European Geosciences Union
General Assembly 2020
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Management-induced soil water erosion and nutrient losses in different land use in Mediterranean environment

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Hrvatska zaklada za znanost **Soil erosion and degradation in Croatia – SEDCRO, 2018-2023**

Introduction

- Understanding land use changes and agricultural practices is essential for the successful development of land management plans

- Erosion in agricultural fields is recognized as main driver of land degradation and desertification

- Combating land degradation processes and desertification should be considered a primary concern because the loss of soils directly affects human and ecosystem health.

Introduction

- Vineyards possess the highest erosion rates in Europe (12.2 t ha^{-1} yr^{-1}) (**Cerdan 2010**)

- However, high erosion rates were also observed in olive orchards (**Gómez et al., 2018**) and cropland (**Bogunovic et al., 2018**).

- These problems appear at marginal anthropic environments with steep slopes, with bare soil and unsustainable land management activities

- In Croatia we can noted:

1) Lack of research of proportion of soil erosion in Croatia;

2) Lack of knowledge of driving forces of erosion - like aggregate stability, effect of slope, and physical and chemical properties, which control aggregates breakdown;

- in contrast to: a) different soil types b) land use and management, c) topography and d) rainfall intensity.

Cerdan, O., Govers, G., Le Bissonnais, Y., Van Oost, K., Poesen, J., Saby, N., ... & Klik, A. (2010). Rates and spatial variations of soil erosion in Europe: a study based on erosion plot data. Geomorphology, 122(1-2), 167-177.

Gómez, J. A.; Campos, M.; Guzmán, G.; Castillo-Llanque, F.; Vanwalleghem, T.; Lora, Á.; Giráldez, J. V. Soil erosion control, plant diversity, and arthropod communities under heterogeneous cover crops in an olive orchard. Environ. Sci. Pollut. R. 2018, 25, 977-989

Bogunovic, I.; Pereira, P.; Kisic, I.; Sajko, K.; Sraka, M. Tillage management impacts on soil compaction, erosion and crop yield in Stagnosols (Croatia). Catena 2018, 160, 376-384

Goal of research

- This work aims to study the impact of traditional land uses in three different types of cultures (vineyards, croplands, and olive orchards) in the Istria region (Croatia).

- The specific objectives are to analyze the effects of land use management on different soil properties and their hydrological response to simulated rainfall.

Study area

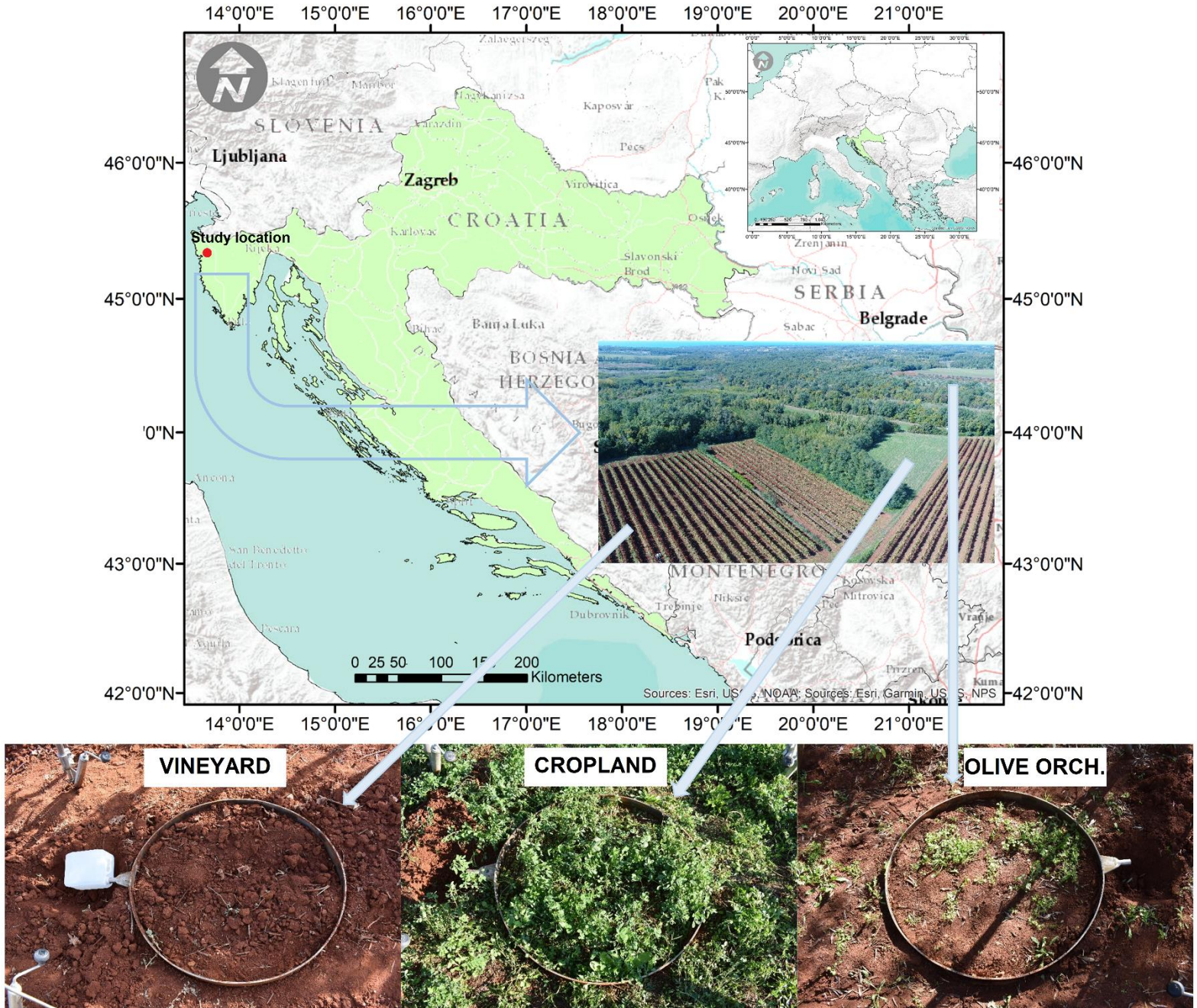
Three treatments:

tilled vineyard

tilled croplands (alfaalfa)

tilled (with herbicidues) olive orchard

- Gentle slopes (5° slopes) near Umag, Croatia
- 8 plots per treatments (24 plots in total) were established to determine soil losses and runoff.



Methodology

A simulated rainfall experiment was carried out with the intensity of 58 mm h^{-1} in the summer of 2018 (> 30% soil water content) for 30 min on 0.785 m^2 circular plots.

Determined properties

- Vegetation cover (%)
- Slope (°)
- Time to ponding (sec)
- Time to runoff (sec)
- Total water runoff (m^3 ha^{-1})
- Sediment loss (t ha^{-1})
- Infiltration (%)

Soil:

- Bulk density (g cm^{-3})
- Water holding capacity (% vol)
- Soil water content (% vol)
- Mean weight diameter
- Water stable aggregates (%)
- Soil organic matter (%)
- Available P_2O_5

Sediments:

- Total carbon (%)
- Total nitrogen (%)
- Available P_2O_5 (mg kg^{-1})

Results – soil properties

Soil properties

Treatment	Slope (°)	Vegetation cover (%)	Bulk density (g cm^{-3})	Water holding capacity (%)	Soil water content (%)
Vineyard	3.8	6.19 c	1.21 b	43.8 a	31.1
Cropland	4.0	93.68 a	1.37 a	39.7 b	28.2
Olive orchard	4.2	20.36 b	1.14 b	40.3 b	32.1
P value	n.s.	***	***	***	n.s.

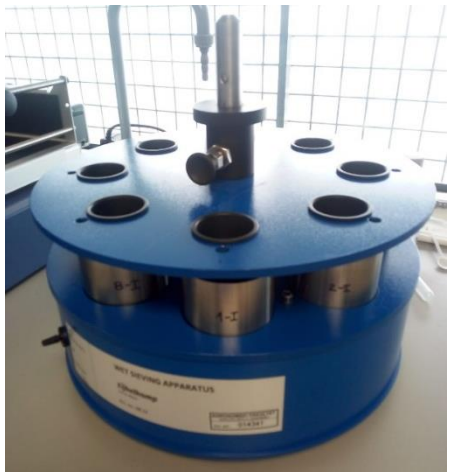
Results of one-way and Kruskal–Wallis ANOVA analysis. The effects of soil management on the soil properties. Small letters in column represent difference of treatment effects at $p < 0.05$. ns, not significant at $p < 0.05$.

Saturated plot

Results – soil properties

Treatment	Mean weight diameter (mm)	Water stable aggregates (%)	Soil organic matter (%)	P_2O_5 (mg kg^{-1})	Total nitrogen (%)
Vineyard	2.59	81.4 b	1.87 c	343.6 a	0.10 c
Cropland	2.69	88.9 ab	2.47 b	61.9 b	0.14 b
Olive orchard	3.27	92.9 a	3.60 a	328.2 a	0.19 a
P value	n.s.	*	***	**	***

Results of one-way and Kruskal–Wallis ANOVA analysis. The effects of soil management on the soil properties. Small letters in column represent difference of treatment effects at $p < 0.05$. ns, not significant at $p < 0.05$.



Results – overland flow properties

Treatment	Time to ponding (sec)	Time to runoff time (sec)	Runoff (m^3 ha^{-1})	Sediment concentration (g kg^{-1})	Sediment loss (kg ha^{-1})
Vineyard	1082.4 ab	1504.8 ab	5.57 ab	5.77 a	37.8 ab
Cropland	1800 a	1800 a	0.00 b	0.00 b	0.0 b
Olive orchard	202.8 b	740.1 b	53.69 a	3.96 a	203.9 a
P value	***	***	***	***	***

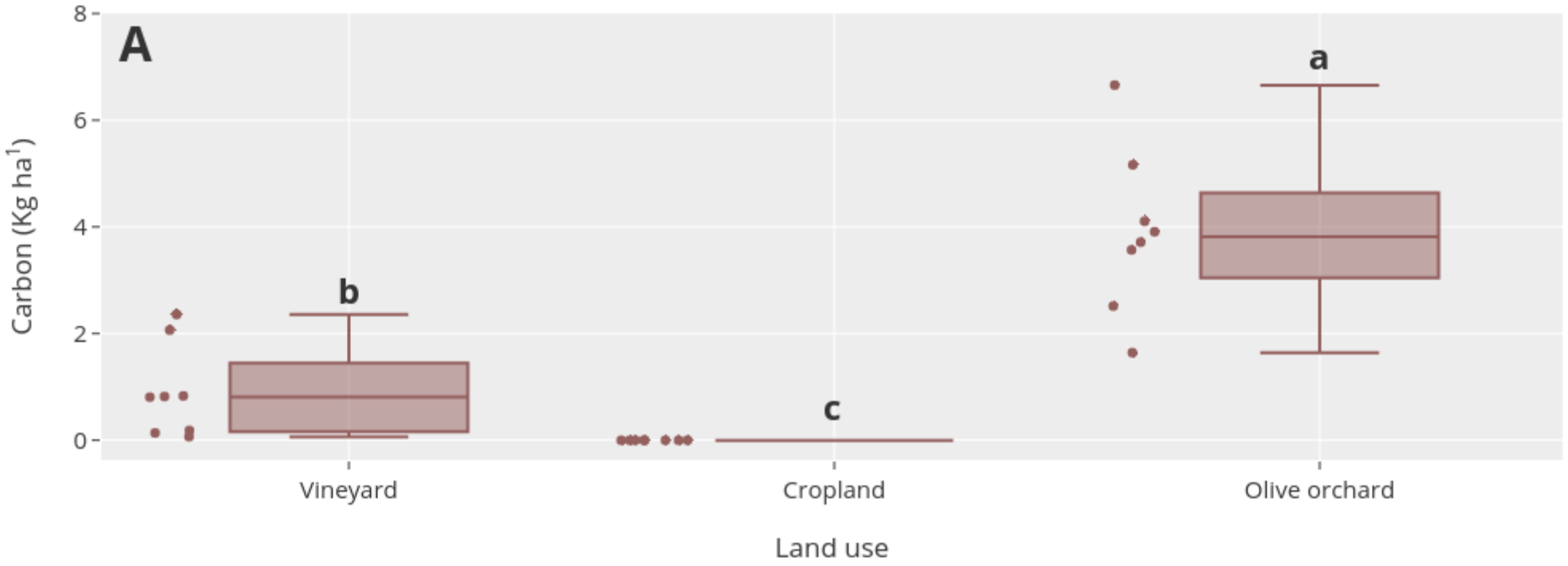
Results of one-way and Kruskal–Wallis ANOVA analysis. The effects of soil management on the vegetation cover and the overland flow properties. Small letters in column represent difference of treatment effects at $p < 0.05$. ns, not statistically significant at $p < 0.05$. ***, statistically significant at $p < 0.001$.

Cropland

Olive orchard

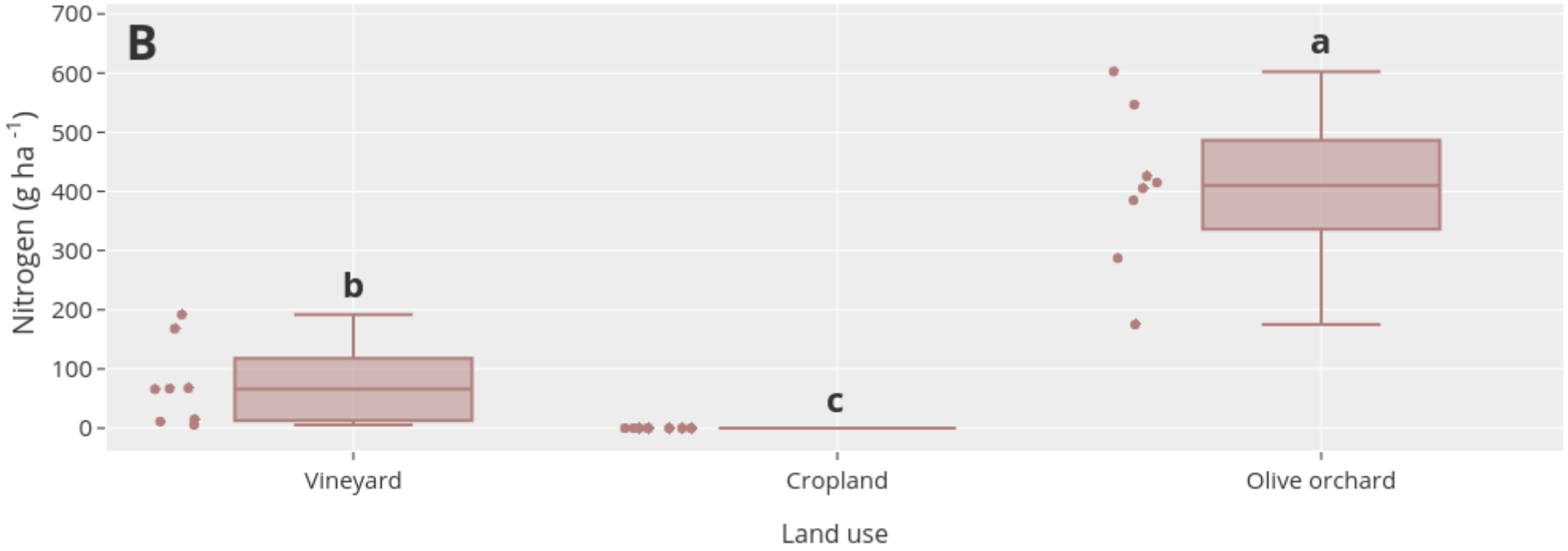
Vineyard

Results – nutrient losses



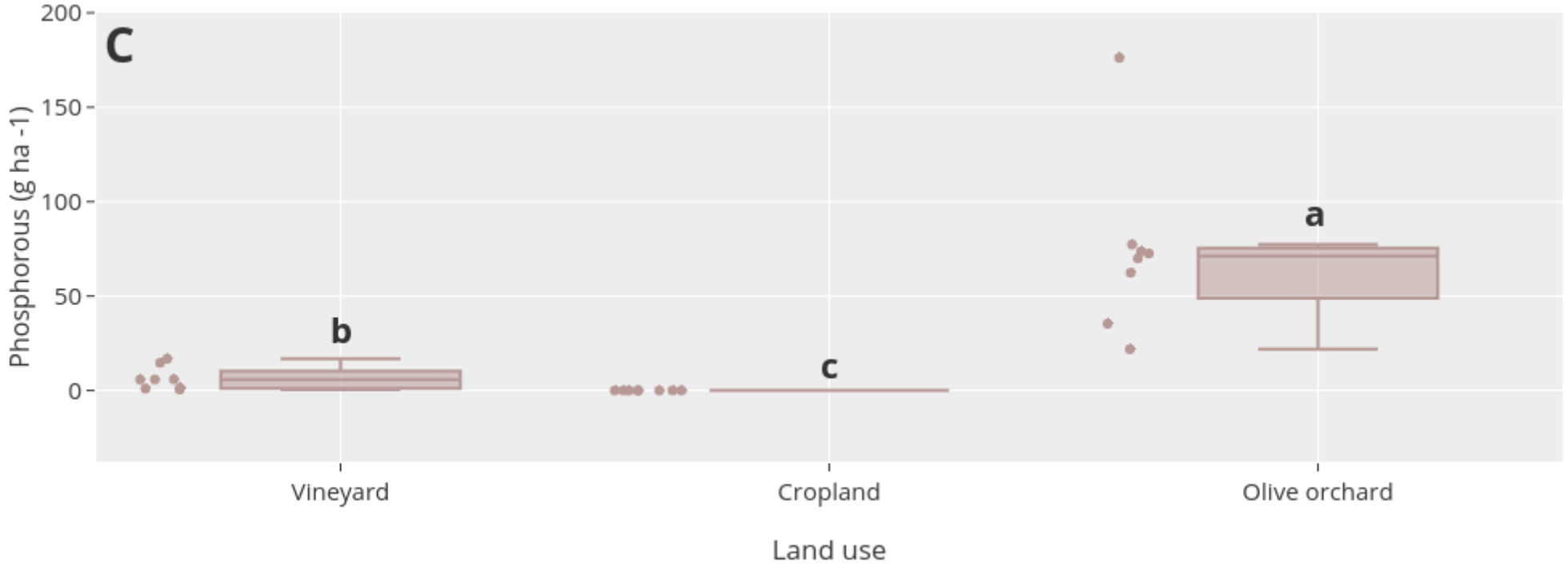
Carbon loss in runoff. Different lower case letters represent significant differences at a $p<0.05$.

Results – nutrient losses



Nitrogen loss in runoff. Different lower case letters represent significant differences at a $p<0.05$.

Results – nutrient losses



Phosphorus loss in runoff. Different lower case letters represent significant differences at a $p<0.05$.

Conclusion

- The tillage practices in vineyard likely decreased soil bulk density and increased water holding capacity.
- The application of organic fertilizers in olive orchard increased soil quality. Nevertheless, tillage management in vertic soils, low vegetation cover and the application of hydrophobic organic material increased the overland flow and sediment and nutrient losses.
- Soil in cropland area with minimal disturbance had a high infiltration → less frequent tillage and cover crops increased soil resistance to rainfall impact.
- The practices applied in vineyard and olive orchard need to be reconsidered.
- Temporal studies are obligatory in order to have a clearer picture of management practices on soil and hydrological response.

Thank you for attention!!!

This work was supported by the **Croatian Science Foundation** through the project

"Soil erosion and degradation in Croatia" (UIP-2017-05-7834) (SEDCRO).