SuMoToRI: a model to simulate growth and sulfur content in rapeseed until the onset of pod formation

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Context and objectives

Sulfur (S) nutrition in rapeseed (*Brassica napus* L.) is a major concern for this high S-demanding crop especially in the context of soil S oligotrophy. Modelling growth according to major environmental factors *i.e.* temperature, photosynthetically active radiation and, S taken up by the plant could help for the diagnosis of S deficiencies during the early stages.

A process-based model, **SuMoToRI** "Sulfur Model Towards Rapeseed Improvement", was developed to predict the dynamics of plant growth and S allocation (between the plant's compartments) and S pool partitioning (repartition of the mobile-S *vs*. non mobile-S fractions) until the onset of pod formation.

Model description

Key features

- Environmental factors :*Temperature, PAR, amounts of S taken up*
- Period of prediction: from end of vernalization to early pod formation
- Daily time step
- Plant and canopy levels
- Processes: PAR absorption for biomass production (Monteith's equation), biomass allocation, S allocation, S remobilization
- Three-compartment model: Green leaves (GL i.e. photosynthetic leaves gathered as a single BIG LEAF), Fallen leaves, Rest of the plant
- Distinction of two pools of S:
  - non mobile fraction (organic fraction used for structural and metabolic functions)
  - mobile fraction (mainly SO_4^{2-} used for remobilization)

Key principles

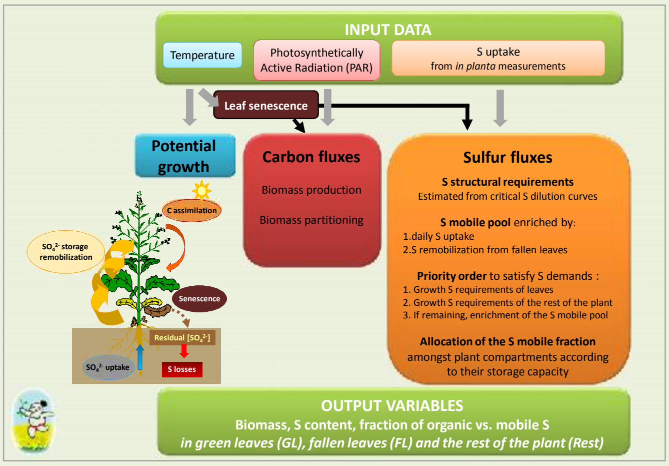

Figure 1: Overview of SuMoToRI. Description of the driving processes that are related to potential growth, PAR assimilation, biomass allocation and S remobilization, compartments' allocation and pool partitionning.

Model calibration

Experimental conditions

- Independent datasets for the model calibration (Exp1) and evaluation (Exp2) from greenhouse experiments with the cv. Yudal in contrasting S supply conditions (HS: High S, LS: Low S).
- Initialization at the end of vernalization.
- Construction of a critical S dilution curve based on the methodology used for N (Colnenne et al. 1998) with the prior assumption and simplification that S requirements for growth only (structural and metabolic functions) is satisfied by the organic fraction.

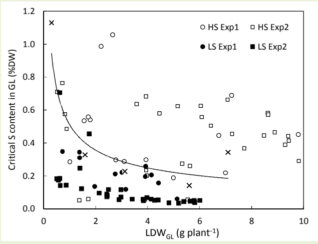

Figure 2: Critical leaf S contents vs. dry weight of GL in the HS and LS conditions for both datasets. The line represents the critical dilution curve obtained by non linear fitting of critical points (cross symbols) calculated with the calibration dataset.

Function calibration and parameters

PAR interception: k	PAR extinction coefficient
Potential leaf growth: LA_{max}, K, n	Leaf area expansion parameters
C acquisition and plant offer RUE $aLDW_{FL}$, $bLDW_{FL}$	Radiation use efficiency Parameters of the function describing the time progression of dry weight of the fallen leaves
C allocation to leaves : β	Coefficient of dry weight allocation to the leaves
Green leaf C demand: SLA	Specific Leaf Area
Growth S Demand α_{GL}, β_{GL} α_{rest}, β_{rest}	Parameters to estimate critical S content in GL/ rest of the plant as a function of the dry weight of the GL /the rest of the plant
Mobile S allocation to leaves : ε_{pot}	Coefficient of potential repartition of mobile S to the leaves

Model evaluation

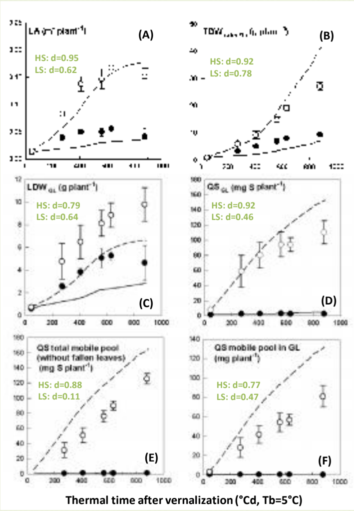

Figure 3: Observed (dots) and simulated (lines) times courses of the main variables for rapeseed plants grown in LS and HS conditions. Bars denote s.d. of mean measurements. The value of the degree of agreement (d) indicates the predictive quality of the simulations (insert).

The model give reliable trends for outputs related to (A) leaf area expansion, (B,C) biomass production and allocation, (D) S allocation and pool partitionning (E, F).

The adequacy between simulated and observed amounts of mobile S in the leaves is satisfying enough to indicate the potential of S remobilization from the leaves.

The evaluation was performed with parameter values (obtained with the calibration dataset) that are independent of the S conditions, except for the RUE which differs between HS and LS.

Under LS, calibrating specifically parameters related to the specific leaf area and C allocation to the leaves was necessary to improve the predictive quality of the model.

Conclusion and perspectives

SuMoToRI is a process-based model of S allocation and partitionning that relies on (i) the establishment of a **critical S dilution curve** has been adapted to estimate the S requirements used for growth only (excluding storage) and (ii) the identification of a **S-mobile pool used to satisfy the demand for growth**. The model allowed plant contrasting behaviours to be predicted with a fixed set of parameter values that are independent of S levels, except for RUE which was showed to respond to S plant status. This observation confirms previous evidence for effects of S availability on photosynthesis and as a consequence on the efficiency to use radiation (Nikiforova et al. 2003; D'Hooghe et al. 2013).

Next steps will be (i) to perform sensitivity analyses in order to rank parameters according to their impact on outputs (ii) to extend the predictive period until seed maturity by integrating a green area index (gathering leaf area and pod area indexes) as a central variable and (iii) to take into account N availability because of the known interactions between N and S metabolisms (Kopriva and Rennenberg, 2004).

14th International Rapeseed Congress, July 5-9 2015- The convention Centre at TCU Place, Saskatoon, Saskatchewan