EuroSciCon
5th Edition of International Conference on
Plant Genomics
June 13-14, 2019 | Berlin, Germany

Assessment of differential responses of rice varieties under drought stress: A value addition to rice phenomics

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Abstract (300-word limit)

Rice is a global staple crop that requires ample amount of water for growth and development. Drought is one of the severe abiotic stresses that affects the productivity of rice. Therefore, there is need to select drought tolerant rice varieties that can efficiently grow in drought-prone areas. The traits responsible for enhancing or adapting drought resistance in rice plants can be selected and studied to improve their growth under stress conditions. Remarkable progress has been made in the direction of trait selection criteria.

Methodology and Theoretical Orientation:

Comparative analysis of various traits have been conducted on drought tolerant and drought sensitive rice varieties. In our study, we have studied morphological, physiological, anatomical, biochemical and molecular variation of different rice varieties. Various root related biochemical and morphological traits such as root length, diameter, area, volume, Relative Water Content (RWC), xylem number, xylem area, proline content, Malondialdehyde (MDA) content, protein and gene expression have been investigated for a comparative study of the plant response to drought stress in different rice varieties. In addition, we implemented novel automated frameworks based on computer vision algorithms for high-throughput quantification of xylem and stomata. This task has been accomplished using Scanning Electron Microscopy images.

Findings:

The results of transcriptome analysis revealed variation in expression of Med37, RSOsPR10, OsPIP2;5 and OsNIP2;1 genes among various rice varieties. The differential proteome analysis using 2-D followed by MALDI-based identification shows role of chitinases in drought tolerance. The learning generated both, through computational/digital image analysis as well as biochemical studies can contribute significantly towards the field of rice phenomics.

Highlights

The salient findings of this work are as follows:

1. Reduction in xylem area as well as xylem number in drought tolerant varieties under drought stress.
2. Lower stomatal density in drought tolerant varieties.
3. Significant correlation of aquaporin genes with the root length.
4. Significant higher root length, area, diameter and volume of root in drought tolerant varieties.
5. Upregulation of OsPIP2;5 and downregulation of OsNIP1;2 was observed in roots of drought tolerant variety.
6. Proline content in the roots found to be significantly higher in tolerant variety.
7. Negative correlation between proline content and RWC.
8. MDA content in tolerant variety under drought is significantly lower.
9. Five proteins (including chitinase) identified that are induced during drought stress.

Conclusion and Significance:

The ultimate aim of our work is to elucidate the drought-related traits using “omics” approach such as phenomics, genomics, proteomics, and transcriptomics that participate in enhancement of drought tolerance. Furthermore, the precise knowledge of morphological, physiological, biochemical, anatomical, and molecular aspects against drought stress is important for selective breeding of high yielding rice varieties. We have analyzed response of both drought-tolerant and drought-sensitive rice varieties under drought stress. In summation, our results indicate that under drought stress a series of changes occur that lead to adaptive responses in tolerant rice crops. Our work provides pivotal insight into trait-based selection that can be used as a potential candidate for improvement of tolerance in drought sensitive rice varieties.

Image:

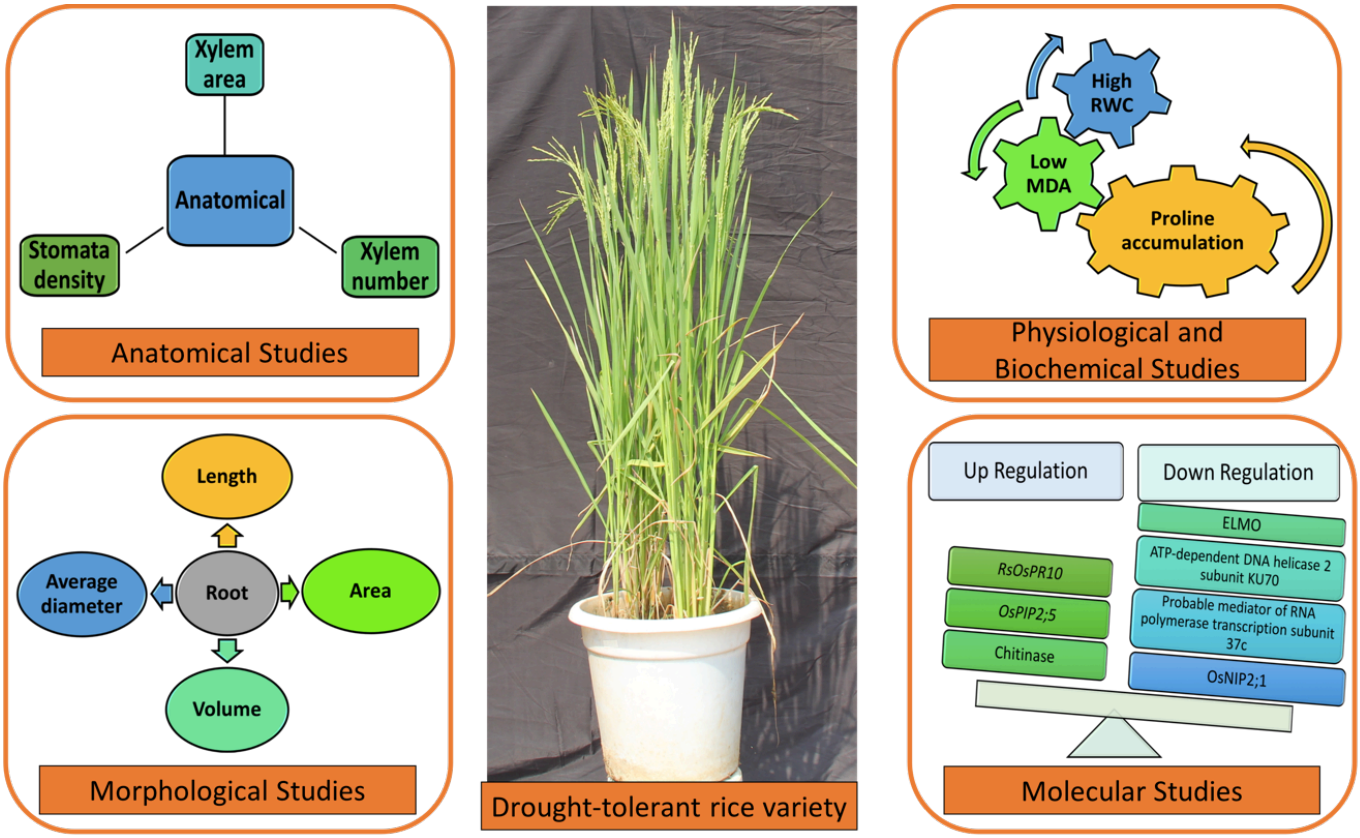


Figure 1: Diagrammatic view of work carried out in the present study.

Recent Publications (minimum 5)

1. Anupama A, Bhugra S, Lall B, Chaudhury S, and Chugh A (2018). Morphological, Transcriptomic and Proteomic responses of contrasting rice genotypes towards drought stress. Scientific Reports (Under Review).

2. Anupama A, Bhugra S, Lall B, Chaudhury S, and Chugh A (2018). Assessing the correlation of genotypic and phenotypic responses of indica rice varieties under drought stress. Plant Physiology and Biochemistry. 127:343-354. https://doi.org/10.1016/j.plaphy.2018.04.001

3. Bhugra S, Mishra D, Anupama A, Chaudhury S, Lall B, Chugh A, Chinnusamy V (2018). "Deep convolutional neutral networks based framework for estimation of stomata density and structure from microscopic images." In: Leal-Taixé L., Roth S. (eds) Computer Vision – ECCV 2018 Workshops. ECCV 2018. vol 11134. Springer, Cham. https://doi.org/10.1007/978-3-030-11024-6_31.

4. Bhugra S, Mishra D, Anupama A, Chaudhury S, Lall B, Chugh A (2018). "Automatic quantification of stomata for high-throughtput plant phenotyping." In 24th International Conference on Pattern Recognition (ICPR). IEEE. DOI: 10.1109/ICPR.2018.8546196

5. Bhugra S, Anupama A, Chaudhury S, Lall B, Chugh A (2018) Multi-modal Image Analysis for Plant Stress Phenotyping. In: Rameshan R., Arora C., Dutta Roy S. (eds) Computer Vision, Pattern Recognition, Image Processing, and Graphics. NCVPRIPG 2017. Communications in Computer and Information Science, vol 841. Springer, Singapore. https://doi.org/10.1007/978-981-13-0020-2_24.

6. Bhugra S, Anupama A, Chaudhury S, Lall B, and Chugh A (2017). "Phenotyping of xylem vessels for drought stress analysis in rice." In Machine Vision Applications (MVA), 2017 Fifteenth IAPR International Conference. IEEE 428-431. DOI: 10.23919/MVA.2017.7986892.

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Biography (150-word limit-mandatory)

Anupama Anupama has her expertise in plant molecular biology. Her area of work focuses on Rice Phenomics, a multi-institutional project first of its kind in India and funded by NASF, ICAR, India. The field of rice phenomics has given her exposure to a multidisciplinary field where she has worked closely with electrical and computer engineers for image processing of rice organelles under drought stress. During the tenure of her PhD, Anupama has acquired a wide range of scientific and technical skills associated with the wet-lab experiments. Anupama is well versed with molecular biology techniques of SDS-PAGE, MALDI, agarose gel electrophoresis, cloning, spectrophotometer, Scanning Electron Microscopy and Nanodrop. Most important among these is her skill in 2-D gel electrophoresis and RT-PCR for the identification of drought-induced protein and genes. She has also worked with mammalian cells (HeLa) and well versed confocal sample preparation and regularly assists students with fluorescence based microscopy experiments. She has experience in MATLAB, WinRhizo software and ImageJ.

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Notes/Comment

Ms Anupama joined my laboratory in July 2013 after she cleared the entrance examination conducted by Indian Institute of Technology Delhi after qualifying the Graduate Aptitude Test in Engineering 2013, (GATE) a highly competitive national level examination. During her PhD she was awarded junior and senior research fellowship from Council of Scientific & Industrial Research (CSIR) for pursuing her doctoral studies in IIT Delhi. Her thesis titled "Assessment of differential responses of rice varieties under drought stress: a value addition to rice phenomics" was under the joint supervision of Prof. Archana Chugh and Prof. Brejesh Lall. Her work also involved close interaction with our collaborator Prof. Viswanathan Chinnusamy, Principal Scientist & Head, Division of Plant Physiology at Indian Agricultural Research Institute (IARI) New Delhi. She has indeed worked meticulously and with dedication to produce an excellent piece of work, and it is the one of the first study on rice phenomics in India. She has successfully presented her thesis synopsis on 31st May 2018 and submitted her thesis on 25th February 2019.