Metabolic engineering: prospects for crop improvement through the genetic manipulation of phenylpropanoid biosynthesis and defense responses — a review

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In leguminous plants such as the forage legume alfalfa, products of the phenylpropanoid pathway of secondary metabolism are involved in interactions with beneficial microorganisms (flavonoid inducers of the *Rhizobium* symbiosis), and in defense against pathogens (isoflavonoid phytoalexins). In addition, the phenylpropane polymer lignin is a major structural component of secondary vascular tissue and fibers in higher plants. The recent isolation of genes encoding key enzymes of the various phenylpropanoid branch pathways opens up the possibility of engineering important crop plants such as alfalfa for: (a) improved forage digestibility, by modification of lignin composition and/or content; (b) increased or broader-spectrum disease resistance, by introducing novel phytoalexins or structural variants of the naturally occurring phytoalexins, or by modifying expression of transcriptional regulators of phytoalexin pathways; and (c) enhanced nodulation efficiency, by engineering over-production of flavonoid *nod* gene inducers. The basic biochemistry and molecular biology underlying these strategies is briefly reviewed, and recent progress with transgenic plants summarized. The potential importance of metabolic compartmentation for attempts to engineer phenylpropanoid biosynthetic pathways is also discussed. Over-expression of an alfalfa glucanase-encoding gene confers significant protection against *Phytophthora* in alfalfa, possibly via indirect effects on phenylpropanoid metabolism.