BALANCING ACT: HOW EXCESS NITROGEN SHAPES ROOT GROWTH AND FUNCTION IN *POPULUS TRICHOCARPA* UNDER WATER STRESS? (*NITRhizo)*

Excess nitrogen in the environment has significant ecological and climatic consequences. While nitrogen is essential for plant growth, its overuse—primarily due to synthetic fertilizers, industrial emissions, and livestock waste—leads to soil degradation, water pollution, and atmospheric imbalances. The excessive application of nitrogen fertilizers can cause nutrient runoff into rivers and lakes, resulting in eutrophication, where algal blooms deplete oxygen levels and harm aquatic life. Moreover, nitrogen compounds contribute to air pollution and acid rain, further disrupting ecosystems. Additionally, human-driven nitrogen inputs have more than doubled the natural nitrogen cycle, leading to severe environmental consequences on both local and global scales. Nitrogen pollution is also primarily a key driver of climate change.

Although plants initially benefit from high nitrogen availability, excessive amounts can lead to imbalanced growth. Rapid vegetation growth often results in weaker root systems, making plants more vulnerable to drought and disease. Nitrogen availability can significantly influence root structural adaptations and anatomical traits in plants. High, but moderate, nitrogen levels often promote increased root biomass and lateral root proliferation, enhancing nutrient uptake efficiency. However, excessive nitrogen can also lead to morphological changes such as reduced root diameter, altered cortical cell structure, and thinner endodermal layers, which may affect water and nutrient transport. These structural modifications reflect a trade-off between maximizing nitrogen absorption and maintaining overall root functionality under nutrient-rich conditions. Nitrogen regulates root growth at the genetic and physiological levels for efficient utilization of nitrogen resources, however, relevant works are usually limited and focused on herbaceous crop plants, rather than trees. Nitrogen fertilization significantly enhances the growth and biomass production of poplar plantations, as poplars, as recommended for years, have higher nitrogen requirements compared to many other tree species. While certain cultivation practices are essential for maximizing productivity, the role of nitrogen fertilization is less clear. Taking into account all the aforementioned arguments and drawing on our experience as well as available literature data, we have formulated the objective of the project to find out the mechanisms that regulate different root growth based on varied nitrogen status and availability. Additionally, we will check if this relationship can be abolished by drought.

The aim of the project will be pursued based on the multifaceted knowledge acquired during this study, with the use of **anatomical, cytological, physiological, chemical, molecular, and breeding methods** for model tree species *Populus trichocarpa*. The main goal of the project is to fill gaps in the knowledge of the **mechanisms controlling plant root functioning in nitrogen excess**, based on the main hypothesis that there is a unique, genetically programmed process that can be switched on during higher nitrogen availability.

An important advantage of the submitted project is the innovative proposed research strategy that considers the root growth's knowledge and comparative characteristics under different conditions, including various nitrogen and water availability, with a strong suggestion that the growth remodeling can be genetically programmed. To date, no explicit reports have addressed this issue; however, numerous studies have emphasized the importance of this area of study. Some authors have raised single suggestions; however, the mechanism of cellular degradation in response to nitrogen excess and the regulation of this process have not yet been elucidated. The project's outcome will be acquiring new knowledge about the molecular and physiological mechanisms of the root system's response to excess nitrogen in the soil, including under conditions of limited water availability. The results obtained may form the basis for developing more sustainable fertilization strategies and support efforts to protect the environment and mitigate the effects of climate change, particularly in the context of forestry and agriculture.