Decontaminazione/Biotrasformazione

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ELSEVIER

Secondary plant metabolites in phytoremediation and biotransformation

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For millennia, secondary plant metabolites have antagonized microorganisms, insects and humans alike, ultimately generating a complex and dynamic mixture of facultative and obligate interactions from symbioses to pathogenicity. Secondary plant metabolites have an important role in developing the myriad of organic pollutant-degrading enzymes found in nature. The link between secondary plant metabolites and enzymatic diversity has yet to be exploited, with potential applications in fields as varied as pest management, bioremediation and fine chemical production.

Between 1997 and 2002, >600 research papers supported the observation that the addition of a plant to a contaminated medium (e.g. soil, wetland and hydroponics) enhances the removal and/or transformation of a pollutant. However, the mechanisms are often left unresolved. The paradox is that most of the persistent pollutants that are bio- and phyto-remediated are novel man-made chemicals (xenobiotics), which are thought to be different decomposing organic matter, (unrefined) fossil fuels and volcanism continually produce a wide range of chemicals (e.g. polycyclic aromatic hydrocarbons; Fig. 1; **2**,**3**) referred to as persistent organic pollutants when of anthropogenic origin. Common pyrolytic and polymerization reactions further extend the range of 'natural' pollutant analogues [1]. Although we recognize the potential importance of such affecters, we will not focus on them here. Rather, we present less investigated mechanisms that, on further study, might prove significant in exploiting the xenobiotic biodegradative capacity of microorganisms.

Plant root exudates

All plants modify the surrounding soil (rhizosphere) through the release of organic and inorganic substrates. Roots receive 30–60% of the net photosynthetic carbon, from which 10–20% is released by rhizodeposition [2,3]. Exudates consist primarily of low molecular weight (LMW) and high molecular weight (HMW) organic acids. Typically, the total concentration of organic acids in roots

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Controllo biologico delle infestanti

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Weeding with transgenes

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Transgenes promise to reduce insecticide and fungicide use but relatively little has been done to significantly reduce herbicide use through genetic engineering. Recently, three strategies for transgene utilization have been developed that have the potential to change this. These are the improvement of weed-specific biocontrol agents, enhancement of crop competition or allelopathic traits, and production of cover crops that will self-destruct near the time of planting. Failsafe risk mitigation technologies are needed for most of these strategies.

From the mid-20th century until recently, the agricultural pest management paradigm of all developed and many developing countries had been based on synthetic pesticides. This now mature technology has been partially responsible for the increases in crop yields seen in the past half-century. Despite increasingly rigorous regulatory protections from potential harm to the consumer and the environment from pesticides, there is considerable public support to find alternatives to these agents. Transgenes conferring crop resistance to pests have provided alternatives to synthetic insecticides and fungicides.

The only transgenes commercially associated with weed management thus far are those that confer resistance to herbicides to which crops are susceptible. The transgenes conferring resistance to the herbicide glyphosate have been a great commercial success, but there is little on the horizon that promises to provide alternatives to herbicides with transgenes. This is ironic because, to quote Amsellem *et al.*, 'weeds are the biggest pest constraint in row-crop agriculture' [1].

The recent book by Gressel discusses several strategies for the use of transgenic technology for weed management without pesticides [2]. There are three potentially effective approaches to meet this objective: (1) transgenic alteration of biocontrol agents to make them more effective in managing weeds; (2) transgenes that produce a more competitive crop or cover crop, or that will allow the crop to produce natural phytotoxins (allelochemicals) to kill or control competitors; and (3) alteration of cover crops in other ways that improve their use in weed management.

Transgenic biocontrol agents

The first of these tactics was considered by several participants in a recent NATO workshop on enhancing biocontrol agents [3,4]. There are several examples of successful classical biocontrol of weeds by inoculation of natural areas with plant pathogens or insects that target particular weed species. Nevertheless, much research and many patented biocontrol agents (primarily microorgan-

F. Geuna 2003

Piante a ridotto contenuto di lignina

RESEARCH

Repression of lignin biosynthesis promotes cellulose accumulation and growth in transgenic trees

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F. Geuna 2003

Decontaminazione batterica

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'Super bugs' for bioremediation

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Chlorinated organic compounds are among the most significant pollutants in the world. Sequential use of anaerobic halorespiring bacteria, which are the key players in biological dehalogenation processes, and aerobic bacteria whose oxygenases are modified by directed evolution could lead to efficient and total degradation of highly chlorinated organic pollutants. Recently three interesting papers on halorespiration and polychlorinated biphenyl biodegradation were published.

There is great concern over chlorinated organic compounds because of their toxicity, persistence and bioaccumulation. Among these compounds, polychlorinated biphenyls (PCBs) and chlorinated organic solvents such as trichloroethene (TCE), tetrachloroethene (PCE) and 1,1,1-trichloroethane (TCA) are the major targets for bioremediation. TCE, PCE and TCA were widely used and are recognized as serious environmental contaminants in soil, groundwater and the atmosphere. An increasing number of bacteria has been isolated that can couple reductive dehalogenation of these chlorinated solvents with energy conservation [1]. A halorespiratory process would therefore be effective for *in situ* bioremediation of these chlorinated solvents. Microbial degradation of PCBs has been extensively documented in terms of the biodegradability and molecular characteristics of enzymes and genes from a variety of soil bacteria [2]. Because PCBs are complicated mixtures containing up to ten chlorine atoms on a biphenyl molecule, microbial degradation is highly dependent on chlorine substitution and is highly strain dependent. Recently, attempts have been made to enhance PCB biodegradation by modifying oxygenases [3]. One of the most efficient methods of biological degradation consists of sequential anaerobic–aerobic treatment for highly chlorinated compounds. Recent biochemical and genetic engineering approaches for dehalogenases and oxygenases could lead to 'super bugs' that could be used for the bioremediation of chlorinated environmental pollutants.

Microbial halorespiration

An increasing number of bacteria has been isolated that can couple the reductive dehalogenation of various chlorinated compounds to energy conservation by electron-transport-coupled phosphorylation [1]. This process is referred to as halorespiration, or dehalorespiration. Recent studies indicate that halorespiring bacteria have

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