RECENT RESEARCH ACTIVITIES

Differential effects of caffeine on phytopathogenic and mycoparasitic fungal growth

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Biological roles of secondary metabolites in rhizosphere were proposed to plant growth regulation, plant-microbe interactions, function in nutrient acquisition, and regulation of microbial community structure. Regarding the interaction with microbes, root exudates serve as signaling molecules, inhibitors and repellants. One of the most popular secondary metabolite is caffeine (1,3,7-trimethylxanthine), which is produced in coffee and tea plants. The physiological functions of caffeine in plants have been proposed to restrict development and growth of other organisms, which is often referred to as allelopathy. Caffeine also indirectly stimulates plant defense response, which is referred to as priming.

Coffee roots secrete caffeine into the culture medium, resulting in an average concentration of 0.03%. Tea seedlings also secrete caffeine up to 0.05% a day.Caffeine released from the primary root was suggested to help seedlings to establish the rhizosphere microbial and physical environment, which was partially substantiated by the finding that coffee rhizosphere was rich in particular fungal species, Trichoderma. Many of *Tricoderma* have been known to kill other fungi. This phenomenon is called mycoparasitism and applied to biocontrol in agriculture. In this study, the effect of caffeine on filamentous fungi, both Trichoderma species and pathogens, were examined.

Eight fungal species were cultured on potato dextrose agar plates with or without caffeine. *Rhizoctonia solani* grew 17 mm/day and 8 mm/day in the absence and the presence of caffeine, respectively. *Fusarium oxysporum* and *Sclerotinia sclerotiorum* grew slower than *R. solani*I Inhibition in growth by caffeine varied depending on species with the growth velocity in the presence of caffeine was about 3 mm/day for pathogens and 7.5 mm/day for *Trichoderma*. The finding showed that the inhibitory efficiency of caffeine is differential, i.e. caffeine may favor predators when they co-grown with prey fungi. Interaction between the prey and the predator was also studied with confrontation test. In the control plate without caffeine, the prey (*F. oxysporum*) steadily grew after inoculation, while in the plate with caffeine, it also grew with reduced velocity. When the prey was co-cultured with the predator (*T. virens*) without caffeine, contact occurred at day 4. When the prey was co-cultured with *T. virens* in the with caffeine, contact occurred before day 7. In both cases, upon contact, growth of the *F. oxysporum* ceased, whereas that of *T. virens* continued, indicating an active mycoparasitism to have occurred.

In summary, these results together with the previous publications suggest that 1) caffeine functions as allelopathic defense by directly suppressing the growth of pathogen, 2) caffeine attracts *Trichoderma* to cope with pathogens, 3) *Trichoderma* allies with coffee plants to secure nutrients and environment, 4) interaction between coffee and *Trichoderma* is mutually beneficial and caffeine fosters the connection. In this regard, caffeine functions as a powerful weapon in arms race between coffee plants and pathogens by fostering enemy's enemy. This phenomenon could be regarded as the previously unidentified role of caffeine, and be called "caffeine alliance".

Reference

A. Sugiyama, C.M. Sano, K. Yazaki, H. Sano, "Caffeine fostering of mycoparasitic fungi against phytopathogens" Plant signaling & behavior 11 (1), e1113362, 2016.