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Prediction and Modeling of Hybrid Performance and Yield Gain in Oilseed Rape by Systems Biology

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Hybrid breeding has significantly increased yields in the last years, because hybrids potentially have a greater capacity to adapt to increasing climate-change related fluctuations of the physical environment. In a hybrid program, generating and testing all hybrids resulting from pairwise combinations of potential parents under different environments is practically impossible. To provide a solution to this problem, we developed a systems-biological approach to predict hybrid yield performance based on information about genomic, epigenetic and regulatory profiles of parental genotypes and their responses to environmental stimuli. The dataset comprises samples of mRNA, small RNA and DNA methylation patterns taken at seedling stages, root architecture data and field phenotypic data of biomass, Leaf Area Indices (LAI) and yield components at different geographical locations and development stages. A photosynthesis-driven growth model with leaf and pod specific assimilation and rapeseed specific development was assembled, calibrated and tested to explain environmental effects on yield of hybrids grown at different locations in Northern Germany. The simulated patterns of physiological state variables among hybrids were subsequently compared against genetic and epigenetic patterns. Aiming at improving predictions of hybrid performances in different environments, we show to what extent genotype-specific physiological parameters can be replaced with inter-genotype specific crop modelling parameters based on machine-learning generated clusters within the genetic and epigenetic data.