Chromium-reducing bacteria mediated biopriming: Exploiting a sustainable strategy for immunity against blast and remediating chromium stress

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Abstract

Rice production is vulnerable to several pressures; one of the main biotic stresses is blast disease, which is brought on by *Magnaporthe oryzae* and can potentially wipe out the entire crop under extreme circumstances. Microbial-mediated seed and root prime in plants enhance defense against a broad range of pathogens by jasmonate (JA) and ethylene (ET) signaling mediated induced systemic resistance (ISR). The present work demonstrates some selected microbes like *Bacillus cereus*, *Pseudomonas aeruginosa*, *Staphylococcus gallinarum*, *Staphylococcus hominis*, *Enterobacter cloacae* show an antifungal effect against the rice blast pathogen (*Magnaporthe oryzae*). Rice (Swarna) seed and root priming with these bacteria enhance ISR in rice against rice blast disease. The MYB transcription factor gene *MYB72* and *NPR1*, *NPR3*, and *NPR4* genes function as long-distance ISR signaling molecules highly expressed in the rice (Swarna) root by co-cultivation with the bacteria in the rice's rhizosphere. These bacteria also resist ~1100 ppm of chromium stress and reduce around 88.94% of Cr^{6+} to Cr^{3+} within 50 days in chromium-contaminated soil. Because Cr^{3+} has a reduced ability to enter cells, it is less poisonous than Cr^{6+}, which is more toxic and soluble and can be transported to cells more easily. The carcinogenic and mutagenesis properties of hexavalent chromium Cr^{6+} make it a hazardous substance. These bacteria act as a key factor against abiotic and biotic stresses.

Results

Microbial Biopriming of rice by *Staphylococcus hominis*

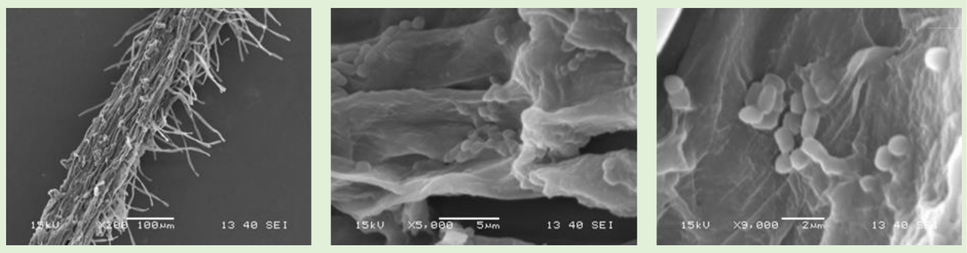

Fig.1. Scanning electron microscopic (SEM) image of Rice (Swarna) root and *Staphylococcus hominis*.

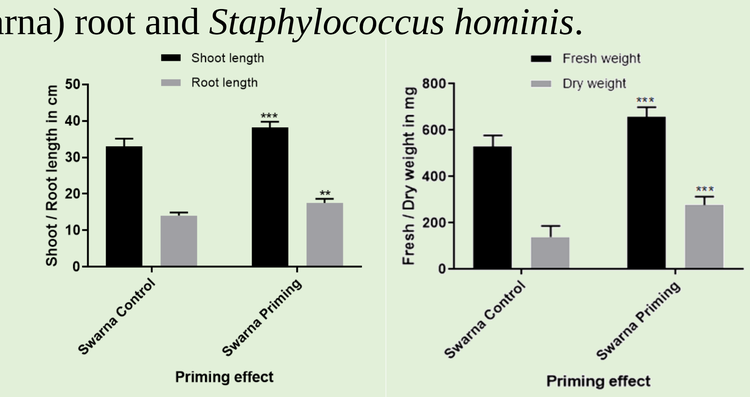

Fig. 2. Priming effect on 30 days Swarna shoot/root length and fresh/dry weight

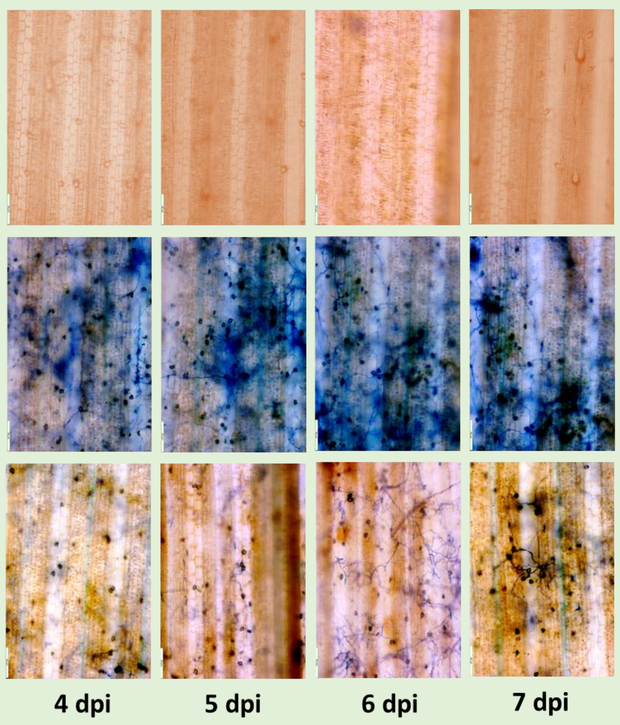

Fig. 3. *M. oryzae* infection, trypan blue staining, and cell death analysis of Swarna wild type and Swarna 30 days primed leaves

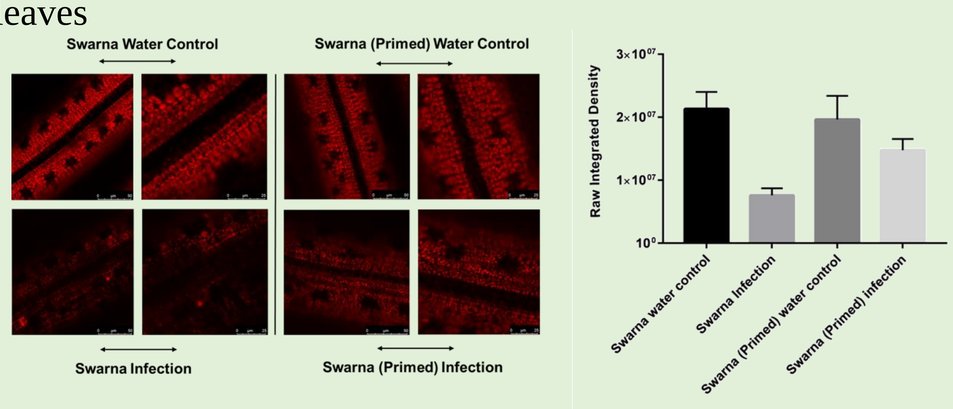

Fig. 4. Evaluation of Chlorophyll autofluorescence by *M. oryzae* infection in Swarna wild type and Swarna 30 days primed leaves.

Cr^{6+} reducing efficiency of *Staphylococcus hominis*

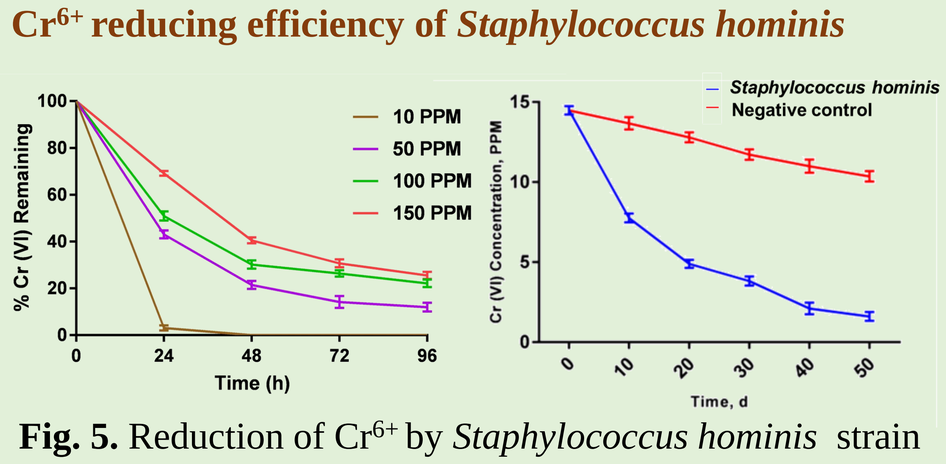

Fig. 5. Reduction of Cr^{6+} by *Staphylococcus hominis* strain in (a) LB medium and (b) Soil conditions

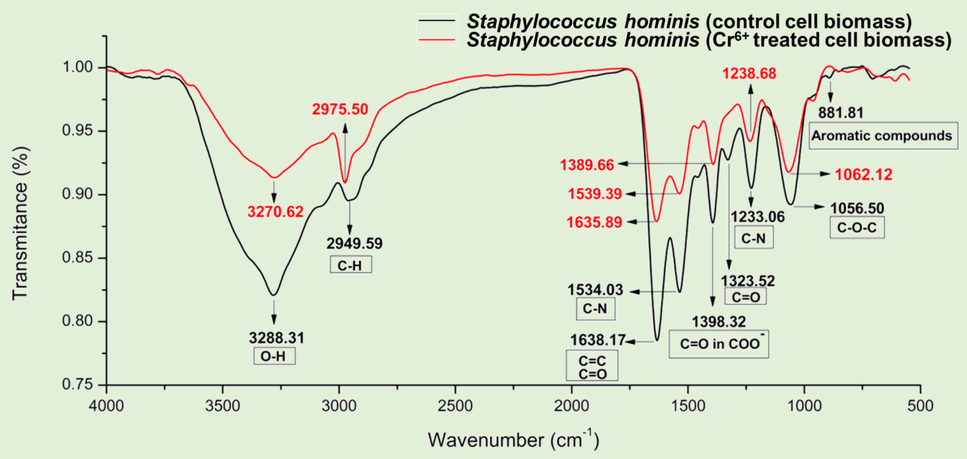

Fig. 6. FT-IR of Cr^{6+} reducing and non-reducing bacterial cell biomass.

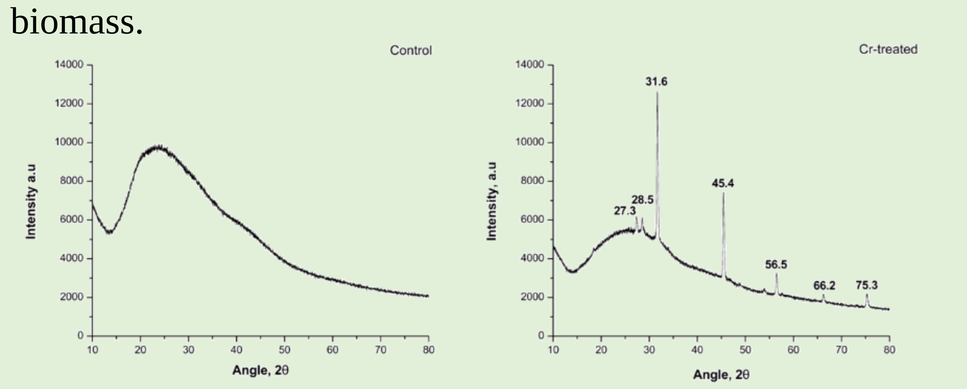

Fig. 7. XRD analysis of Cr^{3+} precipitation by *Staphylococcus hominis* OMCW-10 cell surface functional group

Conclusion

- Rice (Swarna) seed and root priming with selected microbes showing resistance against blast disease.
- Priming with these microbes protects rice leaves from chlorophyll degradation and tissue damage upon *M. oryzae* infection.
- From the Scanning electron microscopic study these microbes shows positive interactions with rice roots.
- These microbes also reduce highly toxic Cr^{6+} to less toxic Cr^{3+} within 30 to 50 days in Cr^{6+} contaminated soil.
- Cell surface functional group of these microbes involved in Cr^{6+} bioaccumulation and Cr^{3+} precipitation.
- Overall, these microbes can protect the rice from both biotic and abiotic stresses.

Future Aspects

- The primed innate immune response in plants and animals exhibits many parallels as we learn more about the molecular mechanism(s) of defense priming. Defense priming will become more widely used in practice as new understanding is developed, enhancing molecular medicine and sustainable agriculture.
- Potential field application of the identified bacteria that can resist the soil chromium and activate resistance against rice blast.
- Advantageous bioremediation method with low energy and material requirements for feasible application against abiotic and biotic stress.
- Further study is anticipated to identify the primary host plant (hyperaccumulator) and microbial signaling particles and analyze their roles in this inter-kingdom communication in the rhizosphere, which may result in the development of novel methods to improve phytoremediation of heavy metals.

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