Thiourea supplementation reduces arsenic accumulation in two selected rice (*Oryza sativa* L.) cultivars in a field study in Bengal Delta Basin, India

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ABSTRACT: Arsenic (As) accumulation in rice is a severe problem in Southeast Asia including West Bengal, India. Thiourea (TU) is a redox active thiol (-SH) based molecule, which has been found to regulate redox equilibrium and As level in lab study. In this work, we, for the first time, evaluated the effect of TU supplementation on growth and yield of rice plants, biochemical changes and As concentrations in rice grains. Both rice cultivars (Satabdi-IET4786 and Gosai) were grown in three fields (Control, Low As and High As) in Nadia, West Bengal. The result indicated positive impact of TU supplementation on rice growth and yield and most importantly, showed reduction in As concentrations in rice grains.

1 INTRODUCTION

Arsenic (As) is well known class 1 carcinogen classified by IARC. Presently, 150 million people around the world are affected by As hazard. The condition is severe in Bengal delta basin region. There are many districts in West Bengal, where groundwater As concentration is $>50 \mu\text{g L}^{-1}$ including Nadia. This groundwater is used for irrigation in rice fields throughout the concerned area. Therefore, rice accumulates As in significant concentrations due to its favorable flooded cultivation, suitable transporters (channel proteins) and reducing environment. Being a staple crop worldwide, rice is the major source of As exposure to humans. Sulphur deficiency, redox imbalance, induced generation of reactive oxygen species (ROS) are key symptoms of As toxicity. Sulfur is important for plants as it affects As uptake, translocation and accumulation in rice plants (Srivastava *et al.*, 2007). TU is sulfur containing redox regulator and ROS scavenger, which has already applied in variety of stresses in plants (Kelner *et al.*, 1990). We applied TU and assessed its impacts on As accumulation in rice grains, yield, growth and antioxidant defense system.

2 METHODS/EXPERIMENTAL

2.1 Site description

The study was conducted in Sarapur, Dewali Gram panchayat $23^{\circ}01'07.8''\text{N}88^{\circ}39'43.1''\text{E}$ - $23^{\circ}01'14.3''\text{N}88^{\circ}38'24.7''\text{E}$, Chakdaha block in Nadia district of West Bengal, India. This area is known for prolonged use of As contaminated groundwater for irrigation purposes. Here agriculture is the primary profession

of the native people and so, this region may act as representative site for agriculture based As study.

2.2 Growth of plants, collection and processing the samples

We choose two rice genotypes (Satabdi-IET4786 and Gosai), which are the local and predominant variety being used in the study area. The cultivation of rice was performed in Monsoon (Aman, July–October 2016) in three selected fields viz. Low As ($38.74 \pm 0.13 \text{ mg kg}^{-1}$), High As ($84.77 \pm 0.51 \text{ mg kg}^{-1}$) and Control ($22.15 \pm 0.2 \text{ mg kg}^{-1}$) with/without thiourea (TU) application ($500 \mu\text{g L}^{-1}$ for seed soaking and foliar application at the flowering stage). The area of per selected field was 400 square feet. The plant samples were taken to lab preserved in ice filled box. Plants were analyzed for pigment and antioxidant enzyme analyses after crushing in liquid N_2 . The remaining plants were washed thrice, air dried after evaluating length, tiller no. and other growth parameter. Further, they were separated into different parts i.e. root, straw, husk and grains etc. and after digestion it has been used for ICP-MS analysis. The crushed sample of shoot, root and grain were also used for synchrotron based XRF analysis after making its pellet. Apart from this, leave's xylem-phloem internal integrity was also assessed under field emission scanning electron microscope (FE-SEM).

3 RESULTS AND DISCUSSIONS

3.1 Arsenic (As) concentration in rice grains

In Aman (monsoon), 2016, the concentration of As (all in mg kg^{-1}) in rice grains in Gosai, Satabdi, Gosai

Figure 1. Arsenic (As) concentration in mg kg^{-1} in two cultivars of rice with and without thiourea (TU). All values are means of triplicates $\pm$ SD.

Figure 2. FE-SEM images of differentiated xylem (X) and phloem (P) integrity in TU amended and non-TU rice plant leaf of both cultivars.

(TU) and Satabdi (TU) were found 1.086, 1.030, and 0.900, 0.866, respectively in low As, 1.31, 1.196, 1.043 and 0.97, respectively in high As and 0.994, 0.77, 0.723, 0.62, respectively in control (Fig. 1). The accumulation of As was thus significantly reduced in grains under TU supplementation.

3.2 Growth and yield parameters

The growth and yield were also improved in two cultivars under TU supplementation as compared to without TU plants. The biomass, tiller no., leaf area were increased in rice plants. The yield of rice grains was also increased in TU ameliorated cultivars in all the fields (Table 1).

Table 1. This table shows the yield of rice in kg.

Setting	Satabdi (IET-4786)		Gosai	
	TU	NON TU	TU	NON TU
Control field	14.4	12.9	14.0	13.8
Low As field	16.1	15.4	15.3	13.5
High As field	12.9	12.6	12.1	11.4

3.3 Alteration in integrity of xylem/phloem

Internal organs (xylem phloem, bundle sheath) OF rice leaves integrity were distorted due to As toxicity. TU actually improved the vascular organ's integrity (Fig. 2). So, this could be a possible reason behind better biomass growth and yield in rice.

4 CONCLUSIONS

This study indicates that TU can reduce the As load in rice grain, which is a significant result. Further, TU supplementation also improved growth of plants along with yield. Hence, TU supplementation through seed soaking and spraying at the time of flowering can be a feasible strategy to mitigate As toxicity through reduce its translocation to grains in contaminated areas and grow rice with low arsenic in rice grains.

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