A new plant-bacterial symbiotic mechanism promising for crop applications

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The growth of most plants depends on the presence of sufficient amounts of nitrogen contained in the soil. However, a family of plants, the legumes, is partially free of this constraint thanks to its ability to live in association with soil bacteria of the Rhizobium, genus, capable of fixing nitrogen from the air.

When these bacteria come into contact with their host plant, they trigger in the roots the formation and development of organs, termed nodules, where they continue to live. This close relationship is symbiosis, which benefits both organisms involved: the plant supplies nutritive elements to the bacteria which in return pass on the nitrogen they have stored up.

These interactions improve crop yields of leguminous plants that are crucial for human diet (soybean, peas, ground nuts and so on…) and as animal feed (alfalfa, clover, sainfoin). In addition, cultivation of legumes living in symbiotic association with bacteria can contribute to vegetation regeneration schemes on soils depleted in nitrogen owing to overexploitation, erosion or desertification. The plant cover thus formed can help achieve ecological restoration, by enriching the soils in nitrogen. However, the symbiotic processes studied predominantly concern the leguminous plants of temperate zones, very little those of the tropics.

The team from the IRD's 'Laboratoire des Symbioses Tropicales et Méditerranéennes' and its partners, taking as model a symbiosis between a tropical aquatic legume, Aeschynomene, and Bradyrhizobium, bacteria of the Rhizobia family, have just revealed a new mode of communication at molecular level between these two organisms. The bacteria of this original model have their own photosynthetic pathway, a unique property in the rhizobia. This special character confers on it the exceptional, rare ability to form nodules on the stems of its host-plant. The plant thus acquires the possibility of fixing much higher quantities of nitrogen than those usually measured in leguminous plants which have nodules only on their roots.

The researchers sequenced the genes of two bacterial strains of Bradyrhizobium, ORS278 and BTAi1, in order to find out their genetic make-up and identify the genes involved in this rather special form of symbiosis. These bacteria were found to have no nod genes, usually essential for nodulation. Bradyrhizobium consequently appeared to use mechanisms that involved other genes. This surprising result calls into question the universally recognized model of molecular communication that initiates the rhizobia-legume symbiosis. This common model requires the presence of several nod genes which allow synthesis of the Nod factor, a compound elaborated by the bacterium which enables the plant to recognize it, by molecular recognition, thereby allowing the microorganism to penetrate inside the plant by the root hairs.

The finding raises the question as to what signalling pathway Bradyrhizodium might use to gain entry to the plant and set off nodulation.

The first observation was that the bacteria did not penetrate the roots of its host-plant by the hairs. It took advantage of "crack zones" comparable with wound areas. The set of results obtained from subsequent work, seeking to identify the genes involved in producing the unknown signal molecule that plays the role of Nod factor, prompted the team's hypothesis that a molecule similar to a plant hormone, cytokinin, could act in the mechanisms by triggering nodulation. The discovery of the nature of the signal molecule itself, which remains to be fully determined, brings a glimpse of future agricultural applications.

Many plants live in symbiosis with bacteria, but the mechanisms are known for only a small number of these interactions. The demonstration of alternative

pathways capable of triggering the nodulation signal in certain rhizobia is promising for future techniques for bringing these bacteria into association with different leguminous plants. It therefore becomes possible to increase agricultural production of a greater number of important plants, notably in tropical countries, while cutting down the use of fertilizers.

Source: Institut de Recherche Pour le Développement