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08. INCREASING YIELD POTENTIAL: FROM PHYSIOLOGICAL PROCESSES TO IDEOTYPING

RICE YIELD POTENTIAL: CAN INTEGRATION OF ‘OMICS’ AND IDEOTYPE MODELING BREAK NEW GROUND?

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Genotypic yield potential (YP) increased substantially with the development of the semi-dwarf ideotype, having improved resource responsiveness and assimilate partitioning. ‘Omics’ now offer to breeders targeted access to the complete phenotypic and genetic diversity of the species, with opportunities to engineer ideotypes having optimal trait combinations. This may ultimately replace trial-and-error approaches but requires solid concepts of how new ideotypes should look like and function. In that purpose, a new brand of integrative physiology and tools predicting trait expression and interactions is needed.

Our approach combines (1) multi-trait, multi-environment ‘phenomics’ mapped by genome-wide association (GWA), and (2) models that integrate structure (emerging from morphogenetic processes), function (resource acquisition/conversion and stresses), and agronomy (environment and crop management). An iterative research process involving physiology, breeding, genetics and modeling ensures relevance for application and feasibility of emerging ideotypes. The GRiSP Phenotyping Network provides the ‘omics’ dimension. Ideotype construction and virtual testing use, among several models, the new *Samara* that simulates trait-to-trait interactions (e.g., compensations) and Genotype x Environment x Management interactions on the phenotype. Extensive field experiments were conducted for model calibration. For key traits and their observed genetic diversity, virtual recombinant populations are then generated in silico, from which ideotypes are selected by multi-environment simulation.

Partial results are presented on (1) observed diversity and GWA for some phenology and assimilate source/sink traits; (2) experimental data on radiation use efficiency (RUE), thermal response of respiration and [CO_2] response of photosynthesis, growth and yield; and (3) simulation outputs. On the background of these results, theoretical concepts for gauging biological margins to improve yield potential are discussed.

An emerging conclusion is that further increases in yield potential (YP) may require increased photosynthesis although most current differences in genotypic YP are not driven by photosynthetic rate. Diversity for photosynthesis exists, in part because of the lag in evolutionary adaptation to rapidly rising [CO_2]. Increased size and mobilization of non-structural carbohydrates (NSCs) reserve pools and improved sink regulation also have potential to increase YP. More research is needed to propose to breeders comprehensive, quantitative and validated ideotype concepts.