# Cytoplasmic inheritance and possible heterosis of protein content in bread wheat

*Case study*
*- Planning a breeding program aiming to improve the protein rate in common wheat grown under conditions of low nitrogen inputs*

The technological value of common wheat is based mainly on the content and composition of storage proteins. A minimum content is required for export (11%) and current industrial processes are increasingly demanding in protein.
At the same time, there is a downward trend in protein content in French national production. The current varieties of wheat have been bred under heavy nitrogen fertilization, which has a strong negative impact on the environment, as well as a significant energy cost. This type of selection is therefore no longer optimal in the current context. However, nitrogen fertilization plays a major role in yield and protein content. This is because the reserve protein composition is determined by the amount of nitrogen in the grain.
Tackling the challenge therefore requires creating innovative varieties which grown in conditions of reduced nitrogen fertilization, show high yield potential as well as good quality of use.

A seed company wants to know if it would be interesting to conduct a breeding program to create a wheat variety with improved efficiency of nitrogen use, based on the cross of two of their elite varieties of bread wheat: Opale and E508.
In addition, the company aims to obtain information on the genetic control of the quantitative level of grain protein, in particular about the possible existence of a heterosis effect (and more particularly of superdominance) and about possible cytoplasmic inheritance.
To answer these questions, a comparative test in the field of the protein content (in%) in the grain is carried out under cultivation under low nitrogen inputs. The performance of the 2 parental lines (Opale and E508), reciprocal F1 hybrids F1OxE (using the Opale variety as female parent and E508 as male parent) and F1ExO (using variety E508 as female parent and Opale as male parent), and segregating F2 populations from the two reciprocal F1 crosses (F2OxE and F2ExO) are evaluated under the same environmental conditions.

During the analysis of this case study, statistics will be used as a decision tool to determine whether it is worthwhile to continue the breeding program and, if necessary, to make the decisions on the strategy to be implemented to carry out this program.

*Based on statistical analyzes, the goal of the breeder is to answer the following three questions to make the necessary decisions to carry out the breeding program:*
*• Is the difference observed in the protein content between the 2 parental varieties due to hereditary factors?*
*• Is there a heterosis effect for protein content?*

• *Is there cytoplasmic inheritance controlling the agronomic trait of interest?*

1. Define what is the heterosis effect. What are the genetic bases underlying this phenomenon? How is it expressed physiologically and metabolically in plants?

2. Define what is cytoplasmic inheritance is. What are the genetic bases underlying this phenomenon?

3. Relying on graphical representations of the data,
   - you will discuss the quality of the data set (eg existence of outliers, etc.),
   - you will discuss the potential existence of an effect of variety on the protein level

4. You will conduct a statistical analysis to test the effect of variety on grain protein levels. After showing that the postulates of the statistical method you have used are verified, you will interpret the results regarding the effect of the factor studied.

5. Identify varieties with significantly different protein levels from each other.

   On the basis of the results of this statistical analysis, answer the three main questions. What does this imply for the seed company regarding the strategy to be implemented for the breeding program?

6. Calculate the heritability in the broad sense of the studied trait and interpret.