# Understanding the genetic and physiological basis of arsenic responses and exclusion in rice (*Oryza sativa* L.)


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## Background & Objectives

- Globally **220+ million people** at risk of arsenic (As) contamination.
- Rice is **Arsenic-sensitive crop**; absorbs As from water and soil.
- Arsenic exposure through rice consumption is a worldwide **health concern**.

➢ This study aims to identifying loci, gene and mechanisms involve in As exclusion/ tolerance and breed rice cultivars with limited uptake of As in grain & shoot thereby developing and deploying safer varieties to the As contaminated rice growing areas of Asia.

**Figure 2.** Evaluation of 300 rice lines from 3K panel at IRRI field to study their performance in naturally occurring arsenic condition for Genome Wide Association Study. Experimental plot demarcated by red boarder.

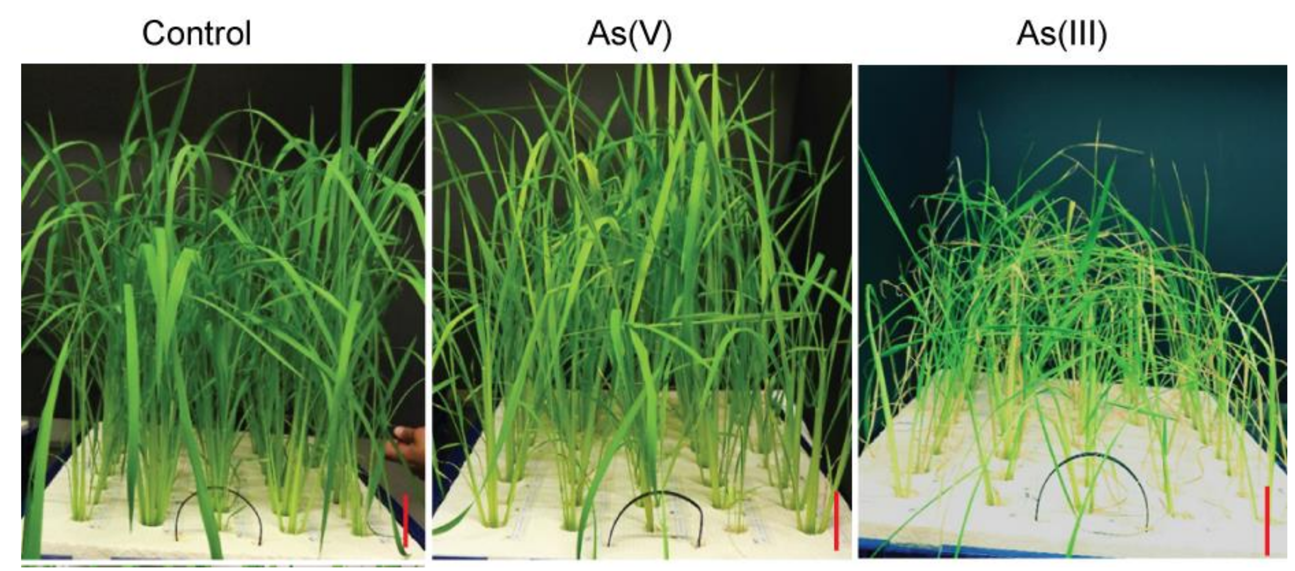


**Figure 1.** Rice seedling at the vegetative growth stage showing the effect of different species of Arsenic

## Highlights

- **Arsenite [As(III)] is more toxic to plants than arsenate [ As(V)]**
- **Arsenic affects the grain filling and induce the straight head disease like symptom in rice plants leading to unfilled panicles.**
- **Glutathione S-transferase *OsGSTU40* gene differentially affects plant reactions and tolerance to different species of arsenic.**


**Figure 3.** Rice panicle of same genotype from different treatment condition. Control pot having filled panicle & arsenic treated pot with sterile panicle

## Preliminary Results

- As(III) was more detrimental to plant growth than As(V) in terms of plant growth, biomass, and lipid peroxidation.
- Overexpression of *OsGSTU40* gene led to better plant growth.
- Transgenic plants exhibited a lower level of lipid peroxidation than wild-type (WT) plants.
- The element composition of plants was dominated by the different As stress treatments rather than by the genotype, while the As concentration was negatively correlated with phosphorus and silicon.
- Overexpression of *OsGSTU40* gene mitigated oxidative stress and plant growth retardation, when exposed to the more toxic As(III), which is the predominant form that occurs in flooded rice production.

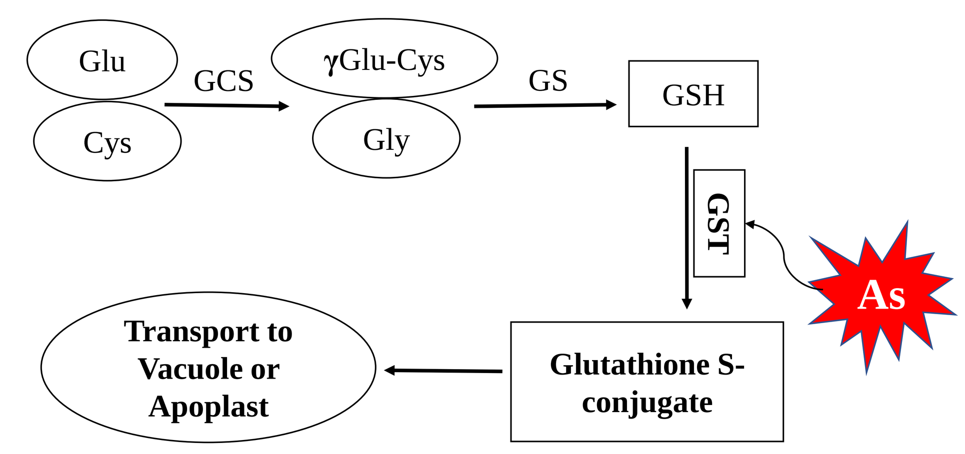


**Figure 4.** Schematic representation of the arsenic detoxification mechanism by Glutathione S- Transferase in plants: Glu: glutamate; Cys: cysteine; GCS: glutamylcysteine synthetase; Gly: glycine; GS: glutathione synthetase; GSH: glutathione; GST: glutathione S-transferase; As: arsenic

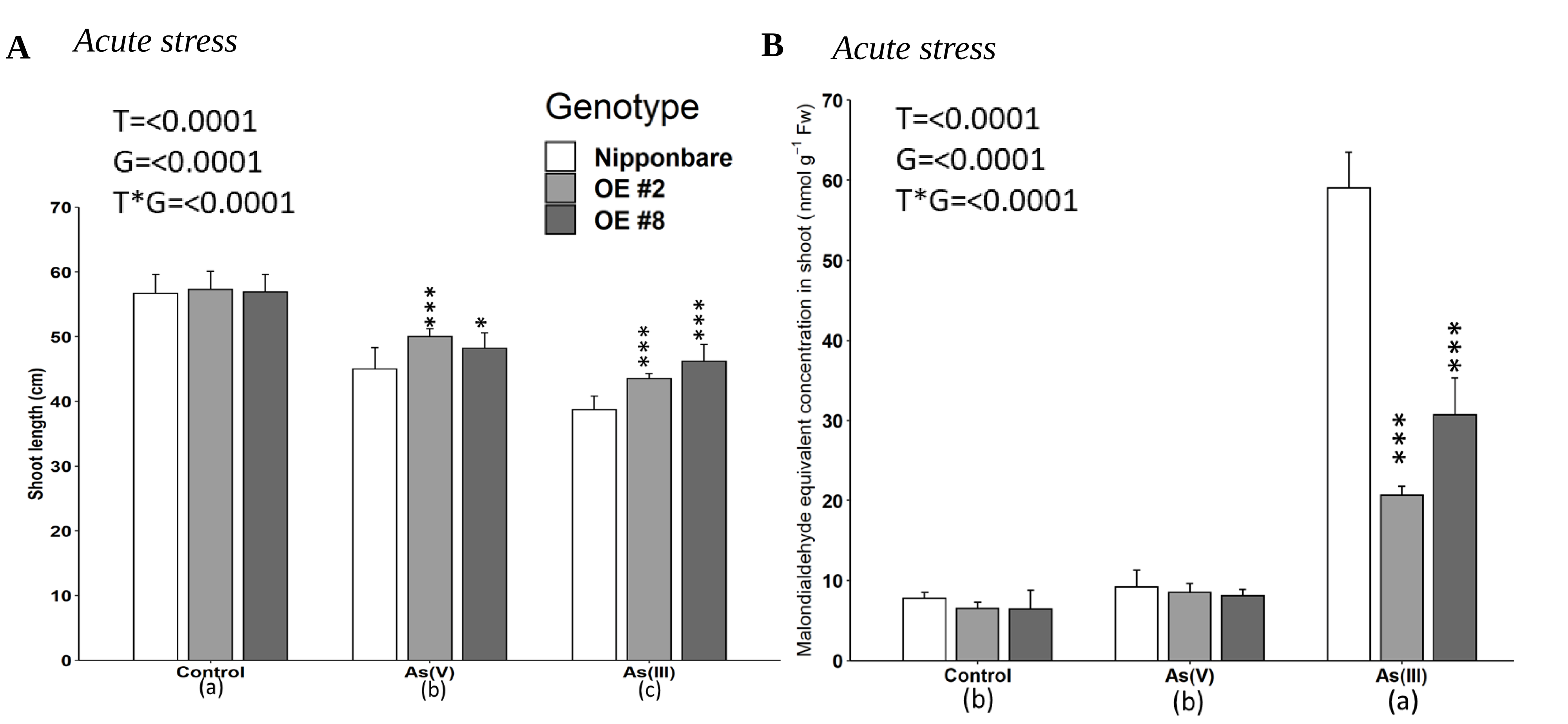


**Figure 5.** Morphological & Physiological responses of Os*GSTU40* overexpression (OE) line and wild type (WT) lines in control and acute As stress conditions (10ppm of As(III) & As (V) for 10 days). Vertical bars indicate the average values with standard errors (n=12). The letters below the treatments in parentheses indicate significant differences between different treatment conditions. As(V): sodium arsenate dibasic heptahydrate; As(III): sodium arsenite; T: treatment; G: genotype; T × G: treatment by genotype interaction. WT lines: Nipponbare; OE lines: *OsGSTU40* gene overexpressed in Nipponbare; *: $p$<0.05; **: $p$<0.01; n.s: $p$>0.05.

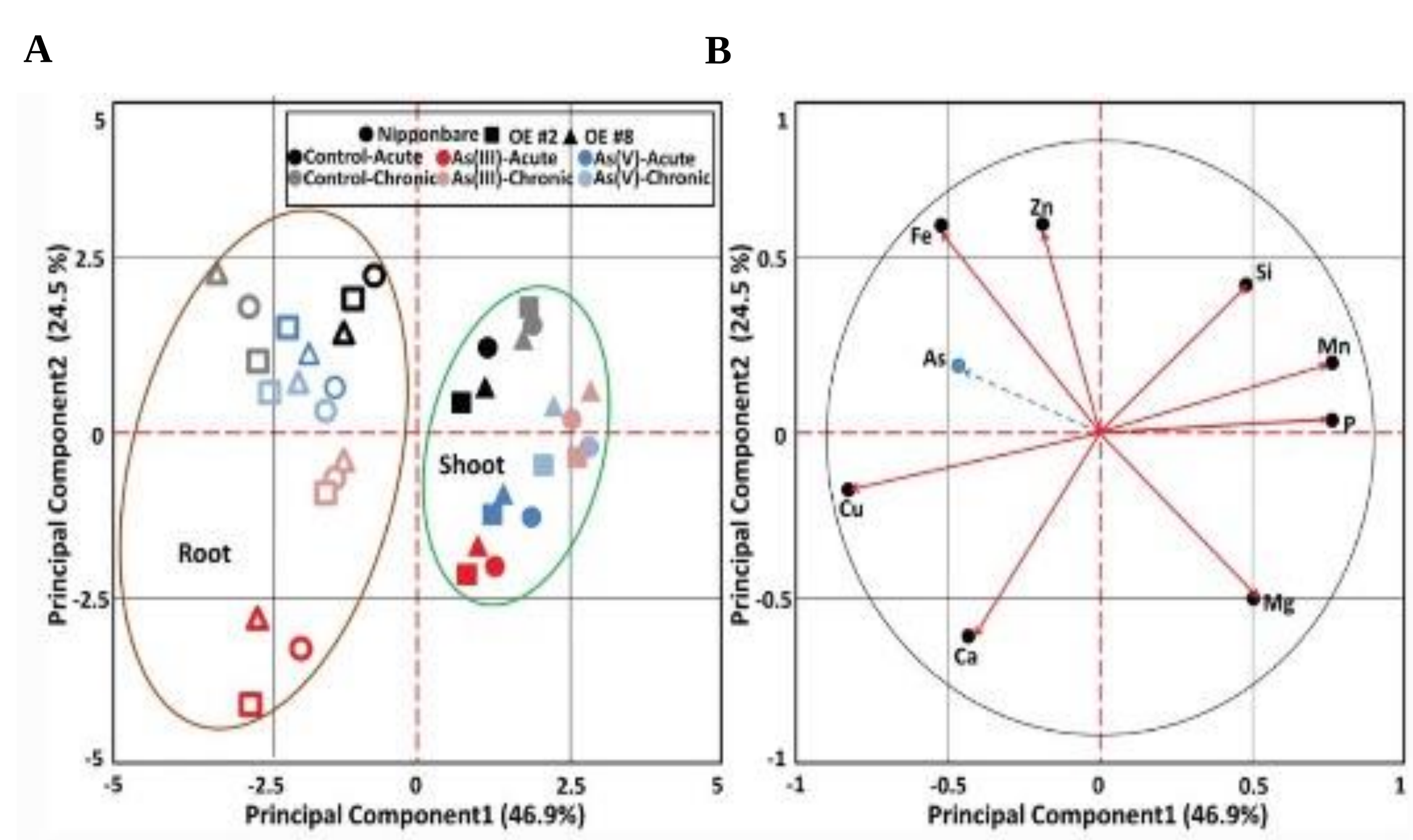


**Figure 6.** Principal component analysis (PCA) for element uptake under As stress conditions (A) Score plot describing the total element uptake in roots and shoots measured for all genotypes under acute (10ppm) and chronic (2ppm) As stress. (B) Loading plot showing the vector coefficients of element concentration variables for the first principal component vs. the coefficient for the second principal component

## Experimental Work Plan

**Germplasm source**

**Experiments**

- 3k Rice genome project → GWAS (Field, Pot, Hydroponics & Germination) → Identifying best performing As excluding lines
- Designed QTL pyramided population of rice → Transcriptome study of susceptible & resistant cultivar → Identifying candidate genes & differentially regulated gene
- Glutathione S-Transferase (GST) gene overexpressed rice lines → Study on the effects of As(III) & As(V) on rice plants differing in GST → Physiological and biochemical response to difference As species & role of GST enzyme in stress regulations

→ Validate by forward and reverse genetics using breeding and molecular tools

→ **Development and deployment of As safe rice varieties**

**Figure 7.** Arsenic safe rice varieties developed by IRRI, grown in larger plots to evaluate yield and yield attributes at field conditions


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