Herbicide may affect plants thought to be resistant

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Purdue University researchers have discovered a fine-tuning mechanism involved in plant root growth that has them questioning whether a popular herbicide may have unintended consequences, causing some plants to need more water or nutrients.

Angus Murphy, a professor of horticulture, and Wendy Peer, an assistant professor of horticulture, study the movement of auxin, a plant hormone essential for plant development. They showed that ABCB4, a protein responsible for moving auxin into cells, also removes the hormone when too much has accumulated.

"We knew that the protein took auxin up, but found that it switched to removing auxin when a threshold is reached," said Murphy, whose findings appeared in the early online version of the *Plant Journal*. "It starts transporting the hormones out."

That fine-tuning mechanism is integral to proper development of plant root hairs, which extend from the main plant root and are where most water and minerals enter.

"The root hairs are doing all the heavy lifting for bringing the water into the plant," Peer said. "And ABCB4 maintains the right auxin levels to keep root hairs growing optimally."

The herbicide 2,4-D, a synthetic form of auxin, could have unintended consequences for the protein, Murphy and Peer said.

The herbicide is used to kill broadleaf weeds, which are dicots, while monocot grasses, such as sorghum and corn, are more resistant. That's because grasses inactivate 2,4-D inside the plant, while broadleaf dicots do not.

But ABCB4 is located on the root surface and can be switched into intake-only mode, disabling its ability to remove excess auxin from cells, before 2,4-D can be inactivated inside the plant. This results in shorter root hairs.

"This suggests that ABCB4 is an unexpected target of 2,4-D action," Murphy said. "It's something that we have to be aware of with the commercial introduction of 2,4-D resistant soybeans and other dicot crops."

Murphy said laboratory testing of ABCB4 in yeast, tobacco and human cells subjected to 2,4-D all showed that ABCB4 could be locked into the uptake-only mode. The root hairs of mutant plants that had ABCB4 removed were not affected by application of 2,4-D.

"It was very clear that what was happening in the plant was what was happening in the cell cultures," Murphy said.

Murphy said the findings suggest that application techniques that limit 2,4-D entry into soils are important to ensure that production with engineered 2,4-D resistant crop plants does not require additional fertilizer and/or water inputs.

More information: The Arabidopsis Concentration-Dependent Influx/Efflux Transporter ABCB4 Regulates Cellular Auxin in the Root Epidermis, *Plant Journal* (2011).

ABSTRACT

Arabidopsis ATP-binding cassette B4 (ABCB4) is a root-localized auxin efflux transporter with reported auxin uptake activity in low auxin concentrations. Results reported here demonstrate that ABCB4 is a substrate-activated regulator of cellular auxin levels. The contribution of ABCB4 to shootward auxin movement at the root apex increases with auxin concentration, but in root hair elongation assays ABCB4-mediated uptake is evident at low concentrations as well. Uptake kinetics of ABCB4 heterologously expressed in Schizosaccharomyces pombe differed from the saturation kinetics of AUX1 as uptake converted to efflux at threshold indole-3-acetic acid (IAA) concentrations. The concentration dependence of ABCB4 appears to be a direct effect on transporter activity, as ABCB4 expression and ABCB4 plasma membrane (PM) localization at the root apex are relatively insensitive to changes in auxin concentration. However, PM localization of ABCB4 decreases with 1-naphthylphthalamic acid (NPA) treatment. Unlike other plant ABCBs studied to date, and consistent with decreased detergent solubility, ABCB4pro:ABCB4-GFP is partially internalized in all cell types by 0.05% DMSO, but not 0.1% ethanol. In trichoblasts, ABCB4pro:ABCB4-GFP PM signals are reduced by >200 nm IAA and 2,4-dichlorophenoxyacetic acid (2,4-D). In heterologous systems and in planta, ABCB4 transports benzoic acid with weak affinity, but not the oxidative catabolism products 2-oxindole-3-acetic-acid and 2-oxindole-3-acetyl-β-d-glucose. ABCB4 mediates uptake, but not efflux, of the synthetic auxin 2,4-D in cells lacking AUX1 activity. Results presented here suggest that 2,4-D is a non-competitive inhibitor of IAA transport by ABCB4 and indicate that ABCB4 is a target of 2,4-D herbicidal activity.

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