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Beta-Cyclocitral Root Growth Stimulation

https://www.hhmi.org/news/a-plant-hormone-that-speeds-root-growth-could-be-a-new-agricultural-tool

A Plant Hormone that Speeds Root Growth Could Be a New Agricultural Tool

Summary
Scientists have identified a plant hormone, beta-cyclocitral, that makes tomato and rice plant roots grow faster and branch more. The hormone could help farmers enhance crop plant growth.

A molecule sold as a food additive has an underground role, too: helping roots grow faster.

When added to soil, the molecule, called beta-cyclocitral, speeds root growth in rice and tomato plants, scientists report May 8, 2019, in the journal Proceedings of the National Academy of Sciences. It also makes rice plants resistant to salty soil, which usually turns plants sickly and stunted. The molecule, a hormone found naturally in plants, could be a useful tool for farmers seeking healthier and more drought-resistant crops.

For centuries, plants have been bred for vigorous foliage and other easily visible traits. Because roots are hidden underground, “they’ve been largely ignored,” says developmental biologist Philip Benfey, a Howard Hughes Medical Institute investigator at Duke University.

And yet, roots make up half the plant, points out coauthor Jazz Dickinson, also at Duke. She and Benfey wanted to find plant hormones that affected root development. Their previous research had hinted that some molecule chemically related to carotenoids – the pigments that give carrots their vibrant orange hue – might be important. But the researchers weren’t sure exactly which one, Dickinson says.

Many of these carotenoid relatives have been repurposed and are available commercially as food additives or dietary supplements. Dickinson rounded up about 20 and tested their effects on a common lab plant, Arabidopsis. She added each compound to the clear agar gel in which the plants were growing – a setup that let her easily see the roots – and monitored what happened over 10 days.

“Beta-cyclocitral stood out,” she says. It made the roots grow faster and also branch out more. And it had the same effect in rice and tomato plants, follow-up tests showed.

In rice plants, the team noticed an even more striking effect: the plants could also withstand salty soil. Irrigation of farm fields can make soil saltier, especially near the top. The team mimicked those conditions in the lab, and then watched how rice plants grew. “Untreated rice plants were very unhappy with that level of salt,” Benfey says. But with beta-cyclocitral added, the plants didn’t seem perturbed.

It’s possible that the compound helped the roots push down through the salty topsoil to reach the

deeper, less-salty soil more quickly, Dickinson proposes.

The researchers hope that beta-cyclocitral will be useful agriculturally, either added to soil or sprayed onto crops. And since the molecule worked in both rice and tomatoes – two very different plants – it may boost root growth in crops more broadly.

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https://www.youtube.com/watch?v=SJz9xz1LLiM

Racing roots

These racing roots show the effects of beta-cyclocitrical, a plant hormone that boosts root growth. The rice plants on the left are growing in a gel that contains the hormone, but the ones on the right aren't getting any help.

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ß-Cyclocitral is a conserved root growth regulator

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Significance

Roots produce hundreds to thousands of small molecules with unknown functions. We targeted the apocarotenoid pathway, which has been linked to numerous developmental processes in Arabidopsis, for a sensitized chemical genetic screen to identify regulators of root development. ß-Cyclocitral, a small molecule derived from ß-carotene, was identified as a regulator of root stem cell behavior in Arabidopsis as well as in rice and tomato. ß-Cyclocitral promotes root stem cell divisions to enhance root growth and branching. In rice, ß-cyclocitral enhanced both root and shoot growth during salt stress, which has important implications for agriculture.

Abstract

Natural compounds capable of increasing root depth and branching are desirable tools for enhancing stress tolerance in crops. We devised a sensitized screen to identify natural metabolites capable of regulating root traits in Arabidopsis. ß-Cyclocitral, an endogenous root compound, was found to promote cell divisions in root meristems and stimulate lateral root branching. ß-Cyclocitral rescued meristematic cell divisions in ccd1ccd4 biosynthesis mutants, and ß-cyclocitral–driven root growth was found to be independent of auxin, brassinosteroid, and reactive oxygen species signaling pathways. ß-Cyclocitral had a conserved effect on root growth in tomato and rice and generated significantly more compact crown root systems in rice. Moreover, ß-cyclocitral treatment enhanced plant vigor in rice plants exposed to salt-contaminated soil. These results indicate that ß-cyclocitral is a broadly effective root growth promoter in both monocots and eudicots and could be a valuable tool to enhance crop vigor under environmental stress.

Beta-Cyclocitral Synthesis Patents

Method for preparing cyclocitral by micro-structural reactors
CN106117027

The invention discloses a method for preparing cyclocitral by micro-structural reactors. The method comprises steps as follows: a liquid raw material citral and organic amine in a mole ratio being 1: (0.8-1.5) are simultaneously pumped into a tubular reactor or one micro-structural reactor

for an amination reaction, the reaction temperature of the reactor is controlled in a range of 10-20 DEG C, a flow velocity of a reaction liquid is controlled, the reaction liquid is enabled to totally stay in the reactor for 0.1-25 min, and obtained aldimine and concentrated sulfuric acid are injected into another micro-structural reactor and subjected to a ring closing reaction; a reaction product is neutralized by a sodium hydroxide solution and is subjected to acidic hydrolysis, liquid separation, reduced pressure distillation and drying, and a pale yellow oily product, namely, cyclocitral, is obtained. According to the method, the reaction time is short, the reaction temperature is accurate and controllable, and product select

PROCESS FOR PREPARING CYCLOCITRAL
US5175373
A process for preparing cyclocitral by expoxidizing a pyronene.

Preparation of alpha - and beta -cyclocitral, and the N-methylaldimines of these compounds
US4358614
An improved process for the preparation of cyclocitrals of the general formula I (I) via the novel N-methylaldimines of the general formula II (II) and the novel N-methylaldimines of the formula II. The cyclocitrals of the formula I are obtained in yields of 80-90%, based on citral employed. The compounds I and II are important intermediates for the preparation of fragrances and carotinoids, such as vitamin A, and products related thereto.

Manufacture of Ionone from Citral and Acetone and of Cyclocitral as Intermediate Product.
GB189823254
Ionone is prepared from citral and acetone by the following operations :-(1) Cyclocitral is first produced. For this purpose citral is condensed with cyanacetic acid, or a salt or ether thereof, in the presence of caustic soda' and alcohol, whereby citralidene cyanacetic acid melting at 124 -122 C., or a derivative thereof, is produced ; then this product is converted into its cyclic isomeride by boiling it at a reflux-cooler with diluted sulphuric acid for twelve hours, after the manner described in Specification No. 22,114, A.D. 1893; and, finally, the cyclic compound, which after removal of bye-products is obtained as a syrup, is distilled in a powerful current of steam in presence of caustic alkali, and the distillate is fractionated to obtain crude cyclocitral as a yellowish liquid boiling at 80 -110 C. under a pressure of 15 mm. The cyclocitralidene cyanacetio acid may also be hydrolysed by boiling it with caustic potash solution and xylene, and then separating and fractionating the xylene layer. A small quantity of a gentle oxidizing- agent, such as lead peroxide or the like, may advantageously be used in these hydrolysing operations. (2) Cyclocitral is condensed with acetone by means of alkaline reagents, for example, a solution of sodium in alcohol, at the ordinary temperature. The mixture is then neutralized by tartaric or other acid, and is distilled in a strong current of steam. On redistillation the fraction which boils at 130 -140 C., under a pressure of 16 mm., is collected as ionone. It is rich in #-ionone, and yields a semi-earbazone melting at 148 C., and a p-bromophenyl-hydrazone melting at 116 C.

MANUFACTURE OF CYCLOCITRAL
GB1494804
Compounds of the formula where R is H or CH 3 are prepared by passing a stream of gas consisting of O 2 and O 3 into a solution of #-ionone or #-isone in a solvent for ozonolysis reactions in an amount to provide 1 to 2 moles 03 per mole of #-ionone or #-isone and the resulting reaction mixture is worked up hydrolytically or reductively.

Tomato products enriched in beta-cyclocitral
EP0983725
The invention relates to processing tomatoes into paste, sauce or related products, in which the

processed products have an improved flavour. More in particular, the processed products have increased amounts of fruity flavour compounds. This is achieved by co-oxidation of carotenoids and polyunsaturated fatty acids, using an enzyme having lipoxygenase activity.
