Plant hormone has dual role in triggering flower formation, study finds

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Flowers aren't just pretty to look at, they are how plants reproduce. In agricultural plants, the timing and regulation of flower formation has economic significance, affecting a crop's yield.

A new paper by researchers at the University of Pennsylvania published in the journal *Science* has revealed that a plant hormone once believed to promote flower formation in annual plants also plays a role in inhibiting flowers from forming. The dual role of this hormone, gibberellin, could be exploited to produce higher-yielding crop plants.

The study was led by Nobutoshi Yamaguchi and Doris Wagner of the School of Arts and Sciences' Department of Biology. Wagner is professor and graduate chair, and Yamaguchi is a postdoctoral researcher. Department co-authors included Cara M. Winter, Miin-Feng Wu and Ayako Yamaguichi. The Penn team collaborated with Yuri Kanno and Mitsunori Seo of RIKEN Center for Sustainable Resource Science in Japan.

Plant scientists used to think that short-lived plants, annuals or bi-annuals, use a different strategy from long-lived plants, perennials, to regulate flower production.

"Anecdotal evidence was that the hormone gibberellin promoted the switch to flower formation in short-lived plants, along with other cues such as temperature, season and photoperiod," Wagner said. "But in the long-lived plants, like in fruit trees, people have known that if you sprayed them with the hormone it inhibited flower production. So it was a big puzzle: why would the same hormone do one thing in short-lived plants and another in long-lived plants?"

To address this paradox, the Penn team began by looking for new genes important to the flower-forming process. Specifically, they performed a genome-wide search of the plant species *Arabidopsis thaliana* to find direct targets of the protein LEAFY, which is known to promote flower formation.

One gene that turned up was called ELA1, which produces a cytochrome enzyme and has been shown to play a role in breaking down gibberellin. Further experiments showed that in plants that lost ELA1 function, flowers formed much later than normal.

The researchers also found that plants that lacked LEAFY had high levels of gibberellin, and plants engineered to produce high levels of LEAFY had lower levels of the hormone and were also shorter with greater levels of chlorophyll—characteristics of gibberellin deficiency.

"At first we were confused because gibberellin was supposed to promote all of this activity that leads to flower formation," Wagner said. "Then when we found a direct target of LEAFY that is linked to gibberellin catabolism, that gave us the clue that gibberellin must have a role in inhibiting flower formation as well."

Plants that were genetically modified to not produce gibberellin properly and plants that were treated with a gibberellin inhibitor showed signs of a delayed first transition to inflorescence but accelerated signs of flower formation. Spraying the plants with gibberellin had the opposite effect.

The results suggested that the two transition steps that lead plants to produce flowers might be regulated distinctly, both involving gibberellin.

While gibberellin promotes the first transition, in which plants stop producing stems and leaves and produce an inflorescence, it inhibited the second stage, in which flowers were formed.

The mechanism, the Penn team showed, involves rising and then falling levels of gibberellin. High levels cause the plant to end the vegetative phase of development. At that point, LEAFY and ELA1 activity cause gibberellin to break down. Freed from the inhibitory effects of the hormone, a suite of proteins are activated that trigger flower formation.

"When it comes to determining the number of flowers formed and when they are formed, we think this pathway is at the forefront," Wagner said.

Farmers already use gibberellin-deficient breeds of rice to produce more compact plants that don't topple over in wind and rain. The new understanding of gibberellin's role gained from this study could help create plant breeds that are even more productive.

"We think it can be used to enhance yield," Wagner said. "Seeds are the product of a flower so if you want more seed you want more flowers. Being able to modulate the accumulation or degradation of gibberellin could allow one to optimize or enhance the seed set and yield in crop plants."

The Penn team plans to explore other plants to see if gibberellin operates the same way across species and in perennials as well and to further explore how different levels of the hormone trigger regulatory events that either inhibit or promote flower production.

More information: "Gibberellin Acts Positively Then Negatively to Control Onset of Flower Formation in Arabidopsis" *Science*, 2014.