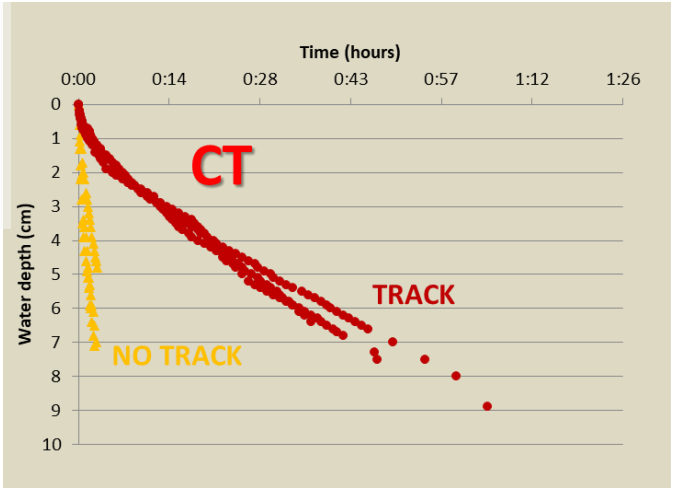
- Elevation 290 m, SE aspect, slope: 15%
- Texture: silty clay loam soil / silt loam soil

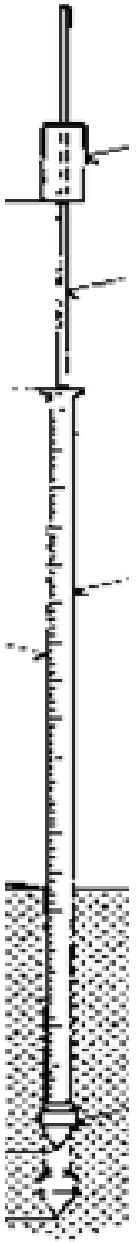
During the investigation (November 2016 – October 2018) soil water content, rainfall, runoff, and soil erosion **were continuously monitored**.



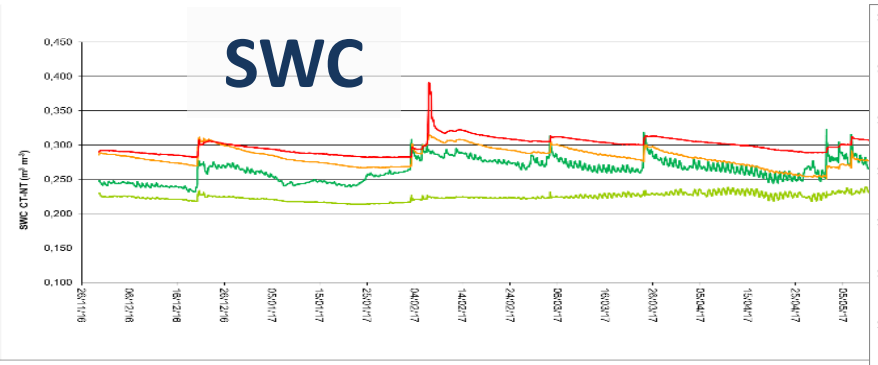
Field-saturated hydraulic conductivity (K_{fs}), soil penetration resistance (**PR**) and bulk density (**BD**) **were recorded periodically** in portions of inter-rows affected and not by the machine traffic.

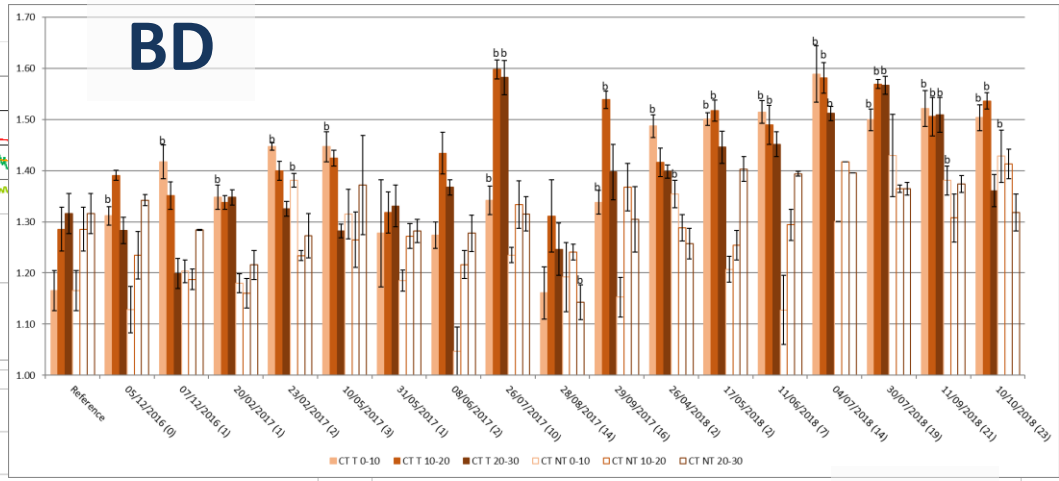
K_{fs} : double ring SFH (simplified falling-head technique), for rapid determination of field-saturated hydraulic conductivity

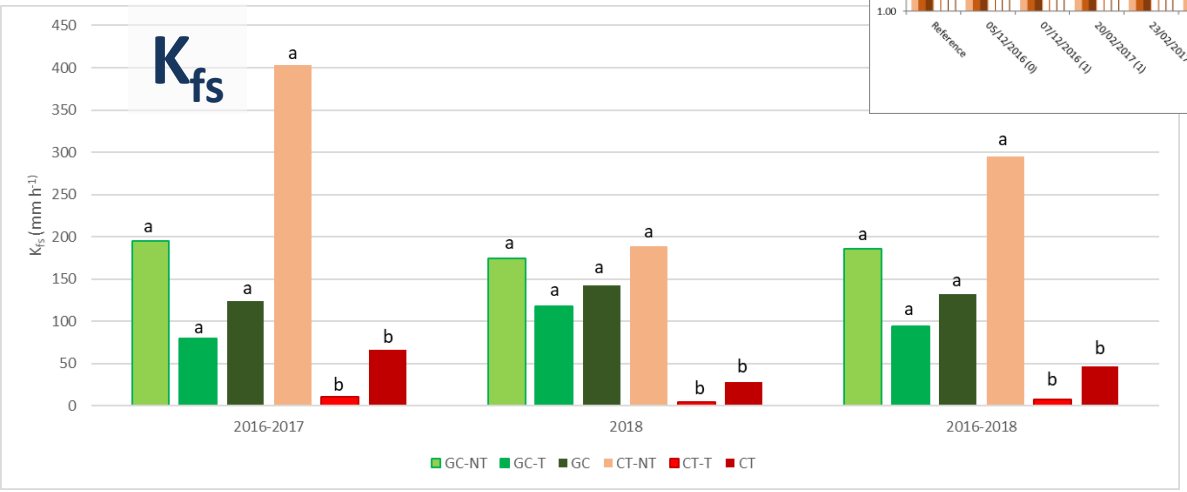


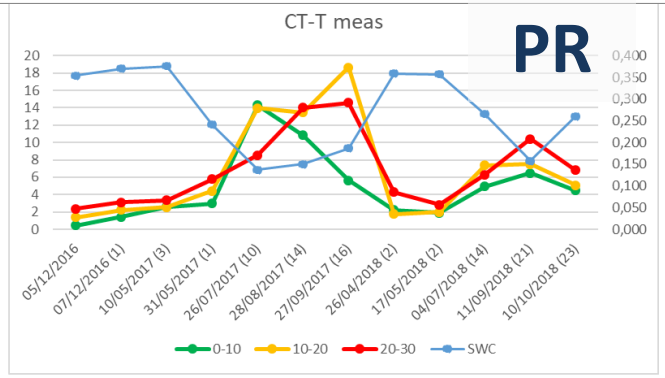


In order to take into account temporal and management variability of soil compaction and hydrological properties, field-monitored data were **statistically analyzed**, in order to **identify existing relationships** between climate and management variables and soil physical and hydrological variables.





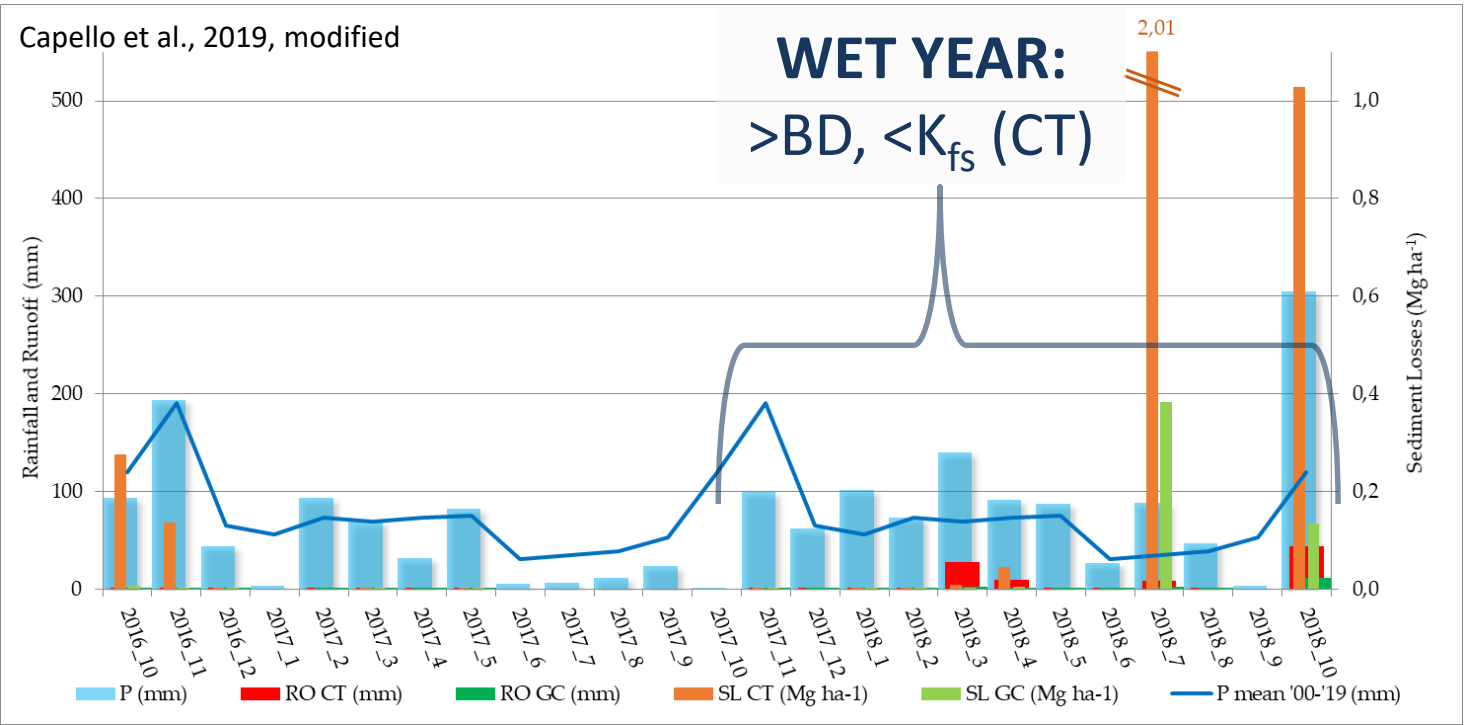




For details see: Capello G., Biddoccu M., Ferraris S., Cavallo E. 2019. Effects of tractor passes on hydrological and soil erosion processes in tilled and grassed vineyards, Water (Basel) 2019, 11, 2118; doi:10.3390/w11102118
https://www.mdpi.com/2073-4441/11/10/2118/htm

Very **different yearly precipitation** characterized the observed period, leading to higher bulk density and lower infiltration rates were in the wetter year, especially in the tilled vineyard, whereas soil penetration resistance was generally higher in the grassed plot, and in drier conditions.

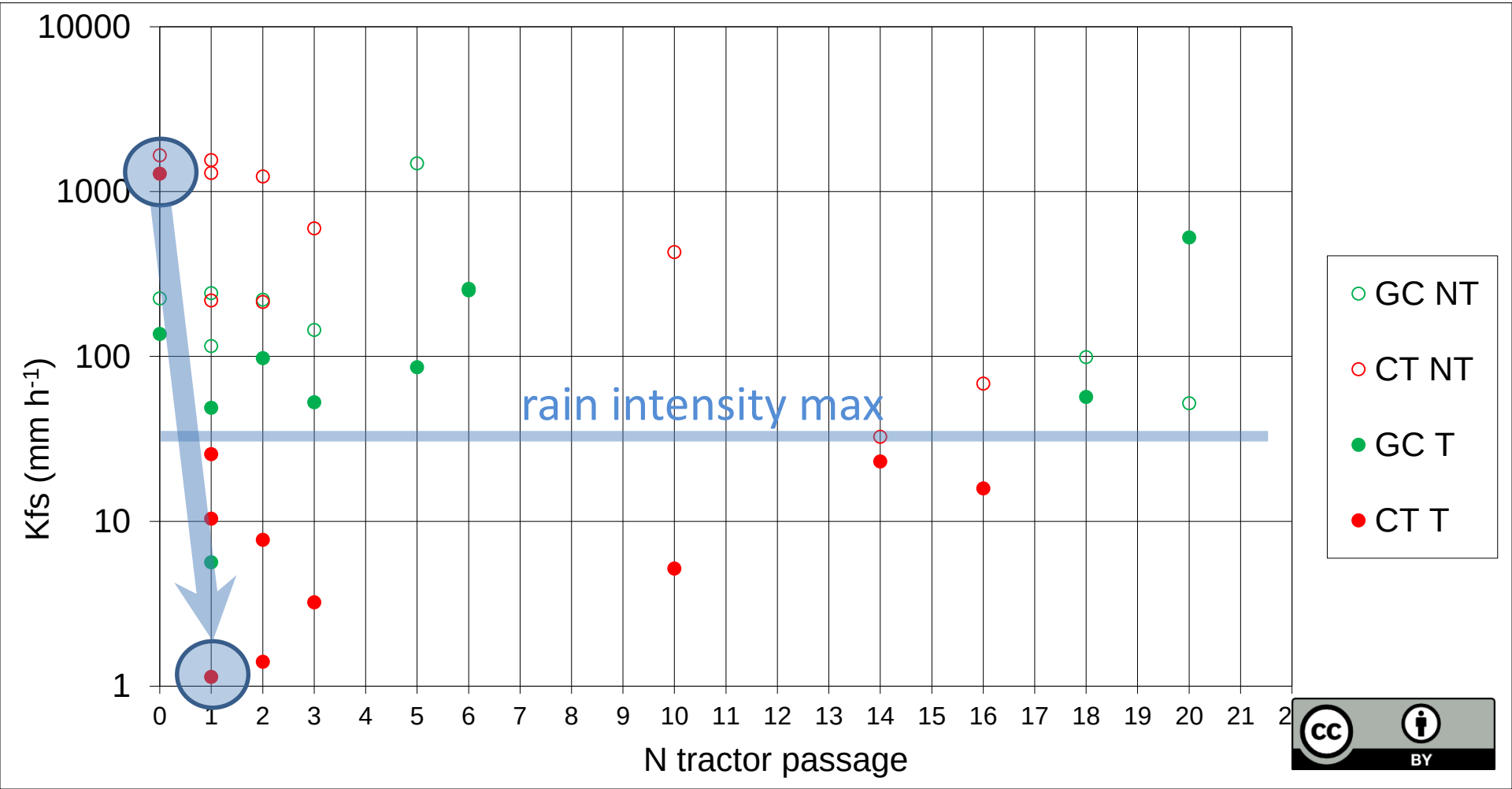
Soil bulk density and penetration resistance in tracked soil of the tilled plot increase, compared to the grassed plot, **after only one to three tractor passages** following tillage operation, especially in the topsoil (first 10 cm).



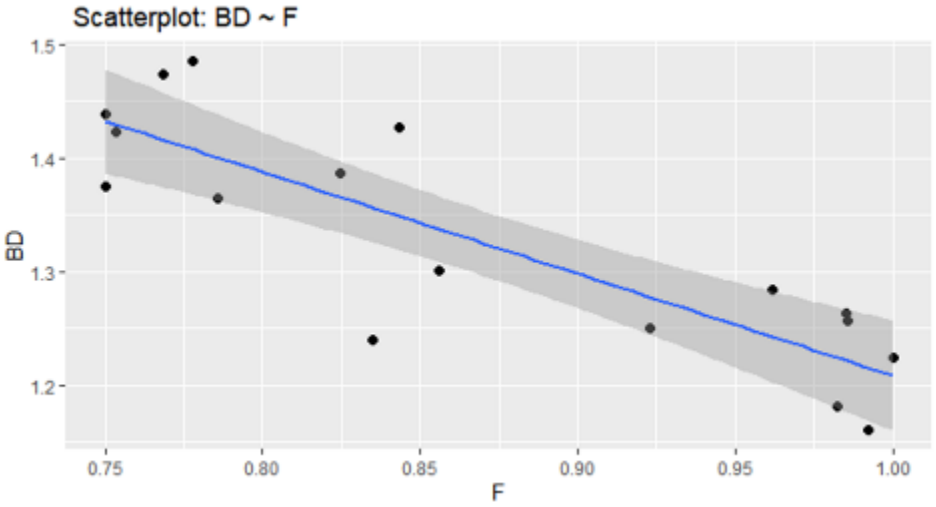
DRY and GC:
> PR

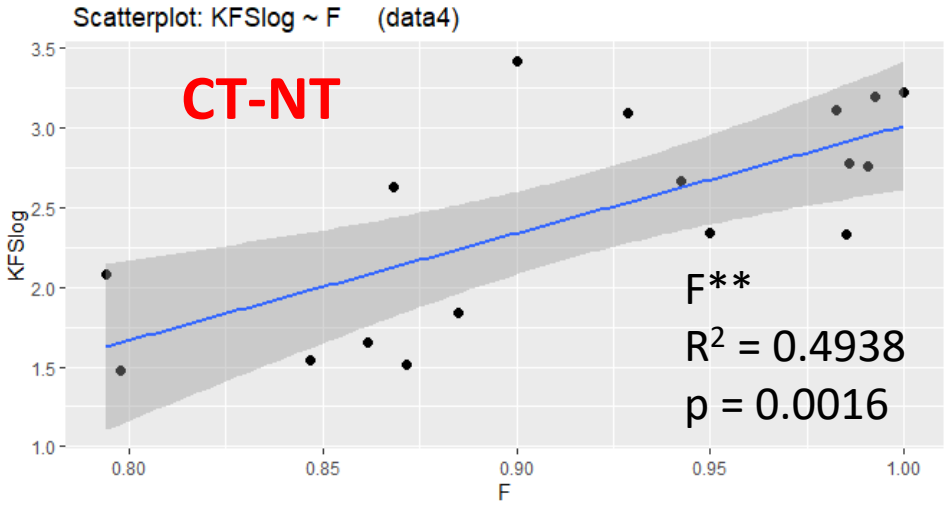
1 - 3 tractor passages:
> BD, > PR
(CT-T topsoil)

Soil compaction affects water infiltration, especially in the wet year. In the tilled vineyard, one tractor passage on wet soil after tillage operation dramatically reduced **K_{fs} from over 1000 to near 1 mm h^{-1}**, while with grass cover K_{fs} remained above the usual rain-intensity values, allowing water to infiltrate the soil.



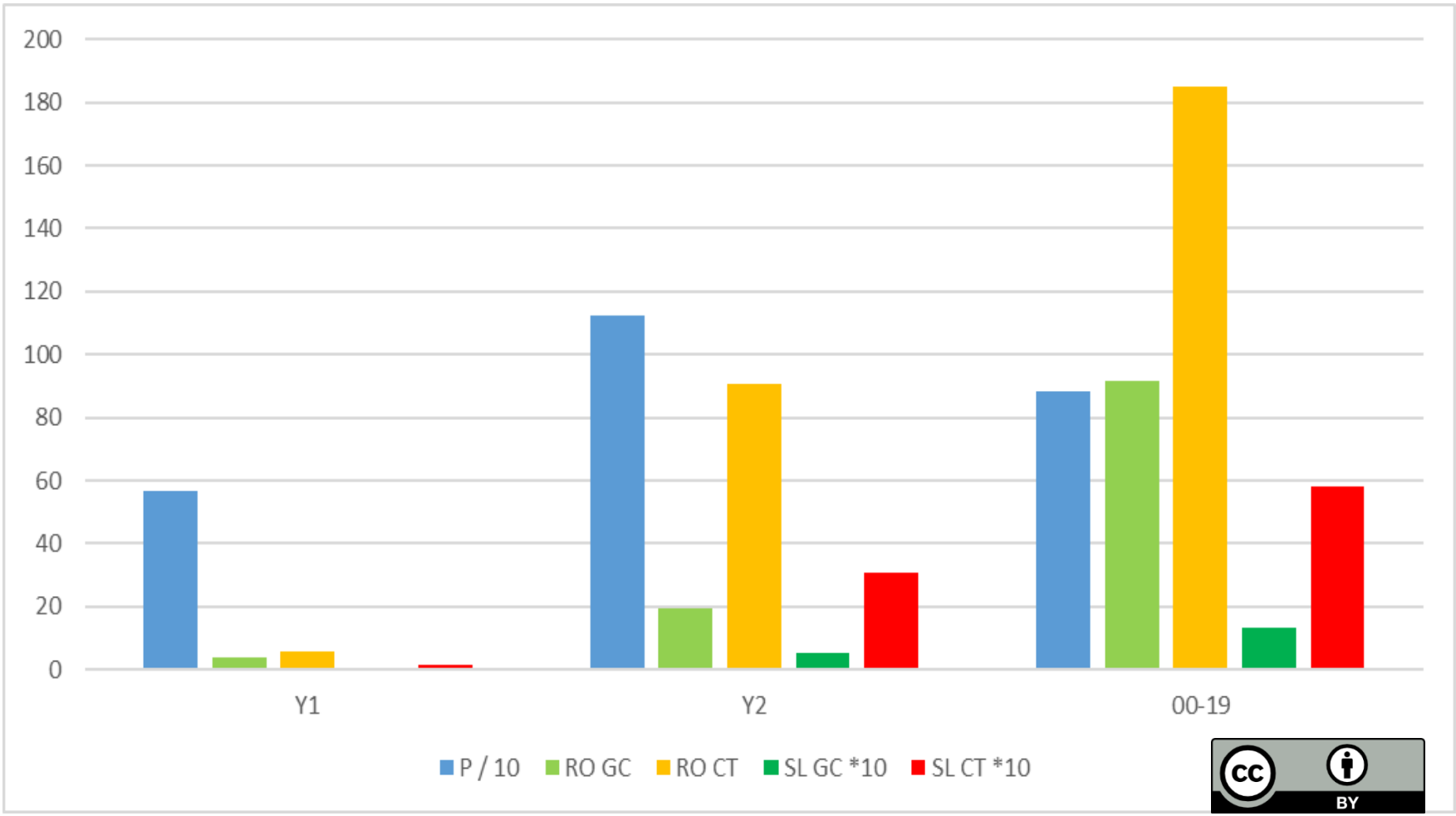
By means of **linear and multilinear regression**, **significant relationships have been found** to relate hydraulic conductivity and soil penetration resistance with soil water content, weather variables and a **factor F** that takes into account the number of tractor passages and the elapsed time from last soil disturbance.





PR MULTI-LINEAR (BoxCox)			
GC-T	GC-NT	CT-T	CT-NT
SWC***, F, P, Temp **R^2 = 0.9335**	SWC***, F*, P, Temp **R^2 = 0.8747**	SWC*, F', P, Temp **R^2 = 0.8251**	SWC, F*, P, Temp R^2 = 0.6268

Lastly, **runoff and soil erosion** were **higher** in the **tilled plot**, even if lower than the long-period average values. Indeed, in the wet year, management with **grass cover** **reduced** considerably runoff (-76%) and soil loss (-83%) compared to tillage and, in the dry season.



The soil management with **grass cover reduced** the impact of tractor traffic on soil compaction, especially in wet conditions **provided greater** soil hydraulic conductivity and water infiltration **reduced** considerably runoff and soil losses compared to inter-row tillage.

A single **tractor passage on wet soil** after tillage operation dramatically reduced soil hydraulic conductivity, meanwhile with grass cover it remained above the usual rain-intensity values, allowing water to infiltrate the soil. **Future investigation** on effects of traffic on sub-soil compaction and on water balance.

Thank you for your attention! **g.capello@ima.to.cnr.it**

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More details in: Capello et al., 2019 https://www.mdpi.com/2073-4441/11/10/2118/htm