Science Societies

Weedy conversation: What weeds are saying to your crops may make them ‘scream’ on the inside

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Source: Karen Brey.

Decades of weed science research have pieced together how weeds communicate with crops and can have permanent and non-reversible effects that result in rapid yield loss when the weeds emerge with the crops. This work has provided valuable information to CCAs to make recommendations to farmers and attracted attention to the ultimate goal of breeding crop plants less susceptible to this kind of damage.

A corn seedling grows in a row among its siblings with only small weeds nearby, none large enough to compete with it for light, water, or nutrients—yet it's still under assault. Far-red light reflected by the weeds is detected by the crop where it sets off a cascade of damaging effects that decreases yield by the day.

Decades of weed science research have pieced together much of the detrimental effects this has on crops and have also started investigating the mechanisms at the molecular level. This work has provided valuable information to CCAs to make recommendations to farmers and attracted attention to the ultimate goal of breeding crop plants less susceptible to this kind of damage.

"It's a conversation between the crop and the weed," explains Clarence Swanton of the University of Guelph in Ontario, Canada, who has been studying this topic for decades. "You can walk by a plant that looks free of what we used to think were the main drivers of competition, and it looks like nothing is wrong. But on the inside the plant is

screaming."

The journey to understanding that this "screaming" was even occurring, much less what was causing it or how to stop it, has been long.

The Critical Period: Start Clean and Stay Clean

Researchers have learned that a weed in the presence of a corn or soybean plant will cause a dramatic and swift rise in free radicals inside the crop plant, such as hydrogen peroxide. The free radicals wreak havoc on cellular processes, membranes, and DNA itself. Photo courtesy of the United Soybean Board.

In the 1990s, Swanton and other researchers were busy isolating the critical period for weed control for different crop plants. This is the period where weed control is essential because it can have the biggest effect on the crop's growth and ultimately its yield and farmers' profits. It's a period during plant development when competition would have the most detrimental effects.

By introducing a weed near a crop plant, they found that weed presence at crop emergence can have permanent and non-reversible effects that result in rapid yield loss. The timing of weed management influences the final yield, they learned, and varies for different crops.

"We could see a surprising impact from relatively few weeds that seems to affect the crop at emergence, despite having 95% of its growth cycle ahead of it," Swanton explains. "It clearly sets the crops on a completely different growth trajectory."

The crops produce lower yield because the competition with weeds has multiple effects on their morphology. Their root structures are reduced; they have fewer root

hairs and shorter root lengths. There is delayed modulation in soybeans and nodulation in corn. The crops also experience changes in stem diameter, timing of grain appearance, and rate of photosynthesis. Additionally, Swanton believes this opens the plants to other stresses during the growing season, such as drought or disease.

They can actually talk about the reductions in yield happening by the minute. Thanks to one study, they can illustrate that in the presence of weeds, a corn crop is losing 0.5 to 3.3 bu/day, changing the way those involved in production think about weed control, he says.

The weeds that emerge with the crop have the biggest effect, and as the crop grows leaf by leaf, the yield loss due to weeds declines rapidly. There comes a point, Swanton adds, where the weeds don't matter as much in terms of effect on yield.

This research led to a slew of recommendations for farmers to "start clean and stay clean" during the critical period.

"It's all about herbicide timing," Swanton says. "It's important to start with a clean field. You want to make sure that the weeds are removed, so you start clean by applying herbicide at the right time and following back with post-treatment if necessary. It's really important to do this management in the first couple of weeks because that's the most important for crop emergence. That's when everything is happening, and it's that early management that's going to set your fields up for success."

Digging Deeper to the Molecular Level

Knowing that the weeds affected the crops and how to prevent that damage was one thing, but Swanton and others began to get interested in the "how." From their field experiments, he knew that young crops didn't have any of the traditional forms of competition, such as sunlight, water, or nutrients. None of the surrounding weeds were

blocking the sun, they were irrigating, and there was plenty of fertilizer. They knew something else was allowing the weeds to communicate and compete with the crop.

About 20 years ago, they had an idea. Plants absorb many wavelengths of light but reflect far-red light—what if nearby plants can detect their neighbors by interpreting this light reflected at them and then their morphology and physiology changed in response?

"We started to ask ourselves if it was possible that crops can detect this light, and so all we did was introduce a weed nearby while limiting other forms of competition, and we were able to change the root structure, rate of leaf appearance, height of the plant, and more where there's really no other change or reason," Swanton explains. "We then switched to looking at the molecular and cellular responses this causes, and that's where we are today."

Weeds that emerge with the crop have the biggest negative effect; therefore, Clarence Swanton stresses that it is important to start with a clean field by applying herbicide at the right time. Source: Adobe Stock/eleonimages.

For example, more recently, they've learned that a weed in the presence of a corn or soybean plant will cause a dramatic and swift rise in free radicals inside the crop plant, such as hydrogen peroxide. The free radicals wreak havoc on cellular processes, membranes, and DNA itself. Swanton says this changes a plant's growth rate because it has to respond to this damage and recover before it can get back on track.

"All that's happening is a conversation between the weed and the crop, and if you walk by, it can look like nothing is wrong," he says. "But, inside the plant is screaming

because free radicals are exploding and causing damage. The plant has to repair itself, and that energy has to come from somewhere. That means it's taking away from growth, and that's how yield projections are disrupted."

Other lines of his research have found very surprising results. For example, he wondered how a plant recognizes its siblings—the other crop plants in the field—and doesn't negatively respond to them. They tested seven commercial soybean cultivars and one ancient one. The seven could recognize each other and made no difference. The ancient one, however, was perceived as a weed and damaged the modern crops, greatly surprising the researchers.

In studying soybeans, they found that a seedling can detect what's above ground before it's even emerged from the soil and begin changing its morphology. Somehow, the plant is detecting something on the surface as it nears it from underneath and turns genes on and off in response to change its characteristics, usually in a negative way in terms of yield.

Swanton says this molecular work arms him and others like CCAs with the basic science behind their recommendations, giving them more information to provide to farmers. At first, farmers would delay their first application of herbicide to wait for as many weeds as possible, but their research has helped show farmers that they should start clean and stay clean, so they don't lose yield. There are so many stresses farmers don't have control over, he adds, that controlling this one is an important step.

The Physiology of Fear

This research area's longer-term mission is to find ways to use this information to help plant breeders make crops more tolerant of these weed stresses. He points out that while there are many commercial crop varieties that are drought or insect tolerant,

there aren't any that are able to say they sustain more competition from weeds than others.

The irony of their results on free radicals, Swanton says, is that many herbicides have this same mode of action, showing that nature beat science to yet another important idea. Breeding plants to better withstand these assaults, quench the free radicals more efficiently, or just recover quicker would be beneficial and is where his work is currently headed.

"A crazy idea would be to get the crop to be able to do this kind of damage to the weeds, but that is far off," he adds. "Some of our next steps might be looking into the mitochondria and chlorophyll to see what is happening there. We are also looking at cover crops and how, down the road, we could help plants recognize them as siblings rather than weeds, which is a common issue if introduced during the critical period."

Swanton's philosophy about this process doesn't stop with plants. He sees a broad "physiology of fear" that governs all organisms' response to fear and stress. His research in plants reveals that plants really aren't that different from animals and humans.

"There is this connectivity with all of life," he explains. "I have a talk titled "Plant Competition and the Physiology of Fear" that highlights how what animals go through when they are stressed is what we humans go through and also what a stressed plant experiences. There's this continuity of life, and to me that's just fascinating."

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