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Abstract

Phytoplasmas are economically important plant pathogenic bacterial diseases, causing severe yield losses worldwide. In this study, we tested nanoformulations such as glycyrrhizic acid ammonium salt (GAS), salicylic acid (SA), and boric acid (BA) as novel antimicrobial agents inducing the resistance against the phytoplasma disease in faba bean. The nanoparticles (NP) were foliar applied to naturally phytoplasma-infected faba bean with three concentrations from each of SA, GAS, and BA, under field conditions. Nested PCR (using universal primer pairs P1/P7 and R16F2n/R16R2) were reacted positively with all symptomatic samples and gave a product size of approximately 1200 bp, while the healthy plant gave no results. Transmission electron microscopy examinations of phytoplasma-infected faba bean plants treated with different nanoparticles revealed that severe damage occurred in phytoplasma particle's structure, degradation, malformation, lysis in the cell membrane, and the cytoplasmic leakage followed by complete lysis of phytoplasma cells. Exogenous application of GAS-NP (1.68 µM), SA-NP (0.28 µM), and BA-NP (0.124 µM) suppressed the infection percentage of phytoplasma by 75%, 50%, and 20%, and the disease severity by 84%, 64%, and 54%, respectively. Foliar application of nanoparticles improved Fv/Fm (maximum quantum efficiency of PSII Photochemistry), PI (the performance index), SPAD chlorophyll (the relative chlorophyll content), shoots height, and leaves number, thus inducing recovery of the plant biomass and green pods yield. The most effective treatment was GAS-NP at 1.68 µM that mediated substantial increases in the shoots' fresh weight, shoots' dry weight, number of pods per plant, and green pods yield by 230%, 244%, 202% and 178%, respectively, compared to those of infected plants not sprayed with nanoparticles. This study demonstrated the utility of using nanoparticles, particularly GAS-NP at 1.68 µM to suppress the phytoplasma infection.