Modeling the effect of climate change and soil organic carbon on baking quality traits of winter wheat cultivars in temperate climate

Wheat, a crop cultivated globally, is known for its high nutritional value and vitamin content. Unfortunately, its cultivation is threatened by climate change, which affects temperature, water availability, and soil organic carbon (SOC). These factors pose a significant challenge for plant breeders worldwide, negatively impacting the food economy and baking quality. However, enhancing the SOC content in the top layer of soil can promote soil aggregation and increase the stabilization of SOC, which boosts crop yields and improves their stability. The Paris Agreement of 2015 recognizes the importance of healthy soils with sufficient SOC in mitigating the impact of climate change on food security. The negative effects of climatic stress on wheat crop quality and stability are well documented, with irregular precipitation patterns, higher temperatures, and water-deficient areas significantly limiting yield and quality.

Moreover, environmental stressors disrupt metabolic and molecular pathways, reducing wheat's protein and mineral content. Genetic diversity in wheat has declined over time, from its wild ancestor to the latest modern cultivars. Landraces of wheat, with a wider adaptation range and a more diverse genetic background, are crucial for future climate change adaptation, as modern genotypes are more susceptible to emerging threats from diseases, pests, and weeds. Therefore, genotypic adaptation is critical for addressing future climatic changes and ensuring food security. Innovative products that improve human nutrition require high-quality wheat grain, which is impacted by the rate and duration of grain filling, protein accumulation, and starch deposition during grain development. In summary, climate change poses a significant challenge to wheat cultivation, potentially impacting food security and the economy. However, enhancing the SOC content in the soil and using landraces with a more diverse genetic background is crucial for developing resilient wheat varieties that can withstand the emerging threats of climate change.

The scientific goal of this project is to predict how baking quality traits in wheat might change in different climate change scenarios. The project aims to answer several research questions: how will climate change affect the baking quality of wheat cultivars under a temperate climate? How will the genetic diversity of wheat cultivars impact their adaptability to climate change and baking quality under climate change? And how will an increase in soil organic carbon affect wheat cultivars' baking quality and stability under climate change?

The project will verify several hypotheses, including the effect of climate change will decrease the baking quality, disturbing the stability of wheat cultivars; cultivars of wheat bred for specific traits are more adaptable to climate change and produce higher baking quality under stress conditions; and an increase in soil organic carbon will lead to an increase in baking quality and the stability of wheat cultivars in the expected climate change. The methodology of the project involves three tasks. The first task will be to analyze historical data on wheat cultivars to assess breeding progress, heritability, genetic trends, and stability of baking quality traits. The second task will be to develop a new model, and the final task will be to use the calibrated model to evaluate the impact of climate change on baking quality traits and the stability of wheat cultivars. The analysis results will identify cultivars likely to maintain their stability in baking quality traits under future climate scenarios.

This project will provide several potential benefits for farmers and breeders. The project's first aim will allow the breeders to use this information to develop new wheat cultivars that will be more resistant to the adverse effects of climate change, ensuring that farmers will continue to produce high-quality wheat and maintain food security. The second aim of the research will provide insights into which wheat cultivars will be more resilient to climate change and help breeders select the most suitable cultivars to develop new varieties. And the third aim will be used by farmers to adopt soil management practices that will increase soil organic carbon, potentially leading to higher yields, improved soil quality, and better baking quality. Overall, this project will provide crucial information to farmers and breeders, allowing them to make informed decisions about which wheat cultivars to grow and how to manage their soils to maintain or improve baking quality in the face of climate change.