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ORIGINAL ARTICLE

# Counteractive mechanism (s) of salicylic acid in response to lead toxicity in *Brassica juncea* (L.) Czern. cv. Varuna

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## Abstract

***Main conclusion*** **Salicylic acid alleviates lead toxicity in *Brassica juncea* (L.) by promoting growth under non-stress and activating stress-defense mechanism (s) under lead stress conditions. It also boosts the ascorbate–glutathione cycle and thus helps in minimizing oxidative and DNA damage.**

*Brassica juncea* plants were exposed to different concentrations (0, 500, 1000 and 2000 mg $kg^{-1}$) of lead (Pb) and subsequently sprayed with 0.5 mM of salicylic acid (SA) to check for morphological and leaf gas exchange parameters like transpiration rate (*E*), stomatal conductance ($GH_2O$), net photosynthetic rate (*A*) and maximum quantum yield of PS II ($F_v/F_m$). Leaf epidermis by scanning electron microscopy (SEM), enzymatic and non-enzymatic components of ascorbate–glutathione (AsA–GSH) cycle, DNA damage by comet assay, lipid peroxidation and endogenous SA quantification by HPLC were analyzed. Lead accumulation in root, shoot and its sub-cellular distribution ratio (SDR) and localization was also determined using atomic absorption spectroscopy (AAS) and rhodizonate-dye staining method, respectively. Results revealed that notable amount of Pb was accumulated in root and shoot in dose-dependent manner which significantly ($P \leq 0.05$) posed the toxicity on the majority of morphological parameters, structural integrity of epidermal and guard cells, photosynthetic pigments, malondialdehyde (MDA) and $H_2O_2$ content. Notable decrease in leaf gas exchange parameters, $F_v/F_m$, poor performance of AsA–GSH cycle and striking amount of DNA damage, was found as well. However, SA revoked Pb toxicity to a great extent by promoting growth, chlorophyll content, improving the *A*, $F_v/F_m$, boosting the overall performance of AsA–GSH cycle and by lessening the DNA damage.

**Keywords** Ascorbate–glutathione cycle · *Brassica juncea* · Chlorophyll fluorescence · DNA damage · Lead · Oxidative stress · Photosynthetic rate · Salicylic acid · Sub-cellular distribution ratio

### Abbreviations

| | |
|---|---|
| *A* | Net photosynthetic rate |
| AsA | Reduced ascorbate |
| *E* | Transpiration rate |
| $GH_2O$ | Stomatal conductance |
| GSH | Oxidized glutathione |
| HM | Heavy metal |
| SA | Salicylic acid |

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## Introduction

Heavy metals (HMs) do not have a specific definition but are usually defined as metals with relatively high densities, atomic weights, or atomic numbers and a density of more than 5 g $cm^{-3}$ (Järup 2003). Contamination by HMs has become a problematic worldwide environmental concern as these accumulate in soil, find their way easily into crop plants and proved to be toxic to all flora and fauna (Fischer et al. 2014). Lead is one of the five most toxic HMs and is known to be toxic to plants, humans and other organisms (Zhong et al. 2017) which can cause seizures, behavioral and neurological disorders, lowers IQ and attention, encephalopathy, hypertension and kidney diseases in humans especially children (Kersten et al. 2017). Other than natural weathering processes, main sources of Pb-contamination of soil and water are intensive anthropogenic activities and industries

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