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ORIGINAL ARTICLE

Treatments with native *Coleus forskohlii* endophytes improve fitness and secondary metabolite production of some medicinal and aromatic plants

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Abstract

Endophytes have been shown to play a crucial role in determining the fitness of host plant during their association, yet the cross-functional effect of endophytes of one plant on another plant remains largely uncharacterized. In this study, we attempt to analyze the effect of native endophytes of *Coleus forskohlii* (*Phialemoniopsis cornearis* (SF1), *Macrophomina pseudophaseolina* (SF2), and *Fusarium redolens* (RF1), isolated from stem and root parts) on plant growth and secondary metabolite enhancement in medicinal plant *Andrographis paniculata*, and aromatic plants *Pelargonium graveolens* and *Artemisia pallens*. Here, we report, endophytic treatments with SF2 (21%) and RF1 (9%) in *A. paniculata* resulted in significant enhancement of andrographolide along with plant primary productivity. Correspondingly, application of fungal endophytes RF1, SF1, and SF2 significantly improved the plant growth (11 to 40%), shoot weight (28 to 34%), oil content (44 to 58%), and oil yield (72 to 122%) in *P. graveolens.* Interestingly, treatment of *A. pallens* with three fungal endophytes resulted in significant enhancement of plant productivity and oil content (12 to 80%) and oil yield (32 to 139%). Subsequently, the endophyte treatments RF1 and SF1 enhanced davanone (13 to 22%) and ethyl cinnamate (11 to 22%) content. However, SF2 endophyte-treated plants did not show any improvement in ethyl cinnamate content but enhanced the content of davanone (10%), a signature component of davana essential oil. Overall, results depict cross-functional role of native endophytes of *C. forskohlii* and repurposing of functional endophytes for sustainable cultivation of economically important medicinal and aromatic crops.

Keywords Cross functionality · Fungal endophytes · *Andrographis paniculata* · *Pelargonium graveolens* · *Artemisia pallens*

Introduction

Plant microbe interaction plays a beneficial role in growth and development. Endophytes are the least explored group of microbes for their beneficial effects in enhancing plant fitness and metabolism. Endophytes reside inside tissues without hurting the plant and have been isolated from the surface disinfected plant parts (Hallmann et al. 1997). Endophyte relation with plants is most common and has been identified in most vascular plant families. Major roles of endophytes include phosphate solubilization, nitrogen fixation, and plant hormone production (Costacurta and Vanderleyden 1995; Verma et al. 2001; Compant et al. 2005). Endophytes confer tolerance to heavy metals during stress conditions such as drought and salinity stress and assist plants in escaping stress by exhibiting ACC deaminase activity and subsequent siderophore formation (Ullah et al. 2015; Kong et al. 2015). Endophytes can also modulate the growth parameters of non-

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