WP3.1 Genotype specific crop growth model

Objectives:
- “Develop” (select and adjust) a crop growth model for prediction of crop yield performance while accounting for environmental differences
- Determine a set of genotype specific model parameters, which can serve as features for a QTL-analysis

Objectives:
- 1. Inventory of crop growth models
- 2. Adapt crop growth models
- 3. Calibration of the models
- 4. Uncertainty and sensitivity analysis of crop growth model parameters

Task 1: Inventory of crop growth models
- Existing models were studied
- Two categories:
  - comprehensive models with many (>100) parameters: e.g. HORTISIM, INTKAM
  - simple models (≤15 parameters): e.g. LINTUL

Deliverable D3.1.1: report on inventory and motivation of model choice

Month 8

Task 2: Adapt crop growth models
- Iterative process between:
  - which model parameters can be measured in WP 2.3
  - which important parameters are present in the model
- Model setup: clear distinction between genotype specific parameters and other parameters

Deliverable D3.1.2: adapted model(s) suitable for QTL-analysis

Month 24

- Important model parameters:
  - light use efficiency (photosynthesis)
  - fraction partitioned to fruits (fruit set, abortion)
  - leaf area development

Deliverable D3.1.2: adapted model(s) suitable for QTL-analysis

Month 24
Crop growth model

Yield of sweet pepper (g m\(^{-2}\))

\[ \text{Yield} = \text{total biomass production} \times \text{Partitioning into fruits} \]

Light interception

Light use efficiency

Extinction coefficient \(k\) (0.7)

Leaf Area Index

Leaf area index development rate

Dry matter production: a simple LUE model

\[
\frac{dW}{dt} = \text{LUE} \left(1-e^{-k \cdot \text{LAI}}\right) \cdot I
\]

\(dW/dt\) = growth rate (g DM m\(^{-2}\) d\(^{-1}\))

LUE = light use efficiency (g DM MJ\(^{-1}\) PAR)

\(k\) = extinction coefficient

LAI = Leaf area index

I = Photosynthetic Active Radiation (PAR) incident on crop (MJ m\(^{-2}\) d\(^{-1}\))

Assumes constant LUE!

LAI determined by temperature sum

8 experiments, including treatments like CO\(_2\), temperature, plant density; 2 countries (F, NL)

Genotypic variation in yield

Heritability

\(N1\): 0.86

\(N2\): 0.80

\(S1\): 0.92

\(S2\): 0.81

Month 30

Deliverable D3.1.3: estimates, uncertainty and sensitivity analysis of model parameters determined for individual genotypes of the mapping population

Task 3: Model calibration

Task 4: Uncertainty and sensitivity analysis

- Estimate crop growth model parameters for individual genotypes of the mapping population
- Uncertainty and sensitivity analysis for these parameters
Genotypic variation in Light Use Efficiency

| Light Use Efficiency (g dm MJ⁻¹ global radiation) |
|-----------------|--------|--------|
| N1              | 0.52   | 0.66   |
| N2              | 0.66   | 0.73   |
| S1              | 0.73   | 0.75   |
| S2              | 0.75   |        |

Heritability

% Variance in yield explained by yield components

<table>
<thead>
<tr>
<th>Component</th>
<th>N1</th>
<th>N2</th>
<th>S1</th>
<th>S2</th>
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<tr>
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<td>0.02</td>
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<tr>
<td>LUE</td>
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<td>0.14</td>
<td>0.30</td>
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<td>0.75</td>
<td>0.82</td>
<td>0.60</td>
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</tbody>
</table>

What makes a phenotype performing well?

Heritability

Simple model with only 3 genotype-specific parameters

Advantages

- All parameters can be determined for each genotype
- Parameters may be ‘estimated’ by fast-phenotyping
  - Leaf Area Index and “fruit load”: imaging
  - Light Use Efficiency: chlorophyll fluorescence

Disadvantages

- Model does not show cross-overs
  - (1 more parameter is needed; more detailed experiments).

Deliverable D3.1.4: Scientific articles on the new QTL-crop model

- Scientific papers in refereed journals
  - Wubs et al. (May 2012). Process-based simulation models: Linking genotype to phenotype for complex traits
  - Wubs et al. (October 2012). Investigating GxE by simulation using observed QTLs

Thank you for your attention