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Seed bio priming with phosphate-solubilizing bacteria strains to improve rice (*Oryza sativa* L. var. FARO 44) growth under ferruginous ultisol conditions

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Abstract

This study investigated the possibility of using phosphate-solubilizing bacteria (PSB) with plant-growth-promoting (PGP) capabilities to improve the growth properties of rice plants under ferruginous ultisol (FU) conditions through bio priming. The following PSB with PGP properties were used in this study: *Bacillus cereus* strain GGBSU-1, *Proteus mirabilis* strain TL14-1, and *Klebsiella variicola* strain AUH-KAM-9, which were previously isolated and characterized based on 16S rRNA gene sequencing. Biosafety analysis of the PSB isolates was conducted using blood agar. The rice seeds were then bio primed with the PSB for 3, 12, and 24 h and then sown in a composite FU soil sample. Differences in germinat ion bioassay were investigated 15 weeks after bio priming using scanning electron microscopy (SEM), morphology, physiology, and biomass parameters. The composite FU soil used in this study had high pH, low bioavailable phosphorus, low water-holding capacity, and high iron levels, which resulted in low growth properties of rice seeds without bio priming in the FU soil. Germination parameters were improved in seeds bio primed with the PSB, especially after 12 h of priming, compared with seeds without priming. SEM showed higher bacterial colonization in bio primed seeds. Bio priming of rice seeds with the studied PSB under FU soil conditions significantly improved seed microbiome, rhizocolonization, and soil nutrient properties, thereby enhancing the growth properties of rice. This indicated the ability of PSB to solubilize and mineralize soil phosphate and improve phosphorus availability and soil properties for optimum plant usage in phosphate-stressed and iron toxic soils.

Key words: bio priming, ferruginous soil, phosphate-solubilizing bacteria, plant-growth-promoting capabilities, sustainable agriculture, rice, scanning electron microscopy

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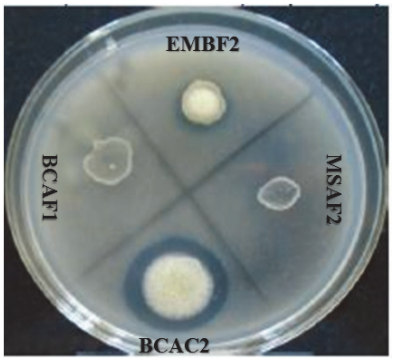
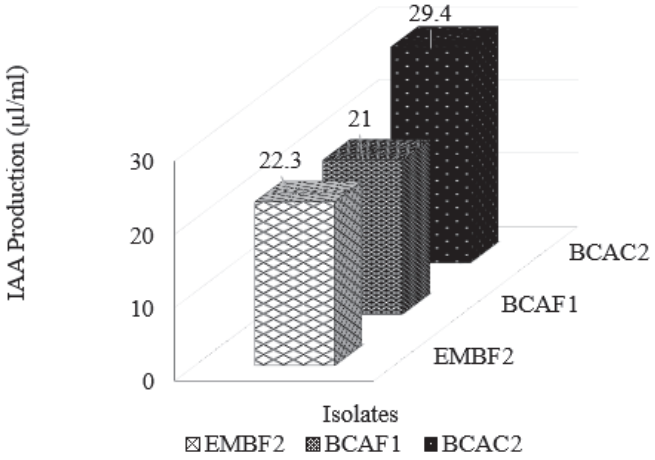
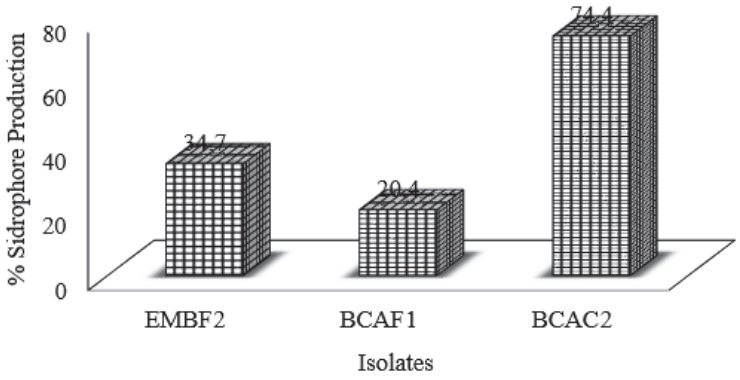


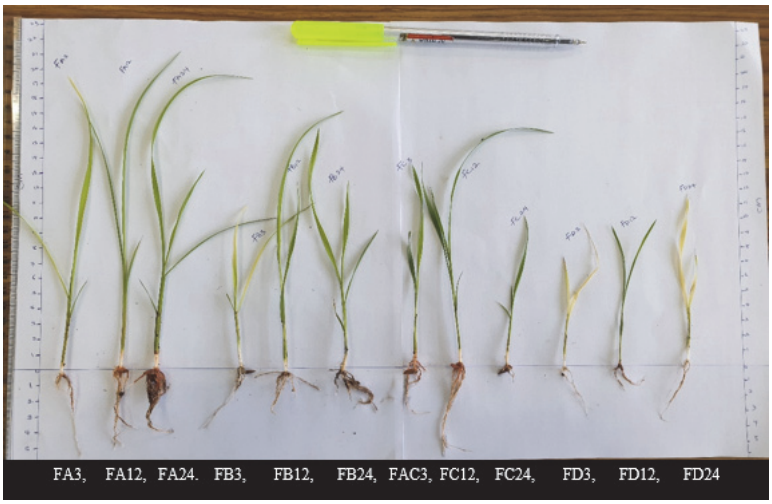
Supplementary Figure 1. Phosphate-solubilizing bacteria showing efficiency in solubilization of insoluble phosphate by forming holo-zone (Musa and Ikhajiagbe, 2020a)



Supplementary Figure 2. Indole acetic acid production by the three isolated phosphate-solubilizing bacteria using Luria–Bertani broth. BCAC2 – *Bacillus cereus* strain GGBSU-1, BCAF1 – *Proteus mirabilis* strain TL14-1, EMBF2 – *Klebsiella variicola* strain AUH-KAM-9 (Musa and Ikhajiagbe, 2020a)



Supplementary Figure 3. Percentage siderophores of the three isolated phosphate-solubilizing bacteria; BCAC2 – *Bacillus cereus* strain GGBSU-1, BCAF1 – *Proteus mirabilis* strain TL14-1, EMBF2 – *Klebsiella variicola* strain AUH-KAM-9 (Musa and Ikhajiagbe, 2020a)



Supplementary Figure 4. Morphological parameters of rice seedlings 3 weeks after biopriming