BIOSYNTHESIS OF PLANT HORMONES BY MICROORGANISMS

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ABSTRACT

Higher plants are exposed to a multitude of fungi and bacteria, which are present in the surrounding phyllosphere and rhizosphere and which may also grow inside the shoot and the root. Compounds, known to act as hormones in higher plants, are produced by many of these microorganisms and are often functionalized in “friendly” or “hostile” interaction with the respective host plant. A large number of bacteria and fungi are capable of producing auxins, cytokinins or ethylene. The pathways for the biosynthesis of auxins and cytokinins in microorganisms are very similar to the ones present in higher plants. In contrast, microbial ethylene production follows different pathways, which are often substrate-specific. Different from microorganisms forming auxins, cytokinins and ethylene, the ability of synthesizing gibberellins or abscisic acid is much less common among fungi and bacteria.

Gibberella fujikuroi is predominantly forming GA_3, GA_4 and GA_7 as active GAs. Fermentations of high-yielding strains of this organism provide these GAs for use in horticulture, agriculture and beer brewing. *Sphaceloma manihoticola* and other species of this genus and *Phaeosphaeria sp.* produce primarily GA_4 and GA_1, respectively. Further GA-producing fungi are *Neurospora crassa* and *Sporisorium reilianum*. GA formation is also found in the bacteria *Rhizobium phaseoli*, *Azospirillum lipoferum*, *A. brasilense*, *Azetobacter diazotrophicus*, *Herbaspirillum serpedicae*, *Bacillus pumilis*, and *B. licheniformis*. Detailed investigations on the biosynthesis have primarily been conducted with *G. fujikuroi*. It can be concluded from these studies that, different from higher plants, mevalonate is the general starting material in microbial GA formation. Likewise, oxoglutarate-dependent dioxygenases, which catalyze the late steps of GA formation in higher plants, are absent in microorganisms. Their function is filled out by cytochrome P-450-dependent monooxygenases.

The ability to synthesize abscisic acid is restricted to a few phytopathogenic fungi. *Cercospora rosicola*, *C. cruenta*, *Botrytis cinerea*, *Ceratocystis coerulescens*, *C. fimbriata*, *Fusarium oxysporum*, and *Rhizoctonia solani* are typical representatives. There are no reports that bacteria would also have this capacity. Strains of *B. cinerea* are in use to produce abscisic acid on a commercial scale. Again, these fungi use mevalonate as a starting material. Via farnesyl diphosphate and ionylidene intermediates, a relatively direct pathway leads to abscisic acid, whereas higher plants use carotenoids as intermediates. According to the patent literature, substrates rich in carotenoids stimulate the production of abscisic acid. Therefore, it should not be ruled out that distinct strains of *B. cinerea* are able to form abscisic acid also from carotenoids.

Over decades, thousands of microbial species have been screened for their ability to produce

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plant hormones or other compounds with PGR activity. As is known to date, many of these substances will only be formed under distinct fermentation conditions. For instance, fungi will only synthesize GAs after depletion of the nitrogen source. With this knowledge in mind, it appears likely that many microorganisms have been "missed" in older investigations and that the ability to produce plant hormones is more widespread than is reported in the literature.