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Model assisted phenotyping of the source-sink relationships underlying the genetic diversity of sugarcane productivity

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Highlights: Ecomeristem, FSPM simulating sugarcane morphogenesis and plasticity depending on its nutritional status (C, H20), was used to analyze the genetic diversity of source-sink related traits controlling structural vs. non structural carbohydrate accumulation and thus sugar production. Results are discussed with respect to the challenge of FSPM assisted phenotyping and breeding.

Keywords: Model assisted phenotyping; complex traits; sugarcane production

Sugarcane productivity depends on its capacity to produce big plants that accumulate high quantity of sucrose per unit of stem volume. Accordingly sugar production is a complex trait resulting from dynamic C source-to-sink relationships and trade-offs within the plant. Up to now, sugarcane breeding largely focused on the observation of stem sweetness and size at harvest, without considering the processes that dynamically determine both structural and non structural carbohydrate accumulation.

FSPM are particularly relevant to formalize such complex source-sink relations. They can be useful to simulate and apprehend the diversity of phenotypes emerging from such hidden trade-offs among traits, depending on the genotype and its environment. Up to now the usefulness of model assisted phenotyping in the context of genetic studies was demonstrated only for models dealing with simple traits (Reymond *et al.* 2003). The application of complex trait models is reported as more challenging but crucial for two reasons (Luquet *et al.* 2012; Quilot *et al.* 2005): (i) complex trait phenotyping requires not only their dissection in simpler traits but also the identification of linkage(s) among them; (ii) similarly the subsequent exploration of plant ideotypes (combining traits to optimize plant behavior in a given environment) implies that such (genetic, physiological) linkages are accounted for.

Recently, *Ecomeristem*, a FSPM simulating rice plant vegetative morphogenesis (topology, biomass allocation, C storage/mobilization) and its plasticity depending on its nutritional status (C, H20), was used to analyze the genetic diversity of traits controlling rice early vigor. Model parameters controlling plant morphogenesis and source-sink relations were used to cluster and understand the behaviors met in the studied rice diversity panel and explore ideotypes (Luquet *et al.* 2012). In the context of DELICAS, project aimed to identify the genetic bases of sugarcane production, *Ecomeristem* was adapted to sugarcane. The present study aims at presenting this model version and its application for exploring the genetic diversity of the source-sink processes controlling sugarcane productivity. Once validated and tested on a panel of 20 genotypes, the model was used for phenotyping a diversity panel of 200 genotypes contrasting for morphology (leaf and internode size, tillering) and sweetness. The results highlight the opportunity and limits of the approach toward applications in a breeding context.

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