Microbial based solutions to low carbon sustainable crop management ~ Multifunctional Bacillus-based probiotics

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Abstract

As global warming exacerbate the impact on crop cultivation, environmental sustainability, and food security, all countries aim to meet the goal of "net zero emission" by 2050. Here, we proposed a Microbial Based Solutions for reducing the use of chemical fertilizers and pesticides, the increase of carbon sink, and the value-added application of agriculture by-product. Our team discovered three Bacillus-based probiotics (Bacillus licheniformis EC34-01, Bacillus subtilis 151B1, and Bacillus subtilis WMA1), and demonstrated their high potential for application in crop health care and bioremediation of agricultural pollutants. B. licheniformis EC34-01 and B. subtilis 151B1 were isolated from the plant rhizosphere, and B. subtilis WMA1 was isolated from natural environment in Taiwan. Our results indicated that both EC34-01 and 151B1 strains could promote growth of various plants including strawberry, tea, and cucumber plants, and suppress plant diseases such as Fusarium wilt, damping off downy mildew on cucumber seedlings. They also possessed plant growth promoting traits including production of protease, amylase, cellulase, lipase and IAA, and phosphorus-solubilizing activity. These two strains exhibited ability to induce

the expression of plant defense genes such as PAL, POX and PR1a in cucumber seedlings. B. subtilis 151B1 was found to produce C14- and C15- family surfactins and C14- and C15-family iturin A to trigger apoptotic-like cell death, reduce mitochondrial membrane potential and interfere with the energy metabolism of the pathogen. All three Bacillus strains were great biofilm formers, and could colonize well on plant roots. Addition of agriculture by-product in the culture could further enhance the biofilm formation by these strains. They also could enhance the stress tolerance of plants to drought and flooding. Moreover, both EC34-01 and 151B1 strains exhibited activities in degradation of pesticides malathion and deltamethrin, and a fungicide tricyclazole. The influence of introducing these Bacillus-based probiotics on the microbiome of the plant rhizosphere were also assessed indicating the increase in beneficial bacterial and fungal communities, but the reduction in pathogenic ones compared to the water control. In conclusion, the Bacillus-based probiotics developed possessed multiple functions and could be as solutions for low carbon sustainable crop management and achieving net zero emission in agriculture.

Keyword: Bacillus, Biocontrol, Probiotics, Stress tolerance, Pesticide degradation

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