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Compatibility of Inherent Fungal Endophytes of *Withania somnifera* with *Trichoderma viride* and its Impact on Plant Growth and Withanolide Content

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Abstract

Withania somnifera (Ashwagandha), also known as Indian ginseng, is an important ancient medicinal plant, used in the Indian traditional systems of medicine. In view of increasing demand for roots of Ashwagandha, the present study was undertaken to investigate the compatibility of inherent fungal endophytes along with the biocontrol agent, *Trichoderma viride*, for enhancing *W. somnifera* plant growth and root secondary metabolites (withaferin A). It has frequently been emphasized by the World Health Organization the use of healthy roots of Ashwagandha for therapeutic applications. To maintain quality of *W. somnifera* roots, an option could be eco-friendly management of root-knot diseases and co-inoculation of native endophytes along with *T. viride*. The in vitro antagonistic activity of *T. viride* (TV) against the *W. somnifera* pathogens, *Alternaria alternata* and *Sclerotium rolfsii*, showed 64.3% and 69.5% growth inhibition, respectively. Here, we investigated the compatibility of TV along with the native endophytic fungi *Aspergillus terreus* strain 2aWF (2aWF), *Penicillium oxalicum* strain

5aWF (5aWF), and *Sarocladium kiliense* strain 10aWF (10aWF) for the cultivation of *W. somnifera*. The co-inoculation of TV and native endophytic fungi resulted in increased shoot, root weight, and plant height to 65–150%, 35–74.5%, and 15–35%, respectively, compared to untreated plants. Withanolide A content in leaves of TV-treated plants increased significantly by 260%, whereas in co-inoculation treatments, it was enhanced up to 109–242%. However, no considerable change was noticed with withaferin A content in leaves, except the 2aWF + TV treatment significantly increased by 27%. In contrast, withanolide A content in roots was not affected by TV alone but co-inoculation with endophyte treatments significantly increased its content (19–73%). TV alone had increased chlorophyll a by 23%; however, in combination treatments, it increased up to 115–164% compared to control. Besides secondary metabolites in roots and leaves, co-inoculation of TV and native endophytes modulated the expression of the withanolide biosynthetic pathway genes *HMGR, DXR, FPPS, SQS, SQE, CAS, SMT1, STE1*, and *CYP710A1* compared to control treatments. Apart from withanolide biosynthetic pathway genes, co-inoculation of TV also ameliorated the host-resistant-related gene NPR1 which was upregulated by ninefold in the TV treatment and 3- to 7-fold in the combination treatment. Overall, our results show that co-inoculation of TV along with inherent endophytes of *W. somnifera* enhanced plant growth and withanolides accumulation.

Keywords

Fungal endophytes Withanolides *Withania somnifera* *Trichoderma viride*

Electronic supplementary material

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Notes

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Compliance with Ethical Standards

Conflict of interest

Authors declare that they have no conflict of interest.

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Supplementary material

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