Origin of root offshoots revealed

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VIB researchers at Ghent University (Belgium) have discovered the substance that governs the formation of root offshoots in plants, and how it works. Root offshoots are vitally important for plants – and for farmers. Plants draw the necessary nutrients from the soil through their roots. Because they do this best with a well-branched root system, plants must form offshoots of their roots at the right moment. The VIB researchers describe how this process is controlled in the prominent professional journal *Science*.

A key player in this process is a protein called ACR4. Depending on the signals that it receives from its environment, this protein triggers the formation of a root offshoot. Now that we know the control mechanism, we can begin to stimulate plant roots to form more, or fewer, offshoots. This can lead to a more ecological agriculture and to the production of better crops at the same time.

It is difficult to overstate the importance of plants in our lives – they are responsible for our oxygen and for food, clothing, energy, and countless other things. And in turn, the importance of a plant's roots is unquestionable: they provide the plant with necessary nutrients and moisture. The more the roots are subdivided, in breadth and depth, the better they can do their work. So, a well-coordinated, controlled formation of root offshoots is crucial to a plant. But, until now, how a plant determines when and where an offshoot should be formed was unknown.

The presence of stem cells is very important in the development of plants and animals. Stem cells are cells that can transform themselves into various types of cells. In animals, tissues and organs are formed before birth; but in fully-grown plants, stem cells continue to play a major role in the formation of new organs or tissues, such as root offshoots.

These stem cells are found inside the root, and several of them will induce the formation of an offshoot. These 'root-founder' cells undergo an asymmetric cell division. In contrast to the usual cell division, which gives rise to two identical cells, asymmetric cell division produces two different cells: a stem cell that is identical to the original cell, and a cell that is ready to become a specialized cell – in this case, a secondary root cell.

With the aid of the mouse-ear cress (*Arabidopsis thaliana*), a frequently used model plant, Ive De Smet and Valya Vassileva in Tom Beeckman's group have been studying how a plant determines which cells will trigger offshoots. To do this, the VIB researchers in Ghent have employed a special technology that makes it possible to make synchronous offshoots develop at different moments. This allowed them to isolate the cells that induce the formation of offshoots. They found out which genes are active in these cells and compared them with the genes that are crucial to normal cell division. In this way, the researchers identified a specific set of genes that control asymmetric cell division and send the signal for the formation of offshoots.

The researchers then examined one of these genes more closely. The ACR4 gene contains the DNA code for a receptor, a protein that is often located on the exterior of a cell to pick up signals from the outside and transmit them to the controlling mechanisms within the cell. When the researchers disrupted the function of ACR4 in plant cells, the precisely orchestrated asymmetric cell division was also disturbed. From this finding, De Smet and Vassileva inferred that ACR4 plays a key role in the creation of offshoots. Because the protein has a receptor function, triggering the formation of offshoots depends on its reaction to signals from the environment.

With this research, the scientists have discovered a fundamental mechanism – fundamental for the plant, and very important for plant-breeders as well. This new knowledge enables us to promote, or retard, the formation of offshoots – both activities are useful in a large number of applications.

Promoting an extensive root system helps plants absorb nutrients more readily, and thus they need less fertilizer. Such plants can also grow more easily in dry or infertile soils. Furthermore, plants with a well-developed root system are more firmly anchored in the soil and can be used to counteract erosion.

On the other hand, slowing down secondary root formation can be advantageous in tuberous plants, like potatoes or sugar beets. This enables these food crops to invest all their energy in the production of nutrients. Fewer root offshoots also makes it easier for farmers to harvest these crops.

This plant research sheds light on the control of asymmetric cell division – and this kind of cell division is similar to the cell division of stem cells in animals, too. So, these results can also provide greater insight into how animal stem cells specialize.

For example, irregular cell division plays a role in the development of various types of cancer, and similar control mechanisms might underlie this process as well. This is clearly an important area for future research.

Source: VIB (the Flanders Institute for Biotechnology)