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Possibility of the application of chitinase to agriculture

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Abstract

Chitinase is produced in plants for their self-defense and in insects for their ecdysis. For its application to agriculture, transgenic plants have been successfully developed by introduction of chitinase gene from plants and insects. Furthermore, we could show that a certain yam chitinase is effective as a biocontrol agent against the strawberry powdery mildew.

Introduction

Nowadays we face population burst and environmental pollution on the earth, and thereby severe starvation problem may occur throughout the world. In order to produce enough amount of food, plant diseases have been controlled by using chemical fungicides. In contradiction to this intent, however, these chemicals have sometimes caused severe environmental and health problems. Therefore, we are investigating the usefulness of chitinase to agriculture on the basis of our long-term basic research. One is development of transgenic plants resistant to pathogens and insect pests, and the other is direct utilization of chitinase as an alternative biocontrol agent instead of chemical fungicides.

Application of chitinase to agriculture

Many groups including us have reported that some chitinases have strong lytic acitivity and/or anti-pathogen activity.[1, 2)] Therefore, it is not so difficult to think about developing the transgenic plants resistant to plant pathogens by introducing chitinase gene. In fact, K. Brogli *et al*. succeeded in development of transgenic tobacco plant carrying the bean class I chitinase gene in 1991. This transgenic tobacco plant grew up well in a soil infected by *Rhizoctonia*.[3)] Then several successful results have been reported: a transgenic canola plant carrying tobacco class I chitinase gene exhibited resistance to *R. solani*,[4)] a transgenic cucumber plant carrying rice class I chitinase gene

to gray mold, *Botrytis cinerea*,[5] a transgenic gravevine[6] and strawberry[7] carrying rice class I chitinase to powdery mildew. We could also develop a transgenic strawberry carring yam class IV chitinase resistant to powdery mildew (not published). So far lots of chitinase genes have been used to develop transgenic plants resistant to plant pathogens. We have also investigated to clarify which chitinase isozyme is effective.[1, 2] Finally we could conclude the following. Class I and IV chitinases but not class II chitinase are effective against plant pathogens in transgenic plants carrying them, since these chitinases have an additional chitin binding domain at N-terminal region and therefore are efficient for binding to solid state of chitin in the cell walls of plant pathogens and possibly the peritrophic membrene of insects.

On the other hand, a transgenic plant resistant to insect pest was developed by K. J. Kramer and S. Muthukrishnan group in 1998.[8] That is a transgenic tobacco plant expressing tobacco hornworm chitinase. Insects grow up by a repeated ecdysis process during which the chitins of the cuticle and the peritrophic membrane of the digestive tube are degraded by chitinase. Of course, insects do not self-hydrolyze their chitin in the stages other than molting stage. If insects feed on chitinase in the stages other than molting stage, their digestive tubes will be damaged by chitinase. Eventually the insects may die.

Another application is direct use of chitinase as a biocontrol agent. We selected a yam chitinase belonging to family 19 and class IV that has a characteristic of thermal and pH stabilities. A scanning electron microscope showed that this yam chitinase degraded the powdery mildew on the leaves and berries of strawberry.[9] This result suggests that such a chitinase is useful as a biocontrol agent instead of chemical pesticides and fungicides that may cause environmental pollution.

Reference

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