JRL 2022
Team Soil Salinity : Carston, Isabella, Maëlle

Introduction

Presently, soil salinisation is one of the most devastating environmental problems associated with soil degradation, threatening around 932.2 Mha worldwide[1]. This phenomenon increases around 10% annually. Causes range from natural environmental events to the influence of human activities in the agricultural sector. By 2050, the situation could become severe; some estimations predict that more than 50% of arable land will be salinized.[2] This threat is most prevailing in arid to semi-arid regions which receive lower levels of rainfall annually, notably southern Europe().

A soil is considered saline if it contains a high enough salt concentration to interfere with plant growth, and if it presents an electrical conductivity superior to 4 dSm^{-1} [3]. There are two main ways soil salinization is characterized: primary salinization and secondary salinization. Primary salinization depends on the natural conditions of the environment, and it usually occurs when leaching is insufficient to move salts out of the soil [4,5] Secondary salinization comes from anthropogenic activities of which the major drivers are irrigation with saline water[6], use of fertilizers[7], compacted and limited leaching soils[8], wastewater treatments[9], and salt based deicing techniques[1].

Salinity stress has major consequences on plant growth and development by inhibiting seed germination, root length, plant height, fruitification, and photosynthesis.[10] In this sense, soil salinity will affect almost all aspects of plant development, thus causing a lower agricultural productivity leading to a lower economic return[11]. Also, the ability to tolerate saline soils can greatly vary from one plant to another reflected by their physiological responses[12].

When it's no longer viable to cultivate crops on agricultural lands, or to adapt any other management practices, the lands usually fall into abandonment. This phenomenon increases with time, and fields follow different trajectories depending on their cultivation legacies. It particularly concerns vineyards[5] in coastal regions. Different stages of abandonment can be characterized through the evaluation of community changes described by functional traits on plants[13].

This research takes place in Narbonne, France, one of the biggest cities in the Aude department[5]. The city is passed by Aude river, which has a southern branch, La Robine, that flows to Bage-Sigean and another northern branch that joins to the sea[14]. For this study, we consider the two ways this region has achieved the current levels of salinization which have led to agricultural lands being abandoned. This region has been historically affected by seawater flooding for both brief and long periods of time[15,16]. Moreover, the region surrounding Narbonne has been used for salt factories which add to the salinization of the soil. Consequently, salinization in the Aude region is already an ancient phenomenon, presently managed through the artificial submersion of land with fresh water ensuring the leaching of salts[5].

The following research examines how the structural properties of the soil, species composition, and functional traits in abandoned vineyards compared at multiple stages of abandonment. This research aims to provide a better understanding of the ecological and pedological processes involved after the abandonment of agricultural lands, specifically vineyards.

Therefore, our work is divided into different phases. First, we delimit the region of study by dividing the abandoned vineyards between several classes of abandonment (by decades) and then select one or two plots from each stage of abandonment. Once the fields are selected, we make measurements to characterize certains soil and ecology traits. For soil properties, we measure a few major traits to differentiate the salinity between our plots. For plants, we measure traits influenced by salinity. And concerning plant communities, we select traits characterizing the ecology of the plots, such as the dominant species occupying the space.

Finally, we will analyze our results to highlight the interactions between soil properties, plants functional traits and communities traits. This will allow us to verify whether the salinity is indeed increasing with the abandonment stage of fields or not; if this difference of salinity impacts the development of plants, at the scale of the species and the community; and see if the specific plants adapted to the new conditions induced by the rise of salinity in plots influence the soil structural properties.

With this interdisciplinary work, we do not expect to have exhaustive and precise lists of traits for each aspect of our subject, though we plan to select the most representative to draw a conceptual scheme of the interrelations between soil properties, plants functional traits and community structure.

In this case, the rehabilitation of former agricultural lands could be especially interesting for maintaining agricultural activities in the area and dealing with salinisation. It seems therefore interesting to investigate the web of soil salinization in conjunction with plant biodiversity[10] to better understand how these fields have been changing through time since their abandonment.

On the other hand, research on *plants'* impact on the salinity of the soil is less studied and could be useful in the remediation of lands affected by high salinity. Salt tolerant species have special physiological characteristics which aid in the compartmentalization of salt ions present in the soil[12]. For this reason, these plants are especially favorable when considering the restoration of distressed fields. In nomenclature, phytoremediation is the biological process of establishing salt tolerant plants for the creation of more suitable soils for agriculture[4].

Among several studies looking at the link between salinization processes and plant development and adaptation plants, the effect of plant communities on soil salinity seems to be less frequently studied in the scientific community working on plant ecology.

References

1. Mateo-Sagasta, J. Agriculture and water quality interactions: a global overview. 46.
2. Jamil, A., Riaz, S., Ashraf, M. & Foolad, M. R. Gene Expression Profiling of Plants under Salt Stress. *Crit. Rev. Plant Sci.* **30**, 435–458 (2011).
3. Allison, L. E. *et al.* United States Salinity Laboratory Staff. 166.
4. Imadi, S. R., Shah, S. W., Kazi, A. G., Azooz, M. M. & Ahmad, P. Chapter 18 - Phytoremediation of Saline Soils for Sustainable Agricultural Productivity. in *Plant Metal Interaction* (ed. Ahmad, P.) 455–468 (Elsevier, 2016). doi:10.1016/B978-0-12-803158-2.00018-7.
5. Présentation au CDA de la Narbonnaise et du Littoral. S.A.L.I.N report. (2020).
6. Trnka, M. *et al.* Consequences of climate change for the soil climate in Central Europe and the central plains of the United States. *Clim. Change* **120**, (2013).
7. Barradas, J. M. Effect of Fertigation on Soil Salinization and Aggregate Stability. *J. Irrig. Drain. Eng.* **141**, (2014).
8. Eckelmann, W. *et al. Common Criteria for Risk Area Identification according to Soil Threats*. (2006).
9. Moray, C., Hua, X. & Bromham, L. Salt tolerance is evolutionarily labile in a diverse set of angiosperm families. *BMC Evol. Biol.* **15**, 90 (2015).
10. Liang, W., Ma, X., Wan, P. & Liu, L. Plant salt-tolerance mechanism: A review. *Biochem. Biophys. Res. Commun.* **495**, 286–291 (2018).
11. Hu, Y. & Schmidhalter, U. Limitation of Salt Stress to Plant Growth. in 191–224 (2004). doi:10.1201/9780203023884.ch5.

12. Munns, R. & Tester, M. Mechanisms of Salinity Tolerance. *Annu. Rev. Plant Biol.* **59**, 651–681 (2008).

13. Gedan, K. B. & Fernández-Pascual, E. Salt marsh migration into salinized agricultural fields: A novel assembly of plant communities. *J. Veg. Sci.* **30**, 1007–1016 (2019).

14. P, A. Geological proof that Clape massif(Languedoc coast) was an island during the Flandrian transgression. *Comptes Rendus Acad. Sci. Ser. 2 Fasc. B Mec.* **316**, 237–244 (1993).

15. Raats, P. A. C. Salinity management in the coastal region of the Netherlands: A historical perspective. *Agric. Water Manag.* **157**, 12–30 (2015).

16. Projet S.A.L.I.N – Salinisation des Aquifères LIttoraux de la Narbonnaise. 106 (2021).