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ABSTRACT

Title: Effect of Selenium on Physiological, Biochemical and Molecular Changes in Rice and Indian Mustard Varieties

Selenium (Se) is known as two-sided-coin because of its toxicity and deficiency effects. Though it is not essential, but found to be beneficial at low doses to living beings. At high doses deleterious effect of Se has been reported by many workers (Paciolla et al. 2011; Aggarwal et al. 2011). In plants, Se mediated toxic effects are due to generation of oxidative stress and formation of malformed proteins. Not only toxicity, Se-deficiency also leads to diseases in masses that feed upon Se-deficient diet. Hence, optimization of Se requirement for all living beings is very important and plants are the best option to cope up with both of the Se related problems. Several workers have analyzed the effect of Se on plants generally at low doses (Lin et al. 2012; Pandey and Gupta 2015) and reports at high doses are few. In the present study, *Brassica juncea* and *Oryza sativa* varieties were selected to carry out comparative evaluation of effect of Se on these two plants as Indian mustard is a good Se-accumulator and rice is a staple crop in various Se-deficient regions round the world.

The major goal of this study was 1) to analyze the effect of Se on *Brassica juncea* and *Oryza sativa* varieties for Se susceptibility or tolerance through various physiological, biochemical and molecular parameters and 2) to study the role of phytohormone (Salicylic acid) and sugar (Glucose) in reducing Se-induced toxic effects. The results are summarized under following headings:

Effect of different concentrations of Selenium on Brassica juncea and Oryza sativa varieties

1) In the present study, preliminary analysis of Se tolerance or susceptibility of rice and mustard varieties was analyzed on the basis of seed germination and root-shoot length at various Se concentrations after 7 days of germination. With increase in Se concentrations, seed germination, root-shoot length and chlorophyll content found to be inhibited with the concomitant increase in MDA content in both varieties of mustard (PB and PJn) and rice (PB1 and IR64). However, inhibition was more in PJn and IR64 variety of mustard and rice, respectively.

2) Protein content was also measured in both plants under Se stress, and found to be more in PB and PB1 variety of mustard and rice, respectively at 300 µM Se after 96 h of Se exposure.

3) Accumulation studies showed substantial Se accumulation in roots of all tested varieties of both plants than leaves. PB variety of mustard and PB1 of rice showed more Se accumulation than PJn and IR64, respectively. Overall, *Brassica* varieties accumulated more Se as compared to rice varieties.

4) Stress modulators (SOD, CAT, Proline, and Cysteine) were also analyzed to check further tolerance or susceptibility of both plants to Se. Broadly, higher SOD and CAT activity and higher levels of proline and cysteine was observed in PB and PB1 variety of

mustard and rice, respectively at 300 µM after 96 h. Results showed that PB and PB1 variety of mustard and rice performed better to tackle Se stress at high concentration (300 µM) and exposure period (96 h) than PJn (mustard) and IR64 (rice).

5) Expression profile of *LAST*, *APS*, *APR*, *OASL*, *GR*, *MT-2* and *PCS* of mustard varieties showed higher upregulation in PB than PJn variety (300 µM, 96 h) as compared to control, which signifies better Se assimilation and tolerance in PB than PJn variety at high concentration and exposure period. Similarly, among rice varieties higher upregulation in sulfur-related gene transcripts was observed in PB1 variety than IR64 at higher dose and prolonged exposure period which confers higher Se detoxification or tolerance in PB1 than IR64 variety.

Results concluded on the basis of various physiological, biochemical and molecular parameters inferred that at high Se concentration, PB variety of Brassica juncea and PB1 of Oryza sativa is more Se tolerant than their competitors PJn and IR64, respectively. Overall, Brassica varieties showed higher Se tolerance than rice varieties under Se stress.

To study the role of phytohormone (Salicylic acid) and sugar (Glucose) in reducing Se-induced toxic effects

1) Combinatorial studies with Salicylic acid (SA) and Glucose (Glc) along with Se was carried out to see the alleviating role of SA and Glc under high dose of Se on tested varieties of both plants. Working concentration of SA used for combinatorial analysis was 50 and 100 µM whereas, for Glc it was 100 and 500 µM.

2) Improved percentage seed germination, seedling length, chlorophyll and protein content, SOD and CAT activities, proline and cysteine content, sulfur related gene transcripts with the concomitant decrease in MDA content in SA/Glc+Se treatments as compared to Se alone signifies alleviating effect of SA/Glc on Se-stressed *Brassica* and rice seedlings. Alleviating effect found to be maximum with 100 µM SA and 500 µM Glc in varieties of both plants.

3) Combinatorial study highlighted the enhanced Se tolerance in PJn and IR64 varieties of mustard and rice respectively in the presence of SA/Glc. Hence, present study demonstrated a way to reduce Se susceptibility or increase Se tolerance in *Brassica* and rice varieties so that they can be used effectively for mankind or environment.

Present study demonstrates dose and duration dependent toxic effect of Se on rice and Indian mustard varieties. Accumulation analysis revealed significant Se accumulation in all varieties of both plants. However, maximum accumulation along with Se tolerance was shown by PB and PB1 variety of mustard and rice, respectively which could be attributed to enhanced level of stress related parameters, antioxidant enzymes and sulfur related genes at high doses and exposure period. Further, on the basis of combinatorial studies, Se toxicity found to be ameliorated in the presence of salicylic acid or glucose in both plants. Results indicated that PB and PB1 variety of mustard and rice, respectively, accumulate substantial amount of Se and showed Se tolerance at high doses of Se. Hence, both varieties are suitable for phytoremediation or biofortification of Se accordingly.