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RNAi-Based Pesticides: A New Tool in the IPM Toolbox

Daniel Frank – Director, VTPP

A molecular technique that turns off (silences) genes within an organism's cells is being evaluated as a powerful new tool for managing pests. This process of silencing genes can be accomplished through a process called RNA interference or RNAi. So, what is RNAi, and how exactly can it be used for pest management? Before answering these questions, you must first understand the connection between DNA and proteins.

DNA is the molecule that contains all the information needed to build and maintain an organism. More specifically, genes (sections of a DNA molecule) provide the information necessary to build specific protein molecules that carry out the various functions of a cell. However, a gene does not build a protein directly. The bridge between DNA and protein synthesis is RNA. In the simplest sense, RNA molecules convert the information stored in DNA into proteins. There are many types of RNA molecules involved in protein synthesis, and each performs a specific function. The role of RNAi is to suppress (or turn off) the production of specific proteins when they are no longer needed within a cell. RNAi can also remove foreign RNA molecules that may have been inserted by an invading organism, such as a virus.

By exploiting the RNAi pathway, scientists can target and remove specific RNA sequences before they can be used to make a protein. Thus, RNAi technology can potentially be used to silence a gene's activity that is essential for the growth, development, or reproduction of a particular pest species. There are many potential advantages of using RNAi technology in pest management. One of the most important benefits, is the ability to selectively target the RNA of a specific pest species without harming nontarget species in the environment. RNAi can be delivered as a pesticide, such as in a formulated spray, or through genetic engineering of transgenic plants, similar to *Bacillus thuringiensis* (*Bt*) crops.

In 2017, the Environmental Protection Agency (EPA) registered SmartStax® PRO,

the first commercial RNAi-based pesticide product. SmartStax® PRO is a genetically modified corn seed that targets the western corn rootworm (*Diabrotica v. virgifera*). The first sprayable RNAi-based pesticide, Ledprona, targets the Colorado potato beetle (*Leptinotarsa decemlineata*) and is currently undergoing EPA review. As the cost of manufacturing RNA has fallen (in part because of the research involved with making mRNA for COVID-19 vaccines), RNAi-based pesticides are increasingly being investigated for control of other important arthropod pests, such as the varroa mite (*Varroa destructor*), diamondback moth (*Plutella xylostella*), cotton bollworm (*Helicoverpa armigera*), Aedes mosquitoes, and various aphid species (among others). RNAi technology is also being used to develop plant varieties resistant to viruses, such as cucumber and tobacco mosaic virus and tomato spotted wilt virus. RNAi is even being considered as a tool to combat herbicide-resistant weeds, fungal plant pathogens, and nematode pests.

Although RNAi has many potential benefits, it is important to realize that it will not be a "silver bullet" for pest control. The possibility of resistance to RNAi technology has already been established in laboratory scenarios. Like traditional pesticides, RNAi-based products will need to be implemented as part of an integrated pest management (IPM) program to prolong their effectiveness. Nevertheless, RNAi-based pesticides have the potential to become an important new tool in the IPM toolbox.

Spray Nozzle Selection **(Part 2 of a 2-part series)**

Kathleen Miller – Extension Associate

This article is the second installment of a two-part series on spray nozzle selection. For information on the components and function of a spray nozzle, as well as the importance of proper nozzle selection, refer to part 1 of the series in the Summer 2023 edition of this newsletter.

Choosing the Correct Nozzle for the Job

Nozzle selection is one of the most important decisions you will make when planning a pesticide application. The type of nozzle you choose can affect not only the amount of spray applied, but also the size and pattern of spray droplets, uniformity of the applied spray, coverage over the sprayed surface, and spray drift potential. When deciding which nozzle to use, always look to the pesticide label first for any specific instructions or recommendations.

Nozzles are classified based on the spray pattern and droplet size they produce. There are a variety of nozzle types. Each type differs in construction to better execute a specific application type, such as broadcast, banding, or spot treatment. Broadcast applications distribute the pesticide uniformly to a large area. Banding applications occur in strips, as opposed to uniformly applying the pesticide across the entire area. Spot treatments apply the pesticide to a small, precise area. The droplet size produced by a nozzle at a given pressure can also influence application coverage. Droplet size categories range from "extremely fine"to "ultra coarse" and are based on the median droplet size produced. Contact pesticide products require greater coverage, which can be achieved with smaller droplets. Systemic pesticide products are less reliant on complete coverage and work well with coarser droplets. It is important to remember that smaller droplets are more likely to drift off target than larger droplets.

Two common types of nozzles used for ground application of pesticides are the fan and cone nozzles (fig. 1). Standard flat fan nozzles, typically used for broadcast application of a pesticide, produce a narrow oval spray pattern with tapered edges. Even flat fan nozzles, typically used for banded applications, create a pattern with uniform coverage across the entire width of the spray pattern. The two common styles of cone nozzles are the solid-cone and hollow-cone. Hollow-cone nozzles create a round, ring shape in which the spray liquid is concentrated on the outer edge of the ring. Solid-cone nozzles generally produce coarser droplets delivered to the entire area of the sprayed circle. Both hollow- and solid-cone nozzles are used primarily when plant foliage penetration is essential and when drift is not a major concern.

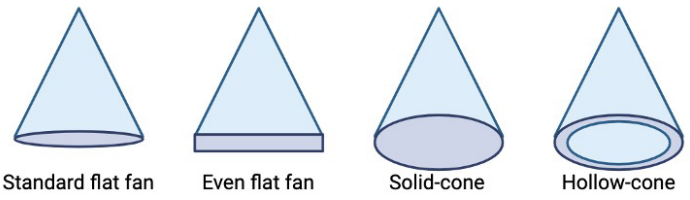

Figure 1. Four common types of nozzles used for pesticide application are the standard flat fan, even flat fan, solid-cone, and hollow-cone.

Determining Nozzle Orifice Size

After choosing which nozzle type to use for an application, the nozzle orifice size must be determined. This is a two-step process:

1. Calculate the nozzle flow rate in gallons per minute (GPM).
2. Use a nozzle manufacturing catalog to determine the nozzle orifice size that best suits your application.

Calculating GPM. To determine the nozzle flow rate in gallons per minute (GPM), use the 5940 Method (equation below). The spray volume in gallons per acre (GPA) for an application can often be found on the pesticide product label. 'W' (width of sprayed area per nozzle) can be determined by measuring the spacing between two nozzles or the spray width of one nozzle, measured in inches. The speed in miles per hour (MPH) for a particular application also contributes to the application rate. Plug each of these values into the 5940 equation to solve for GPM. (Note: You can adjust pressure and speed to make minor changes in application rate. If major changes are needed, you must use a nozzle with a different orifice size.)

5940 Method:

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

Using a nozzle manufacturing catalog. Once GPM has been calculated, use a nozzle manufacturer's catalog to determine the nozzle orifice size best suited to your application. First, find the table for the nozzle type you are using. Then use the GPA, sprayer pressure (in pounds per square inch [PSI]), MPH, and W of your application to narrow down the nozzle orifice size options with the GPM closest to what was calculated using the 5940 Method.

Example. You want to apply an herbicide as a ground broadcast application at or below 40 PSI, at a spray volume at or above 15 GPA, and at a speed of 5 MPH. The nozzle spacing is 20 inches.

You have decided to use a standard flat fan nozzle to make this broadcast application. To determine nozzle orifice size, first calculate the required GPM:

$$GPM = \frac{GPA \times MPH \times W}{5940} = \frac{15 \times 5 \times 20}{5940} = 0.25$$

Next, consult a nozzle manufacturer's catalog. For example, we can narrow down nozzle orifice size choices that best suit the scenario using the table found on page 14 of the TeeJet Technologies Catalog 51A. According to the catalog (fig. 2), TP6503 is the nozzle best suited for this specific application. If the label or site/environmental conditions require a nozzle that produces a larger droplet size, you would need to change one or more of the variables listed in the 5940 equation to increase the flow rate (i.e., GPM).

Additional Resources

- TeeJet Technologies Catalog 51A (https://www.teejet.com/literature/catalogs-and-bulletins).

	PSI	DROP SIZE		CAPACITY ONE NOZZLE IN GPM	CAPACITY ONE NOZZLE IN OZ./MIN.	20" GPA								GALLONS PER 1000 SQ. FT.			
		80°	110°			4 MPH	5 MPH	6 MPH	8 MPH	10 MPH	12 MPH	15 MPH	20 MPH	2 MPH	3 MPH	4 MPH	5 MPH
TP650050†	30			0.043	5.5	3.2	2.6	2.1	1.6	1.3	1.1	0.85	0.64	0.15	0.10	0.07	0.06
TP800050†	35			0.047	6.0	3.5	2.8	2.3	1.7	1.4	1.2	0.93	0.70	0.16	0.11	0.08	0.06
TP1100050†	40			0.050	6.4	3.7	3.0	2.5	1.9	1.5	1.2	0.99	0.74	0.17	0.11	0.09	0.07
(100)	50			0.056	7.2	4.2	3.3	2.8	2.1	1.7	1.4	1.1	0.83	0.19	0.13	0.10	0.08
	60			0.061	7.8	4.5	3.6	3.0	2.3	1.8	1.5	1.2	0.91	0.21	0.14	0.10	0.08
TP650067†	30			0.058	7.4	4.3	3.4	2.9	2.2	1.7	1.4	1.1	0.86	0.20	0.13	0.10	0.08
TP800067†	35			0.063	8.1	4.7	3.7	3.1	2.3	1.9	1.6	1.2	0.94	0.21	0.14	0.11	0.09
TP1100067†	40			0.067	8.6	5.0	4.0	3.3	2.5	2.0	1.7	1.3	0.99	0.23	0.15	0.11	0.09
(100)	50			0.075	9.6	5.6	4.5	3.7	2.8	2.2	1.9	1.5	1.1	0.26	0.17	0.13	0.10
	60			0.082	10	6.1	4.9	4.1	3.0	2.4	2.0	1.6	1.2	0.28	0.19	0.14	0.11
TP6501†	30	F	F	0.087	11	6.5	5.2	4.3	3.2	2.6	2.2	1.7	1.3	0.30	0.20	0.15	0.12
TP8001	35	F	F	0.094	12	7.0	5.6	4.7	3.5	2.8	2.3	1.9	1.4	0.32	0.21	0.16	0.13
TP11001	40	F	F	0.10	13	7.4	5.9	5.0	3.7	3.0	2.5	2.0	1.5	0.34	0.23	0.17	0.14
(100)	50	F	F	0.11	14	8.2	6.5	5.4	4.1	3.3	2.7	2.2	1.6	0.37	0.25	0.19	0.15
	60	F	VF	0.12	15	8.9	7.1	5.9	4.5	3.6	3.0	2.4	1.8	0.41	0.27	0.20	0.16
TP65015†	30	F	F	0.13	17	9.7	7.7	6.4	4.8	3.9	3.2	2.6	1.9	0.44	0.29	0.22	0.18
TP80015	35	F	F	0.14	18	10.4	8.3	6.9	5.2	4.2	3.5	2.8	2.1	0.48	0.32	0.24	0.19
TP110015	40	F	F	0.15	19	11.1	8.9	7.4	5.6	4.5	3.7	3.0	2.2	0.51	0.34	0.26	0.20
(100)	50	F	F	0.17	22	12.6	10.1	8.4	6.3	5.0	4.2	3.4	2.5	0.58	0.39	0.29	0.23
	60	F	F	0.18	23	13.4	10.7	8.9	6.7	5.3	4.5	3.6	2.7	0.61	0.41	0.31	0.24
TP6502†	30	F	F	0.17	22	12.6	10.1	8.4	6.3	5.0	4.2	3.4	2.5	0.58	0.39	0.29	0.23
TP8002	35	F	F	0.19	24	14.1	11.3	9.4	7.1	5.6	4.7	3.8	2.8	0.65	0.43	0.32	0.26
TP11002	40	F	F	0.20	26	14.9	11.9	9.9	7.4	5.9	5.0	4.0	3.0	0.68	0.45	0.34	0.27
(50)	50	F	F	0.22	28	16.3	13.1	10.9	8.2	6.5	5.4	4.4	3.3	0.75	0.50	0.37	0.30
	60	F	F	0.24	31	17.8	14.3	11.9	8.9	7.1	5.9	4.8	3.6	0.82	0.54	0.41	0.33
TP6503†	30	F	F	0.26	33	19.3	15.4	12.9	9.7	7.7	6.4	5.1	3.9	0.88	0.59	0.44	0.35
TP8003	35	F	F	0.28	36	21	16.6	13.9	10.4	8.3	6.9	5.5	4.2	0.95	0.63	0.48	0.38
TP11003	40	F	F	0.30	38	22	17.8	14.9	11.1	8.9	7.4	5.9	4.5	1.0	0.68	0.51	0.41
(50)	50	F	F	0.34	44	25	20	16.8	12.6	10.1	8.4	6.7	5.0	1.2	0.77	0.58	0.46
	60	F	F	0.37	47	27	22	18.3	13.7	11.0	9.2	7.3	5.5	1.3	0.84	0.63	0.50
TP6504†	30	M	M	0.35	45	26	21	17.3	13.0	10.4	8.7	6.9	5.2	1.2	0.79	0.60	0.48
TP8004	35	M	M	0.37	47	27	22	18.3	13.7	11.0	9.2	7.3	5.5	1.3	0.84	0.63	0.50
TP11004	40	M	M	0.40	51	30	24	19.8	14.9	11.9	9.9	7.9	5.9	1.4	0.91	0.68	0.54
(50)	50	F	F	0.45	58	33	27	22	16.7	13.4	11.1	8.9	6.7	1.5	1.0	0.77	0.61
	60	F	F	0.49	63	36	29	24	18.2	14.6	12.1	9.7	7.3	1.7	1.1	0.83	0.67

Figure 2. Using a nozzle manufacturer's catalog, you can narrow down which nozzle orifice size to use by finding the GPA, PSI, MPH, and W that best suit your specific application. (Nozzle data chart taken from TeeJet Technologies Catalog 51A).

Blast From the Past

Stephanie Blevins Wycoff – Extension Associate

Fig. 195.—The Jamain capsule.

Figure 3. The Jamain Capsule, circa 1880s.

Jamain Capsule

The Jamain Capsule was a pest management tool developed to control grape phylloxera in the 1880s (Marlatt, 1889). Grape phylloxera is an important insect pest of *Vitis vinifera* grape and can be particularly devastating to vines when it infests the root system. As this insect spread through Europe, the Jamain Capsule became an important control tool for French grape growers. The capsule (fig. 3) was made of gelatin and designed to be inserted into the ground where it slowly released a bisulphide insecticide around the root system of the vines. As you can see in figure 4, the applicator used a handheld injector to insert the capsule at the base of each grapevine.

Fig. 197.—Method of inserting the Jamain capsule.

Figure 4. An applicator inserting Jamain Capsules at the base of grapevines.

Reference

Marlatt, C. L. (1889). Useful and injurious insects. In C. V. Riley (Ed.), *Reports of the United States commissioners to the universal exposition of 1889 at Paris: Agriculture* (pp. 427-459). Washington Government Printing Office.

VTPP Program Updates

Private Applicator Recertification Course Approval

As the Private Applicator Recertification (PAR) season approaches, here are some reminders about how to plan and host a successful PAR course. This article summarizes "Steps to Hold a Successful Private Pesticide Applicator Recertification (PAR) Course: A Behind the Scenes Look at Rachel and Jackie's Roles" — a handout from PSEW 2023.

Before the Course

- Plan out your course. Course length should be a MINIMUM of 2.5 hours. Course content must include three components, each with a minimum of 45 minutes of instruction.
  - Legal Update: 45 minutes. Contact a Pesticide Investigator in advance to deliver the Legal Update.
  - Pest Management and Application Technology: 45 minutes.
  - Pesticide Safety: 45 minutes. DO NOT DOUBLE COUNT CONTENT – mentioning safety during the Legal Update or a Pest Management and Application Technology talk does not count. You need to have 45 minutes dedicated to the topic of pesticide safety.
- Secure a location(s) and date(s) for your course, and confirm with guest speakers and the investigator(s). Submit a PAR Course Credit Request form using the QR code or link in figure 5. You can bypass much of the form if you upload an agenda or brochure for your course! If you have not heard back from Rachel Parson within one week of submitting the form, contact Rachel Parson and Jackie Brown (rparson@vt.edu, jbrown06@vt.edu).

- Print copies of the Course Roster, Application for Recertification Credit, Course Evaluation, and Applicator Change of Information form. Be sure to have more than enough copies for your estimated attendence. DO NOT USE OLD PAPERWORK FROM PREVIOUS YEARS. Print on light-colored paper.

Day of the Course

- Bring black ink pens to give to the attendees when they fill out any course paperwork.
- At the start of the course, have attendees fill out the Course Roster.
- At the end of the course, have each attendee fill out an Application for Recertification Credit, Course Evaluation, and, if needed, an Applicator Change of Information form. Make sure they include their signature on the credit application and change of information forms.

Figure 5. PAR Course Credit Request form: https://vce.az1.qualtrics.com/jfe/form/SV_3T-L5I8GSkowSFls

After the Course

- Organize the Applications for Recertification Credit in the order that attendees signed the Course Roster. Double check that each form has been filled out and signed. If an applicator attended the entire recertification but did not sign in, you can write their name on the Course Roster. Cross out the name(s) of anyone who left early (do NOT use white out). If an Application for Recertification Credit form or signature is missing, contact the applicator to obtain the completed document. You may NOT sign the application form for them. Their friends, family, or coworkers may NOT sign for them either.
- Make a copy of the Course Roster, Applications for Recertification Credit, and any Applicator Change of Information forms for your records.
- Mail the original Course Roster, Applications for Recertification Credit, and Course Evaluations to: Rachel Parson, 302 Agnew Hall, 460 West Campus Dr. Blacksburg, VA 24061.
- Email Rachel Parson and Jackie Brown or call the VTPP office (540-250-6543) to let us know the forms are in the mail. Do not staple the originals together.
- Mail the original Applicator Change of Information forms to: VDACS-OPS, P.O. Box 1163, Richmond, VA 23218.

2023-24 Online Private Applicator Recertification Course

For the 2023-24 private applicator recertification (PAR) season, VTPP will be managing a PAR online course for interested Virginia private pesticide applicators. The 2023-24 PAR online course will give private pesticide applicators full credit in Categories 90 and 91 if completed. Each user enrolling in the course must have their own unique email address. Recertification credits can only be provided to a single individual registered under that email address (only one registrant per email address). Access to the course will be given through an emailed VCE Canvas guest account invitation following registration and confirmation of enrollment.

The PAR online course enrollment information is as follows:

- Link: tinyurl.com/VCE-VTPP-PAR-90-91 (same as last year).
- Email Jackie Brown if you would like a QR code for the enrollment link.
- Title: VTPP-PAR-01-2023 Online Private Pesticide Applicator Recertification.
- Cost: $30.
- Enrollment period: Oct. 1, 2023 - Feb. 25, 2024.
- Deadline to complete the course: Feb. 29, 2024.

Applicators with certificates that expire on Dec. 31, 2023, must retest if they do not complete a recertification course before March 1, 2024. No extensions will be given.

The public can find the registration information at register.ext.vt.edu/ by searching under “Programs,” and then under “Agriculture” or “Natural Resources” or by using specific keywords (e.g., pesticide, applicator, private, recertification, PAR, private applicator, VTPP, Category 90, or Category 91). For guest account issues, please contact Traci McCoy (tsmccoy@vt.edu) and copy Stephanie Collins (collinss@vt.edu) and Patty Taylor (ptaylor1@vt.edu). For questions about course content, please contact Rachel Parson.