SUSTAINABLE AGRICULTURE

Something in the air

Chemical control of insect pests is considered a necessary evil of modern intensive agricultural practices. New approaches exploiting chemical ecology and genetically modified plants as 'green factories' point the way to harvests that are less reliant on insecticides.

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Despite being responsible for feeding more than seven billion mouths, agriculture has an image problem. Modern farmers are often caricatured as having scant interest in the environment, despite their close relationship with nature. Yet food production in 2022 is a precarious business, from the war in Ukraine to the ever-more obvious effects of climate change and the continued aftershocks of the COVID-19 pandemic and associated worldwide economic downturn. One key component of growing crops is ensuring that they are not eaten by pests, and the global crop-protection industry effectively represents the last bastion between ourselves and hunger. This is exemplified by the current situation in Sri Lanka, where in 2021, the government banned all use of chemicals in agriculture and, as a consequence, harvests have failed and the hungry have rioted in the streets. But behind this ill-judged political decision is a wider acknowledgement that agriculture, although essential, needs to tread less heavily and be less dependent on chemical inputs such as fertilizers and pesticides, products which themselves are dependent on non-renewable petrochemicals for their synthesis. In an exciting departure from the current paradigm for modern crop protection, Hong-Lei Wang et al[1]. now report in *Nature Sustainability* how they use genetically engineered plants as 'green factories' to make insect-pest pheromones that disrupt the insect's ability to locate mates and reproduce.

Camelina sativa, here in a field, can be engineered to express precursors of pheromones used by common moth crop pests. Credit: Philip Robinson / Alamy Stock Photo.

Put bluntly, most approaches dealing with crop pests involve killing them. This includes insects, which might eat the plants and/or act as vectors for viral and other diseases. Enormous expense and effort go towards controlling insect pests in industrial agriculture's vast monocultures, leading to a range of troubling problems such as 'collateral damage' to non-pest insects, contamination of watercourses and the build-up of chemical residues in the ecosystem. None of these is desirable, but, until recently, they seemed to be tacitly accepted as part of the quid pro quo of ensuring that everyone gets their daily bread. However, shifts in public awareness of the environmental impact of agriculture have galvanized researchers into looking for new ways to protect our harvests.

The study by Wang et al. offers one way: engineering plants to contain DNA from other organisms — making them transgenic — to become factories for making the crop protectant. Many insects use volatile chemicals as behavioural cues to locate host plants or to identify mates. Chemical ecology approaches exploit these signals but have restricted utility due to the limited natural chemical repertoire of most plants. Taking advantage of modern plant biotechnology, Wang et al. engineered camelina, an oilseed crop related to canola, to accumulate precursors of the volatile chemicals that two important moth pests, diamondback and cotton bollworm, use as sex pheromones, which enable males to locate females for reproduction. This 'green factory'[2] approach produced sufficient amounts of the precursors for ready conversion and use in the field, to literally put the males off the scent. The use of sex pheromones in agriculture is not new[3], but, until now, synthesis of the volatile chemicals precluded their use in all but the most valuable production systems (such as almonds). The game-changing use of transgenic plant factories to grow the limiting compounds radically changes the economics, potentially reducing costs by several orders of magnitude and moving away from (environmentally harsh) direct chemical synthesis.

Wang et al. also took two critical steps to validate their innovation and to demonstrate that this was more than just some nice bioengineering. Firstly, they carried out field trials of their genetically modified (GM) camelina to show that the crop performs well in the 'real world' — vital if the technology is to be scaled up, yet sadly lacking in the vast majority of such research[4]. These field trials proved successful and sufficiently high yielding. Secondly, two formulations of these plant-derived volatile signals were tested for their ability to change the behaviour of male moth pests in the field, one as a lure attracting males and one disrupting the ability of males to localize these cues. Both demonstrations, carried out in China and Brazil, validated the promise of this approach. Excitingly, the precursor volume required is modest and, as the authors noted, can be cultivated under the US Department of Agriculture regulations that do not require the costly full approval of a transgenic crop. This study also confirms the wider potential of this green-factory approach. Wang et al. specifically focused on making one pheromone precursor, (*Z*)-11-hexadecenoic acid, but it would be straightforward to use analogous strategies to synthesize others to target a range of insect pests.

Economically, this approach will reduce substantially the cost of using volatile pheromones in agriculture and should encourage their wider use. Environmentally, reducing the routine spraying of crops with insecticides seems a net positive. Some open questions remain, such as around the ecological impact at the landscape scale of deploying pheromones that disrupt mating. Yet consider that while insecticides encourage the evolution of resistance, this is much less likely to happen with pheromones, as a mutation changing sex-pheromone preference would have a very low chance of spreading. And, as a final thought, it is worth remembering that GM agriculture is now a well-established part of the global food chain, with 190 million hectares of transgenic crops being safely produced by this technology in 2019 alone[5]. This innovation of a green pheromone factory could usher in a new wave of low-volume, high-value transgenic crops that deliver value to the farmer, reduce the environmental footprint of agriculture and contribute to a new form of GM-enabled agroecology. ❐

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Published online: 1 September 2022
https://doi.org/10.1038/s41893-022-00954-0

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Competing interests

The author declares no competing interests.