Combating Pests with a New Class of RNA-Based Pesticides

Our agricultural system is facing tremendous challenges in sustainably meeting the food demands of the growing world population. An evaluation of the crop protection sector found that the total cost of using chemical pesticides — including regulatory, human health, environmental, and exposure-prevention costs — exceeds $39.5 billion per year in the U.S. *(1)*.

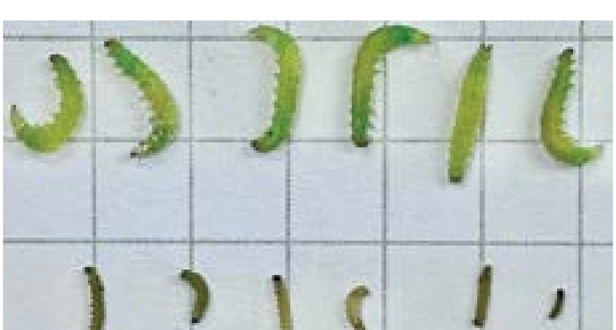
One approach to decreasing the use of chemical pesticides and their societal impacts is to use safer alternatives such as biopesticides. Biopesticides include naturally occurring substances and microbes that control pests, as well as substances produced by genetically modified plants. While microbial pesticides are the most popular sprayable biopesticide, they are currently in an early stage of market introduction, with less than 1% of the overall sprayable pesticide market.

Another type of sprayable biopesticide is based on double stranded ribonucleic acid (dsRNA). These pesticides function by preventing pests from producing proteins that are essential to their survival. Their selectivity toward the target pests makes them safer than chemical pesticides. However, because very few pests are susceptible to dsRNA, dsRNA-based pesticides have not been commercialized. For dsRNA-based pesticides to become viable alternatives to chemical pesticides, they would need to be effective against a wide range of pests.

The efficacy of dsRNA-based pesticides is limited by two characteristics. First, dsRNA is readily degraded by ubiquitous enzymes present in the field (crops and soil) and in the target pests. Second, dsRNA is hydrophilic and thus has limited ability to cross biological membranes in the targeted pests.

Researchers at NanoSUR, a Florida-based start-up funded by the National Science Foundation (NSF), have recently developed a new class of dsRNA materials with improved delivery to their targets and costs compatible with large-scale application.

This new technology was developed by chemically modifying previously assembled dsRNA in a manner that does not interfere with its ability to act as a pesticide. By carefully selecting a lipophilic chemical modifier and varying the extent of modification of the dsRNA, the researchers created novel, more stable materials with greater affinity for cell membranes, longer half-life in the insect mid-gut, greater stability in plants, and higher efficacy than unmodified dsRNA. Thus, NanoSUR's modified dsRNA, which they call MdsRNA, are more efficacious and can be used to control more pests than unmodified dsRNA.



◀ Typical diamondback moth larvae, raised on cabbage leaves, seven days after hatching. In the top row, most of the larvae provided with untreated leaves are alive and healthy. Most of the larvae provided with leaves sprayed with MdsRNA died, and those that survived, pictured in the bottom row, are stunted. The sides of the squares in the background measure 5 mm.

NanoSUR's first product, D-BACKSTOP, targets the diamondback moth (DBM), which feeds on Brassicas such as cabbage, canola, and kale. DBM is the costliest invasive worldwide pest. It belongs to a class of pests insensitive to dsRNA; however, it has been found to be susceptible to MdsRNA in greenhouse testing, as shown in the figure. It will be tested for efficacy on cabbage field plots in November 2021.

NanoSUR is also working with the National Institute of Food and Agriculture to develop MdsRNA for controlling two of the most difficult-to-control pests in the U.S.: the European gypsy moth and the red imported fire ant. MdsRNA technology could be adapted to counter a wide variety of unwanted moths (lepidopterans), aphids and stinkbugs (hemipterans), and beetles (coleopterans).

The use of NanoSUR's MdsRNA for crop protection has attracted the interest of large agricultural companies. Corey Huck, Global Head of Biologics at Syngenta, says, "We view the development of RNA-based biocontrol solutions as an exciting opportunity to deliver solutions which target key pest species specifically. Syngenta will explore options to work with NanoSUR in this area." Large agricultural companies also know that the potential for sprayable dsRNA extends to eliciting desirable plant traits (*e.g.,* drought resistance) without having to resort to their genetic modification. CEP

1. Bourguet, D., and T. Guillemaud, "The Hidden and External Costs of Pesticide Use," in "Sustainable Agriculture Reviews," Springer International Publishing, pp. 35–120 (2016).

This technology was funded through the NSF Small Business Innovation Research Program.

This article was prepared by the National Science Foundation in partnership with *CEP*.