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From ideotypes to genotypes: approaches to adapt wheat phenology to climate change

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Abstract

Introduction:
Simulations using crop models can assist in designing ideotypes for current and future agricultural conditions. This approach has been often in recent years to identify avenues for adapting wheat to climate change. However, this approach has rarely been used to guide commercial breeding programs. We hypothesize that the lack of link between models and the available tools for breeding, i.e. available genetic variability and selection methods.
Materials and methods:
- We use a modified ARCWHEAT2 phenology model and future climate data from the ARPEGE global circulation model to identify targets for future phenologies
- We genotyped over 400 French cultivars for known phenology genes and confronted the genetic make-up of these varieties to their success in France over the past 25 years
- We developed a methodology to link model parameters to underlying marker data. We tested the performance of the methodology against circa 60 varieties
Results:
- Earlier phenology may be an avenue for stress avoidance in the future.
- Current photoperiod sensitivity of early cultivars already poses problems in terms of adaptation, as exemplified by the interaction between Ppd-D1 and Vrn-A3

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- We show that a gene-based model can be used to predict wheat phenology without a significant loss in predictive performance.

Discussion :

Analyzing current phenology genes of existing cultivars and their adaptation allowed us to identify a limit to past breeding efforts in obtaining early cultivars. This requires that a more knowledge based approach be taken. Gene-based modelling of phenology is possible on a collection of elite, adapted varieties and provides the tools for constructing genotypes with specific allelic combinations leading to more appropriate constructions of earliness.

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Keywords: Wheat; earliness; marker-based model; plasticity; photoperiod sensitivity

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