Scientists unravel root cause of plant twists and turns

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To feed the world's burgeoning population, producers must grow crops in more challenging terrain – where plant roots must cope with barriers. To that end, Cornell University physicists and Boyce Thompson Institute plant biologists have uncovered a valuable plant root action, in that roots – when their downward path is blocked, as often occurs in rocky soil – display a "grow and switch" behavior, now reported in the latest *Proceedings of the National Academy of Sciences*.

The group observed growth patterns arising from how plant roots cope with limitations of their gravity sensors. When there is no root barrier, its growth is straight down. When barriers are present, roots coil in some instances and wave in other situations.

"We found that the roots make planar coils when the barrier they encounter is flat, and transition to wavy geometry when the barrier is at an angle," said Tzer Han Tan '14, lead author on the new paper, "How Grow-and-Switch Gravitropism Generates Root Coiling and Root Waving Growth Response in Medicago truncatula."

Plant roots have gravity sensors in each cell at the root's tip, which are comprised of dense particles called "statoliths" that enable the roots to determine which way is down.

When a root encounters a barrier, such as a mild slope, the root conquers the barrier with a search strategy: "To our surprise, the strategy the plants adopt is basically the same search algorithm as the 'run-andtumble' strategy found in many bacteria," Tan said. "Essentially, the roots grow in a particular direction, and from time to time curve to switch their growth directions."

The scientists learned that these course corrections have a 90 percent accuracy.

Tan and his colleagues grew Medicago plants – related to alfalfa – in a transparent hydrogel and used 3-D imaging to record root growth. The scientists embedded an angled glass slide underneath the seedling that blocked straight-down root growth. By varying the angle of the glass barrier, the scientists observed different root responses –the coiling, waving and straight growth.

The project resulted from a collaboration between Tan, an engineering physics undergrad at the time of this research at Cornell, and co-authors Jesse Silverberg, M.S and Ph.D. '14; Itai Cohen, professor of physics; Daniela Floss, Boyce Thompson Institute (BTI) for Plant Research; Maria Harrison, the William H. Crocker Professor, BTI; and Christopher L. Henley, professor of physics.

Henley drove this project heavily, explained Cohen, "Chris mentored Tzer Han Tan and really pushed the project forward while contributing some of the key ideas for the project," he said. Sadly, Henley passed away earlier this year.

With climate change, emerging drought possibilities, a growing world population and finding agricultural land a more difficult task, Harrison said the detailed knowledge of how roots grow is critical for the future of efficient food production.

More information: How Grow-and-Switch Gravitropism Generates Root Coiling and Root Waving Growth Response in Medicago truncatula, *PNAS*, DOI: 10.1073/pnas.1509942112

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