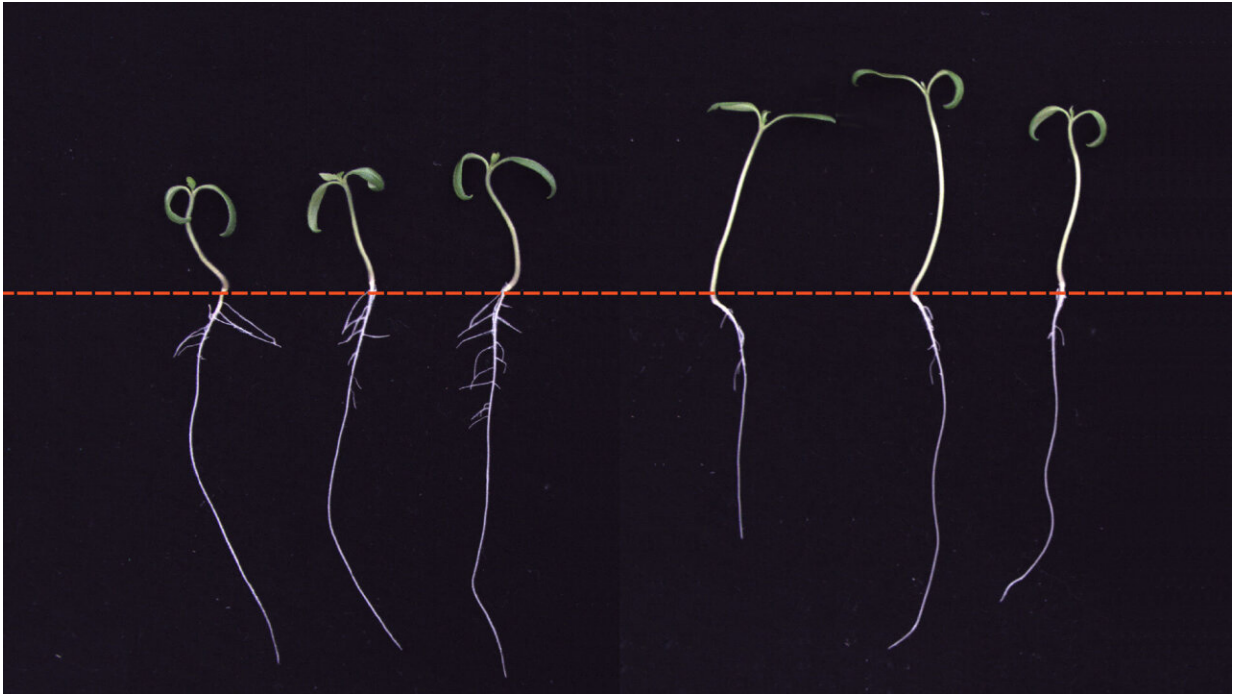


Why roots don't grow in the shade

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Plants depend on sunlight for photosynthesis. When they find themselves in too much shade, they will redirect their resources from root development towards stem growth, so they can grow taller and access the sun. In this image, the three plants on the left were grown in full unshaded light: they have lots of branched roots. In contrast, the three plants on the right were grown in the shade: They have fewer branched roots because the plant is focusing on growing a longer stem to try and reach more light. Credit: Daniele Rosado / Pedmale lab / CSHL, 2021

When a plant finds itself in too much shade, it redirects its resources to

reach for light. Crop yield and root development stall as the plant focuses on growing taller, striving to rise above neighboring plants to access the sun.

Shade avoidance is a vital survival strategy for an organism that depends on photosynthesis—but it's a problem for farmers, says Cold Spring Harbor Laboratory (CSHL) Assistant Professor Ullas Pedmale. It limits the density at which growers can plant their crops, and thus, limits yields.

"Because of crowding, there is a competition for sunlight—so their option is to grow taller," says Pedmale. He adds:

"The plants are putting all this energy to try to grow taller, but now it's at the expense of fruits that we depend on, biomass. Then it's also at the expense of the roots, so the roots don't grow."

Researchers have been studying plants' [shade](#) response for decades in hopes of finding ways to help plants flourish at higher densities. Most of that research has focused on changes in stems and leaves, but Pedmale's team wanted to know what happens underground when a plant is deprived of light. It's an urgent issue because plants without strong [root systems](#) are more vulnerable to droughts, flooding, and hurricanes—threats that are becoming more common due to climate change.

Using tomato plants and the model plant *Arabidopsis*, postdoctoral researcher Daniele Rosado and other members of Pedmale's team compared the roots of seedlings grown in full unshaded light to the shorter, less developed roots of plants grown in shade. They found that hundreds of genes that plants use to respond to stress were switched on in the shade-grown plants—including dozens that encode proteins called WRKYs, which regulate [gene expression](#).

To confirm that they limit root growth, Pedmale's team engineered plants in which specific WRKY genes remained highly active, regardless of conditions. They found that plants with high levels of certain WRKY proteins grew the same stunted roots seen in shade-grown plants, even when provided with plenty of light. The plant's stems, in contrast, grew at a normal rate. In addition, they discovered that the plant hormone ethylene (required for fruit ripening) may also be involved in roots' shade response.

Pedmale hopes that revealing these proteins' role in shade avoidance will help researchers develop better high-yielding [plants](#): Plants that can thrive under more crowded conditions, withstand [extreme weather](#), and maybe even reduce global warming by pulling carbon dioxide out of the air and into extensive [root](#) systems.

More information: WRKY transcription factors and ethylene signaling modify root growth during the shade avoidance response, *Plant Physiology* (2021). [DOI: 10.1093/plphys/kiab493](https://doi.org/10.1093/plphys/kiab493)

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