

## PHD PROJECT DESCRIPTION

(4000 characters max., including the aims and work plan to be published online)

**Project title: Selection of salt-tolerant medicinal plant ecotypes from natural saline habitats**

### 1.1. Project goals

Soil salinity is becoming a serious problem worldwide in agriculture (Cardenas Perez et al., 2026). There is an increasing need to breed salt-tolerant crops, to identify alternative crops among naturally adapted halophytes, and to identify salt-adapted ecotypes among economically important glycophytes (Piernik et al., 2017). However, the natural resources of salt-tolerant plants remain largely undiscovered. In temperate Europe, saline habitats occur both in coastal salt marshes (habitat 1330, Natura 2000) and inland salt marshes associated with saline groundwater and salt deposits (priority habitat 1340; Council Directive 92/43/EEC). These environments host a range of plant species, including widely known medicinal plants such as *Achillea millefolium*, *Taraxacum officinale*, *Polygonum aviculare*, *Plantago intermedia*, *Trifolium fragiferum*, and *Salicornia europaea* (Piernik, 2012). Previous studies demonstrated that salinity tolerance in halophytes such as *Salicornia europaea* and *Tripolium pannonicum* depends on maternal environmental conditions, particularly salinity. This suggests that populations of medicinal plants occurring in saline habitats may represent locally adapted ecotypes with enhanced tolerance to salt stress (Piernik et al., 2025; Ludwiczak et al., 2024). Therefore, we hypothesize that maternal exposure to salinity drives adaptive differentiation in medicinal plant populations, resulting in ecotypes with enhanced salt tolerance compared to non-saline populations. The aim of this project is to select and characterize salt-tolerant ecotypes of medicinal plants by analyzing morphological, anatomical, and physiological traits under controlled salinity conditions and comparing populations originating from saline and non-saline environments.

### 1.2. Outline

The project builds on previous research on inland salt-marsh vegetation in Central Europe and on experimental studies of plant responses to salinity (Piernik, 2012 - Project KBN 3 P04F 069 24; Project NCN 2021/43/D/NZ8/01137). First, medicinal plant species associated with saline habitats will be identified using an existing vegetation database combined with medicinal plant inventories. Environmental parameters, including salinity, will be used to assess species occurrence patterns along salinity gradients. Based on these analyses, the most frequent and relevant species will be selected for experimental studies. Laboratory experiments will then be conducted to identify mechanisms of salt tolerance and to determine the most tolerant ecotypes.

### 1.3. Work plan

#### Task 1. Identification of medicinal plant species associated with saline habitats.

Using an existing database of inland salt marshes in temperate Europe (Lubińska-Mielińska et al., 2023) and a medicinal plant checklist (Jędrzejko, 2001), we will identify species frequently occurring in saline environments. Environmental and vegetation data will be used to assess relationships between species occurrence and salinity gradients (Piernik, 2012; Pätsch et al, 2024; e-haloph database). We assume that medicinal plant species occur across a range of salinity levels. (Year 1-2)

### Task 2. Seed collection and germination experiments

Field sites representing different levels of maternal salinity will be selected. Seeds of target species will be collected and tested for germination under controlled conditions. We assume that populations from saline habitats produce viable seeds under salinity stress. Preliminary tests on *Achillea millefolium* confirm this assumption. (Year 1-2)

### Task 3. Assessment of salt tolerance in selected populations

Plants will be grown under controlled conditions at different salinity levels. Morphological, anatomical, and physiological traits will be measured and compared between populations (Rajabi Dehnavi et al., 2025a, 2025b; Piernik et al., 2022, 2025; Ludwiczak et al., 2024). We expect salt tolerance to vary among populations and to depend on maternal salinity, as demonstrated in previous studies. Soil samples' properties will be taken into consideration. The most tolerant ecotypes will be identified based on integrative trait responses. (Year 2-3)

Envisioned results. The project will result in a series of scientific publications for each task and will provide a comprehensive assessment of salt tolerance in medicinal plant ecotypes. (Year 3-4).

Importance. This project addresses a key challenge: adaptation to increasing soil salinity for modern agriculture. The results will improve understanding of plant adaptation to salinity and help identify salt-tolerant plant material. This knowledge may support the development of crops suitable for saline and marginal lands and promote the use of medicinal plants in sustainable agricultural systems. The project will provide both fundamental ecological insights and practical applications for agriculture and environmental management.

## **1.4. Literature (max. 7 listed as a suggestion for a PhD candidate preliminary study)**

Cárdenas Pérez S., Rajabi Dehnavi A., Leszczyński K., Lubińska-Mielińska S., Ludwiczak A., Piernik A. (2022). DOI:10.3390/plants11081051

Lubińska-Mielińska S., Kącki Z., Kamiński D., Pétilon J., Evers C., Piernik A. (2023). DOI:10.1016/j.scitotenv.2022

Ludwiczak A., Kapusta P., Chapko P., Wojtasik J., Wojciechowska A., . (2024). DOI:10.1016/j.envexpbot.2024.106008

Piernik 2012. Ecological pattern of inland salt marsh vegetation in Central Europe. NCU Press, Toruń.

Piernik, A., Gargouri, N. E., Hulisz, P., Rajabi Dehnavi, A., & Cardenas Perez, S. (2025). <https://doi.org/10.3390/plants14213383>

Rajabi Dehnavi A., Lubińska-Mielińska S., Lewandowska W., Piernik A. (2025a). DOI:10.1038/s41598-025-21547-9 Q1

Rajabi Dehnavi, A., Lubińska-Mielińska, S., Lewandowska, W., & Piernik, A. (2025b). <https://doi.org/10.1186/s12870-025-07900-0>

### **1.5. Required initial knowledge and skills of the PhD candidate**

A background in plant ecology, ecophysiology, and plant stress adaptations, experience in both laboratory and field work, and a solid understanding of basic statistical methods, with a willingness to further develop skills in multivariate data analysis.

### **1.6. Expected development of the PhD candidate's knowledge and skills**

The PhD candidate will develop advanced knowledge in plant ecology and ecophysiology, with a focus on plant responses to salinity. They will gain experience in experimental design, laboratory and field methods, and trait-based analyses. The project will strengthen skills in statistical and multivariate data analysis, as well as in handling ecological datasets. The candidate will also develop competencies in scientific writing, publishing, and presenting research, as well as in independent research and critical thinking.