

Advancing on the phenotyping front

For genetics research (association genetics, QTLs; => markers)?
For direct selection (specific breeding context)?

- Field vs. controlled E
 - « Real » (complex) situations vs model experiments
 - Make sure there's comparability (relevance!)
 - Repeat
- Field: economic & efficient choices
 - Rapid, non-destructive methods
 - Few but « strategic » variables
 - Choose design and environment intelligently to bring out traits
 - Models: Apply simple, robust tools?
- Controlled E: complex traits, process traits, hidden traits
 - Ensure relevance (always in conjunction with field studies)
 - Reductionist vs integrative models?
 - Multi-trait capture in integrative models, but numerous risks
 - Single-trait capture in reductionist models
 - Whatever you do, put in the means and time necessary

Examples of rapid, non-destructive field phenotyping methodologies

Biomass / LAI

**NDVI (green seeker)
LAI-2000, inceptimeters...**

Canopy behaviour (Tr, Pn, TE)

**IR thermography/photography
delta-13C (destructive, but samples small)
Senescence ratios**

Leaf behaviour

**PAM fluorometry
porometry
Leaf rolling/folding score
Extension rates**

Root behaviour (depth)

**Indirect indicators? (shallow/deep soil?)
Tube experiments useful???**

Plant water status

Needed???

Soil water balance / stock

**Heuristics (water balance models)
TDR, neutron probe...**

Yield components of great diagnostic value (extend set of variables?)

Phenology

Architecture???

Model assisted phenotyping with whole-plant models: Current status

Case of EcoMeristem

- Achieved

- Model operational for vegetative stage (rice, sorghum)
 - Sensitive to drought, T and solar radiation
 - Soil water depletion (FTSW) feeds back directly on...
 - Transpiration and C assimilation
 - Organ expansion rates
 - Indirect FTSW feedback on...
 - Transpiration & C assimilation (via leaf rolling)
 - Phyllochron (via extension rate)
 - Tillering (via longer phyllochron & sometimes source limitation)
 - Tiller & leaf senescence (via source limitation)
- Notion of sugar signalling (Ic) & root signals (cstr fn(FTSW))
- Applications to large populations (but quality poor, were we ready?)
- Integrated methodology (dry-down experiments, heuristics)

=> Proof of concept OK for process analysis, but not yet for phenotyping => need to study profiles of genetic diversity

Model assisted phenotyping with whole-plant models: Research/development needs (1)

- Extend to full crop cycle
 - Floral induction
 - PP- and drought-sensitivity
 - Internode elongation
 - Management of elongation
 - Management of C cost & storage (new sink)
 - Panicle development & grain filling
 - # fertile tillers
 - Sink dimensioning (# spikelets)
 - Spikelet filling duration (drought & T) and staggered filling
 - Leaf terminal senescence
 - Is « killing » of leaves via I_c sufficient?
 - Specific effects of stay green traits

Model assisted phenotyping with whole-plant models: Research/development needs (2)

- Look at roots
 - Increase detail of root growth & morphology?
 - How to measure / calibrate in a phenotyping context?
- Microclimate
 - Meristem temperature? (development rate)
 - Panicle temperature? (spikelet sterility, filling duration)
- Inventory of parameters & characterization of their stability
 - Parameter stability across environments
 - Conservation of parameter values lab/field?
 - Parameter stability across genotypes
 - Use heuristics only for paras that show genetic diversity
 - Identify minimum parameter set for heuristics, fix the others

Model assisted phenotyping with whole-plant models: Demonstrate model usefulness

- Skill of genotype discrimination
 - Genetic diversity >> experimental noise?
 - For which traits/parameters?
 - Are these traits/parameters relevant?
- Appropriateness for phenotyping
 - Added value compared to existing phenotyping methodologies?
 - Cost / practicality of application to large numbers?
 - Parameter stability lab/field?
 - And finally: results of association analyses???
- Other applications of model
 - Phenotyping: Extract model concepts and apply in simplified form?
 - Ideotype development (application of full model)
 - Link with 3D visualization (Amap platform)
 - Develop into full crop model (advantage vs. existing models?)

Outlook

New project cluster building on WPM

Rice phenotyping & association genetics network for Drought & Thermal Stresses

