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Name of the Topic: "The Coordinated Role of Proline and Submergence Regulated Factors in Arsenic Stressed Rice Genotype under Submergence"

Keywords: Arsenic, Submergence, Rice, Proline, Glutathione, cis-OPDA, gibberellin, ProDH, salicylic acid

Findings of the study:

In today's world of climate change, the co-occurrence of arsenic (As) contamination and unpredictable submergence stress (Sub) imparts severe and integrated threat to rice farming and food security around the world. This study deals with unravelling the complex adaptive mechanisms of Mini mansoori (M.M.) rice *var.* obtained from As-toxicated and flood affected areas of Eastern U.P., at acute (3d) and chronic (7d) stress periods, highlighting its natural robust dual-tolerance strategy. Under the coupled stress of As and Sub, M.M. seedlings enacted the key survival trade-off: a dominant shoot elongation response to escape submergence coupled with curtailed As accumulation in the shoot for improved food quality. The escape was carried by Gibberellic Acid (GA) with the high energy demand sustained by a critical re-routing of carbon flux towards anaerobic respiration and proline (Pro) catabolism. The salicylic acid (SA) and GA enhancement triggered the glutamate dehydrogenase activity to accentuate Pro production under Sub. This metabolic shift towards Pro breakdown at 3d supported the vigorous elongation of the shoot. The induction of radial oxygen loss barrier, aerenchyma, stomatal closure, superhydrophobic leaf surface and evident gas film thickness also accentuated the resistance. Moreover, the substantial As+Sub-induced Reactive Oxygen Species (ROS) burst was effectively neutralized by a systematic and pre-activated defense system. The defense machinery featured a Sub-regulated signalling cascade initiated by cis-OPDA and MAPK6. The cis-OPDA uplifted the Glutathione content for As-sequestration while the proposed interaction of MAPK6 with SA-linked WRKY45 further up-regulated the major defense pathways, i.e. phenylpropanoid metabolism, to boost flavonoid production under Sub.

This innately resilient nature of M.M. *var.* offers a significant genetic reservoir, bringing forth a molecular blueprint for creating next generation rice for superior durability and yield consistency in multi-stress environments, thereby ensuring nutritional stability in high-risk regions.

Comprehensively, this study highlights the pre-adapted, integrated tolerance of Mini mansoori rice *var.* towards simultaneous stress of As and Sub. It rejects the simple hypothesis of additive response, rather, displays the remarkable and holistic strategy to withstand and resist the dual stress. The observations points towards the synchronized phenotypic-physiological and biochemical response which effectively curtails the repercussions of two most dangerous threats of rice cultivation. The escape response depicted against the Sub stress was driven by a coordinated hormonal crosstalk involving elevation of GA and SA while limiting ABA production. The substantial energy demand for shoot elongation was met by redirecting the carbon flux towards anaerobic respiration complemented with streamlined GABA and Pro catabolism. Despite the low oxygen conditions, the overall development of seedlings was supported by this carbon shift and low level of aerobic respiration. The energy extracting pathways along with As-toxicity generated enough ROS, which was sophisticatedly managed through a pre-initiated defense system which prompted cross-tolerance. The enhanced accumulation of *cis-OPDA* embarked the cysteine metabolism for the synthesis of key antioxidants like glutathione and cysteine. Along with that the glutathione-ascorbate pathway was activated to lower the levels of ROS. Simultaneously, the pre-stimulated MAPK3-WRKY45 cascade elevating the phenylpropanoid pathway under As-stress was further exerted by additional effects possibly from MAPK6 on WRKY45. The concurrent Sub stress suppressed the lignin production while accelerating flavonoid synthesis to scavenge ROS and maintain cellular redox homeostasis. The commendable resilience of M.M. *var.* functions as an important genetic blueprint for developing new climate smart *var.* with strengthened tolerance towards flooding and As-contamination. However, further research is needed to identify and explore more such rice cultivars depicting tolerance towards multiple abiotic stresses. The major governing framework behind the hormonal dynamics and MAPK regulation could be investigated in near future to cultivate robust defense and balanced cellular redox state. Moreover, by elucidating the underlying unexplored hormonal, metabolic, and signaling pathways, this study delivers a foundation for future breeding programs intended to improve crop productivity and securing nutritional stability under future changing climatic scenarios.