Alberta Farmer Express

Dec. 19, 2016

Plants' secret chemistry could change the way you farm

Science is discovering plants produce their own pesticides and warn each other of threats — but tillage, spraying, and even breeding can disrupt these defences

By Jennifer Blair Af Staff / Medicine Hat

A war is being waged in your fields. Every day, your crops are fighting for their lives against insects, diseases, weeds, and weather. And their best line of defence isn't the chemicals we spray or the traits we breed into them. It's their sense of smell. "Anything that anybody has ever done to any plant causes that plant to produce a unique set of smells, like a fingerprint, and every time you wound a plant or infect it with something, it increases the production of these chemicals," said Jack Schultz, a plant scientist and leading expert on how plants use chemicals to defend themselves. Exploiting that chemical defence system could revolutionize crop production through a new approach that relies less on pesticides and more on natural processes, the University of Missouri professor said at the recent Farming Smarter conference. "If a plant is attacked on one of the young leaves on top, the entire plant changes its chemistry and becomes resistant," said Schultz. "If you damage one small leaf on a plant, pretty soon all the leaves within a certain distance of that leaf will start changing their chemistry and become better defended." Some of these chemicals are toxic to their enemies and act as frontline troops. The heat of a spicy pepper, the chill of a peppermint candy, the jolt you get from your morning cup of coffee or cigarette — plants create these 'defensive' chemicals to guard against pests, said Schultz. But that's only part of the story. Other chemicals emitted by the plant travel through the air and soil to act as 'messengers.' And these messengers not only tell a plant's various parts to ramp up their defences — they also give other plants in the field advance warning that a pest or a disease is coming their way so they can do the same. As well, beneficial insects can also 'eavesdrop' on these messages to track their prey. "Plants are doing these things not because it's entertaining, but rather, to protect themselves. It's an amazing trick," said Schultz. And it's a trick that Andy Kirschenman hopes to one day employ on his farm near Hilda, northeast of Medicine Hat. "It's something we don't think much about — the ability of plants to talk to themselves and to each other both through the soil and the air," said Kirschenman, who heard Schultz speak at the conference. "But I think there will be a day that comes where we will have products that make your plants talk to each other better and help the connection from plant to plant within the soil."

Plants fighting back

There's a number of ways producers are already doing that, said Schultz. "One application of this in agriculture is called 'push-pull agriculture,' which is doing very well in Africa on very small family farms," he said. "If you know which plants are attractive to beneficial insects and

you know which plants repel pest insects, you can manipulate the mix of plants to both attract good ones and repel bad ones." There are other applications as well. A damaged tobacco plant, for instance, will increase the production of nicotine — a powerful neurotoxin for insects. "That makes a tobacco plant more valuable because the pricing is based on nicotine content." Another example is brassicas, which produce chemicals that act as fumigants. "In fact, brassicas outperform methyl bromide (a broad-spectrum pesticide) in many situations because the chemicals that protect the brassicas from their enemies are excellent fumigants and excellent anti-fungal agents," said Schultz. But these defensive chemicals are mostly used today in greenhouses, he said. "If you flood a greenhouse with methyl salicylate (wintergreen oil), you'll increase the resistance to several pathogens that way," said Schultz. "Airborne stuff, however, is really hard to control outdoors. It's remarkable that plants influence each other at all given that the wind blows. So it's really hard to commercialize that."

Soil health and hardy plants

Still, with resistance on the rise, farmers are going to need new control methods for insects, weeds, and diseases, said Kirschenman. "Anything we do changes how plants react. I think we have to assume that what we do as humans in our crop protection choices has an impact on that," he said. "If we lose the natural plant defences and then, through overapplication, we lose our crop protection products, we're basically out of luck." But producers are already adjusting their production practices to boost plants' natural defences through crop rotations, no-till, and cover cropping — and "exploiting" those defensive chemicals is a logical next step in crop protection, he added. Kirschenman is doing all three to improve soil health on his 5,000- acre operation instead of "looking for a solution in a jug or in a bag or in a breeding technique." "Up until about 2004, we had never grown anything other than cereals and flax, along with summerfallow," he said. He now grows fall rye, flax, sunflowers, corn, durum, triticale, yellow peas, canola, and mustard. Longer rotations combined with no-till not only lowers disease and pest loads, but also builds soil structure. That's greatly reduced both water pooling and salinity that became problems when chem-fallow was employed on Kirschenman's farm. But by doing that, he's also making the plants' defensive chemicals work for him, said Schultz. For instance, when brassica leaves decompose, they release chemicals that have anti-fungal properties. "When plant litter enters the soil, it's carrying with it a chemistry that can modulate the activities of all of the organisms there," he said. "The mix of plants growing on a site turns into a mix of litters, which represents a mix of chemistry that then influences everything else that's going on in the soils. A healthy soil is rich in chemistry."

'Sitting ducks'

Healthy soils also make it easier for messenger chemicals to travel from one plant to another via the soil — something that is greatly disrupted by tillage. "There's a real underground connection going on here. If you break mycorrhizal connections, plants are not going to communicate with each other," said Schultz. "I'm not telling you that we know all the specific

outcomes. But don’t assume that you can do anything — including breaking connections with tilling — and expect things to operate normally.” Similarly, producers can also negate plants’ natural defence systems by spraying. Messenger chemicals can call in reinforcements in the form of beneficial insects when a plant is being attacked by harmful insects. But if a pesticide kills the beneficials, this advantage is lost. Even plant breeding can weaken plants’ natural defences, said Schultz, who argues that the relentless focus on yield has inadvertently bred out or reduced these mechanisms. “Breeding plants for such a heavy investment in productivity has deprived them of the ability to defend themselves, and what that does is commits you to pesticide use,” he said. “The reason we don’t have any choices is, in large part, because we have created plants that are sitting ducks. “There’s no free lunch.” That’s something that worries Kirschenman on his own farm. “Whatever we do to our fields affects our plants in positive and negative ways, and it also affects the growing soil we have underneath them in positive and negative ways,” he said. “Everything we do has consequences, and we have to take a hard look at that.”

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