Machine learning for selecting crop varieties as climate adaptation measure

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Objective
This project aims to develop hybrid methodologies based on machine learning, statistics, and (dynamic) process-based modelling as a proof-of-principle for a tool for the selection of optimal crop genotypes for changing climates.

Background
- Climate change affects conditions for crop growth.
- Crop traits like yield result from time-dynamic GxE (genotype-by-environment interactions).
- Selecting new crop genotypes suitable for new conditions requires forecasting.
- Current crop modelling lacks reliable descriptions of essential GxI under heat conditions.
- Increasing availability of time series data of crop phenotypic traits of multiple genotypes in multiple environments (High Throughput Phenotyping, remote and proximal monitoring).
- We aim to combine statistical, Machine Learning (ML), and process-based modelling approaches to obtain GxI describing heat responses for crop models from these time series data.

Key results

- Low-complexity Differential Equation (DE) based crop growth models were fitted to time series data (in silico as well as experimental) of different genotypes in different environments.
- Different ML methodologies were tested for classification of time series data to identify critical growth processes with the inclusion of different types of noise.
- The model Tipstar for potatoes was coupled with Prosail (a canopy reflectance model) for crop disturbance classification with ML.

Main activities

- Logistic model: Emerald 1985 g018 model #2
- Irradiance model

- Water model, Emerald, 2002, g017
- Soil water

- Above. The best-fitting model differs per genotype and per environment. This suggests there are different limitations for the various genotypes in these environments, including around climate-affected attributes such as water and temperature response. These need to be included in future work. (Van Voorn et al., Frontiers in Plant Science 14, 2023)

Next steps

- Research will continue in
  - KB DDHT2 programme, likely resulting in an app on Farmmaps;
  - Follow-up D3-C2 project ‘Hybrid Machine Learning process-based modelling approaches for climate adaptation strategies’ focusing on applications of ML to assess climate adaptation measures in the agri-food value chain;
  - Two PhD projects and several MSc topics on using ML for classification of time series and reconstruction of dynamic systems (such as GxI in crops) from such data.