Dr. Bijayalaxmi Mohanty
Systems Biology and Bioinformatics Research Group, ChBE, NUS.

Systems Biology Approach to Understand the Rice Plant Metabolic and Transcriptional Regulation Under Abiotic Stress

Factors affecting rice production

- Light stress: Light quality and intensity affect photosynthesis and other morphological processes
- Drought stress: Water deficit decreases photosynthesis and produces reactive oxygen species (ROS)
- Salt stress: Salinity increases osmotic stress and decreases nutrient uptake
- Biotic stress: Various pathogens infect rice as host
- Flooding stress: Waterlogging causes oxygen deficit

Characterization of stress response is essential for crop improvement and productivity!

Wealth of plant high-throughput data in genomic era: Rice as an example

- Genome: Approximately 389,802,44 bp, 12 chromosomes
- Proteome: Approximately 19,000 proteins
- Micro: More than 20,000 gene expression datasets
- Metabolome: More than 20 studies have reported the metabolome under various stresses

How to combine these data to decipher knowledge? Genome Systems Biology!

Modeling cellular metabolism

Types of Modeling

- Simplest: Infers just the connectivity
- Most comprehensive: Often lacks required experimental parameters
- Realistic solutions due to additional constraints
- Simple & extensible

Depth of coverage in each type of modeling

Rice metabolic modeling

Methods

- Regulatory/metabolic model

- Modeling cellular metabolism

- Types of Modeling

- Depth of coverage in each type of modeling

Rice metabolic modeling

- Regulatory/metabolic model
**In silico** analysis of rice metabolism under drought stress

Metabolic differences in photorespiring leaf cells under normal and drought stressed conditions

Almost all of photosynthesis, Calvin cycle and photorespiration are essential!

---

**Anoxic adaptation of rice coleoptile (contd..)**

Transcriptional mechanisms underpinning anoxic coleoptile adaptation

Comparing the differences in gene expression and flux levels reveals transcriptionally regulated reactions

Comparison of simulated flux changes with public microarray data

---

Identification of candidate network hubs involved in metabolic adjustments of rice under drought stress

**Expansion of central model to genome-scale model**

Reconstruction procedure

Potential transcription factors involved in metabolic adjustments of drought tolerance

---

Characterization of light-specific metabolic and regulatory features in rice

Overall design of the study

---

ICBA conference, 20-22 December, 2012, Bhubaneswar, India
Characterization of light-specific metabolic and regulatory features in rice (contd..)


Summary

- Constraints-based modeling can be used as an effective tool to investigate plant cellular metabolism
- An integrative systems analysis of rice cellular behaviour is initiated by combining model and “-omics” data
- Key transcriptional and metabolic adaptations during anoxia stress are unravelled
- Active adaptation to fermentation and sucrose degradation via MYB, bZIP, ERF and ZnF
- Cellular metabolism during drought stress is characterized
- Critical transcription factors such as AP2/ERF, bZIP, MYB and NAC control the important nodes in the gene regulatory pathway
- These candidate transcription factors involved in metabolic adjustments were previously linked to phenotypic variation for drought tolerance
- Effect of light quality on rice metabolism and the key signalling routes are studied
- Blue light has highest metabolic efficiency but not plant growth
- bHLH, bZIP – blue light specific; MYB – red light specific
- Potential applications: Crop improvement, design of better growth environment, synthetic circuit design and many more…

Acknowledgements

- Department of Chemical and Biomolecular Engineering, National University of Singapore
- Biomedical Research Council of A*STAR (Agency for Science, Technology and Research), Singapore
- Next-Generation BioGreen 21 Program (SSAC, No. PJ008184), Rural Development Administration, Republic of Korea

National University of Singapore, Singapore
1. Dr Dong Yup Lee
2. Dr Weijing Zhang
3. Dr C. Y. Maurice Cheung

Kyung Hee University, Republic of Korea
1. Prof Sun-Hwa Ha

National Academy of Agricultural Science, Suwon, Republic of Korea
1. Dr Sun Hyung Lim

School of Biology and Ecology, University of Maine, USA
1. Prof. Shilada G. de los Reyes
2. Ak Ramesh

Temasek Life Sciences Laboratory, National University of Singapore, Singapore
1. Dr In Cheol Jang

THANK YOU