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Insecticidal Genes

Part 2: Human Health Hoopla

Dr. Allan S. Felsot, Environmental Toxicologist, WSU

Whom Do You Trust?

Transgenic crops have been good for publishers of both print and internet media. Websites have proliferated touting the various "truths" about genetically modified crops, ranging the gamut from safety and benefits to lurking catastrophe. Printed books proclaim fearful postures with titles like *Against the Grain: Biotechnology and the Corporate Takeover of Your Food* (5) and *Genetically Engineered Food: Changing the Nature of Nature* (subtitled *What You Need to Know to Protect Yourself, Your Family, and Our Planet)* (14). Forwards penned by crusaders like Ralph Nader destine these books for the best-seller list. But should the man who told us not to buy the rear engine-mounted Corvair be trusted about the dangers of biotechnology?

Therein lies a big problem. Who and what information do we trust to decide whether transgenic technology is safe? The books mentioned above (which were actually copyrighted by environmental advocacy groups), as well as the Greenpeace website (4) are obviously against genetic engineering of food. But they do raise the following legitimate concerns about the short- and long-term safety of transgenic crops:

❶ Possible production of allergenic or toxic proteins not native to the crop

❷ Adverse effects on non-target organisms, especially pollinators and biological control organisms

❸ Loss of biodiversity

❹ Genetic pollution (unwanted transfer of genes to other species)

❺ Development of pest resistance

❻ Global concentration of economic power and food production

❼ Lack of "right-to-know" (i.e., a desire for labeling transgenic foods)

Legitimate Concerns, Testable Hypotheses

Greenpeace et al. argue that these concerns were not addressed prior to commercializing and planting millions of acres of transgenic crops, or, as the Euro-

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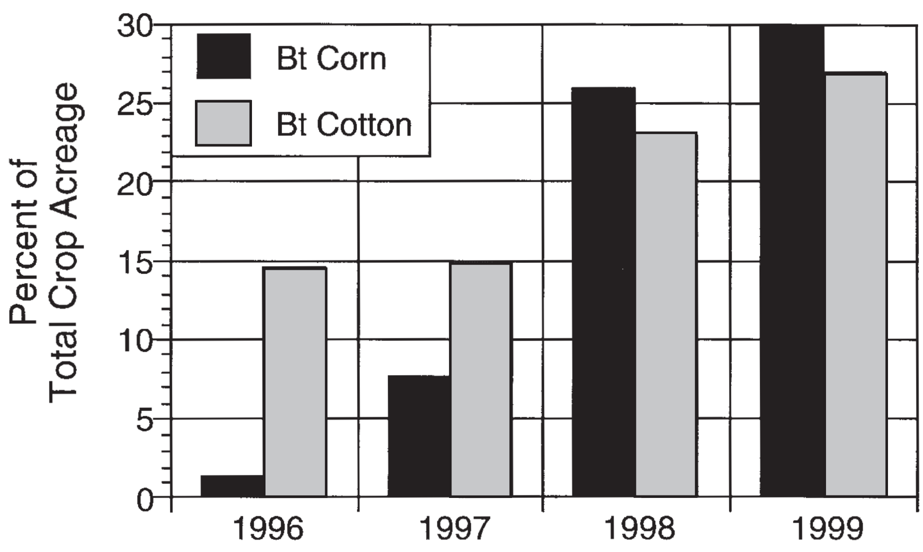
peans call them, GMOs (genetically modified organisms). But based on the acreage of Bt transgenic corn and cotton planted in the United States (Figure 1), we and our livestock have already been exposed to transgenic crops for at least four years, apparently without any health problems. Are we all just guinea pigs? Or has the safety information been available all along, but not accessed by those concerned?

FIGURE 1
Use of Bt transgenic corn and cotton in the U.S. (15)



I can understand why many feel uncomfortable with GMOs. The study of genetics in high school biology classes was not a particularly pleasant experience. If you haven't followed the transformation of high school genetics into college biology and beyond to molecular biology, then transgenic technology will seem simultaneously new, miraculous, and overwhelmingly mysterious. The arcane jargon of molecular biologists makes their tricks of trade inaccessible to all but ardent practitioners. Thus, genetic engineering seems remote and untested. Yet for over twenty-five years we have had the capability to move genes from one species to another. Such feats grew in parallel with our understanding of how to map gene locations on the chromosomes.

Nevertheless, the concerns posed by environmental advocacy groups are legitimate. To address the validity of these concerns, we must separate what is testable and what is sociological. In this essay I address the question of whether Bt proteins can be toxic to humans and whether they can pose risks of allergic reactions.

Something Old, Something New, Something Borrowed

Bt transgenic crops are considered "plant pesticides," and they are subjected to the same battery of tests given to old and new chemical pesticides. Perhaps on the surface, it looks as though the U.S. Environmental Protection Agency (EPA) gave the major transgenics producers the green light to commercialize their seed lines with just a cursory critique. But, in fact, the risk assessment process was expedited by the nearly forty years of positive experiences with commercial Bt sprays.

The place to start with questions about the safety of Bt transgenic crops is with Bt itself. Bt is one of many microbial pesticides. Its formulated fermentation cultures can be sprayed on foliage to control selected insects because the ubiquitous bacterium synthesizes a toxic protein, known as the delta-endotoxin, every time it stops growing and produces a spore. In 1998, the EPA compiled many years of collected data into a re-registration eligibility decision document (RED) that covers all Bt products not produced by genetic engineering (17). The data overwhelmingly supported the safety of Bt to humans and nontarget organisms. Certain Bt spray formulations are among the few insecticides certified for organic agriculture (19).

Over twenty years ago, scientists began to discover numerous strains of Bt that were toxic to different spectra of insects. More than fifteen years ago,

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molecular biologists began to identify the genes coding for the various insecticidal proteins characteristic of the individual Bt strains. Eventually they successfully moved these genes across species lines and into production crops.

The insecticidal gene the molecular biologists moved into corn, cotton, or potatoes is actually a truncated version of the natural gene. For the gene to function in plant cells, small snippets of DNA are attached that allow the code to be read. To track the location of the gene and help select plant cells that have successfully incorporated the gene into their chromosome, marker genes encoding for either antibiotic or herbicide resistance are also spliced onto the toxic protein gene. The plant cells, however, do not activate the antibiotic markers. The herbicide resistance gene specifically confers protection to a naturally occurring bacterial amino acid called phosphinothricin, which is the active ingredient of the commercial herbicide glufosinate.

Are Bt Transgenic Crops Toxic to Humans?

We have known for a long time that the insecticidal proteins produced by the various strains of Bt are toxic only to comparatively few species of insects by virtue of the coincidence of the insects specialized gut physiology and shape of the proteins themselves. All other organisms, lacking these unique factors, tolerate Bt exposure without exhibiting symptoms of injury. Indeed, high doses of Bt that are fed, injected, or placed in the air of laboratory rats are essentially non-toxic. Similarly, feeding rats high doses of any of the purified insecticidal proteins causes no measurable toxic effects (Table 1). For comparison, the table shows how common substances around the house (table salt, caffeine, vitamin A, and the lawn herbicide 2,4-D) could cause illness at much lower doses than Bt proteins.

Controversy surrounds the potential for *non-protein* chemicals to cause adverse effects after long-term (i.e., chronic) daily exposure. However, when *proteins* are toxic, the effect is immediate (acute), never cumulative (chronic) (11).

Despite the good news shown in Table 1, it might be argued that Bt sprays do not leave as much insecticidal protein as is present in a transgenic plant, in which every tissue makes large quantities of the protein. Dose makes the poison, so how do we know that we just haven't fed the rats enough protein to cause an effect? To answer this question, we need to know how much protein we might be exposed to if eating food made from transgenic corn.

Fortunately, the amounts of Bt protein in various tissues of transgenic corn plants throughout the growing season have been measured and reported to the EPA (16).

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TABLE 1
No Observable Effect Level for mortality following exposure of rats to purified Bt toxic protein[1/]

Registered Transgene	Registrant	NOEL (mg/kg)	Digestibility
Bt CryIA(b)	Monsanto	>4000	rapidly degraded
Bt CryIA(b)	Novartis	>3280	rapidly degraded
Bt CryIA(c)	Dekalb	>5000	rapidly degraded
Bt Cry9C	AgrEvo	>3760	stable
Bt spray	several	>5050	degraded
table salt		3750[2/]	
caffeine		25	
vitamin A		4.3[3/]	
2,4-D		1	

[1/]All information from the EPA Biopesticide Safety Sheets (16)
[2/]LD_{50} for oral exposure of rats
[3/]Level of exposure causing adverse effects

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The levels of Bt protein in currently registered transgenic corn hybrids range from non-detectable quantities (<0.005 micrograms per gram of plant tissue, µg/g) to 4 µg/g. (Table 2. Note that, contrary to popular perception, different tissues do not express the same amount of protein. For these calculations we are referring to the edible component, the grain.) Using the highest amount of protein present in grain, we can calculate the amount of popcorn needed to be consumed by a human two-year-old child to reach the highest doses fed to rats. To reach a human-equivalent dose of 5000 milligrams of Bt protein per kilogram of rat body weight (mg/kg), a child would have to eat 27.5 pounds of popcorn. Assuming every new video release is equivalent to one pound of popcorn, even a movie critic can't see that many movies in a day. In other words, the EPA justifiably declared the risk of a toxic reaction from Bt proteins as essentially nil.

TABLE 2
Concentration of protein (microgram per gram of wet plant tissue) in various corn tissues and estimated grams of protein per acre of corn

Registered Transgene	µg protein per gram of wet plant tissue					Grams of insecticidal protein per acre
	Whole Plant	Leaf	Roots	Pollen	Grain	
Bt CryIA(b)	3.65-4.65	7.93-10.34	NA	0.09	0.18-0.39	16.4-20.9
Bt CryIA(b)	0.6	4.4	<0.008[1/]	7.1	<0.005[1/]	2.7
Bt CryIA(c)[2/]	0.22	0.10-0.26	0.03	NA	0.01	1.5
Bt Cry9C[2/]	4.7	9.5	5.6	0.1	4.0	21.3
Bt spray[3/]	NA	NA	NA	NA	NA	14

[1/]Limit of detection for the Novartis transgene protein was roots, 0.008µg per gram tissue and grain, 0.005µg/g.
[2/]In the RED the data were expressed per unit of dry tissue weight; all values were adjusted to wet weight using a median wet weight transformation factor of 0.215 published for sweet corn (18).
[3/]Assumed a maximum rate of spray application of 0.81 kg/acre with a formulation containing 1.7% delta-endotoxin (1).
[4/]Data not available.

Is the Bt Protein Allergenic to Humans?

I found a very scary website the other day published by a group called STOP (Society Targeting Overuse of Pesticides) (13). In a four part "exposé" they used a combination of physician anecdotes, testimonials, and out-of-context statements from toxicology studies to paint a very alarming picture of Bt sprays, despite overwhelming evidence of the safe use of Bt sprays for over forty years (remember—it's certified organic). STOP does, however, raise an important issue of whether some individuals are uniquely sensitive. Allergic reactions to proteins are not uncommon, but allergy has a well-defined etiology (i.e., biochemical cause) that is quite distinct from toxicity .

It is clear from my interpretation of the STOP anecdotes, that reports of illness following woodland sprayings of Bt products have not been clinically confirmed as toxicity, but could conceivably enter the realm of allergic reaction. (It is important to note that, because Bt sprays are formulated with other non-insecticidal ingredients [officially known as inerts] to ease their delivery, adverse reactions are not necessarily a result of the Bt protein itself.)

A number of food proteins are definitively associated with allergenic reactions. Fortunately, we know quite a bit about the biochemical events associated with allergic reactions, as well as the kinds of proteins that cause problems (6). First, an allergic response should be distinguished from toxicity. Toxicity is the cascade of reactions resulting from exposure to a dose of chemical sufficient to cause direct cellular or

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tissue injury or otherwise inhibit normal physiological processes. Allergic responses are immune system reactions resulting from stimulation of a specific group of antibodies known as IgE.

Many food allergens are proteins that are fairly stable to digestion or only partially broken down (6). The protein or its fragments migrate across the intestinal wall and stimulate immune cells known as lymphoctyes. Lymphocytes stimulate the production of the IgE antibodies that are specific for each allergen (which is also known as an antigen). Eventually, subsequent exposures to the antigens lead to release of biochemicals known as histamines and prostaglandins. These chemicals, in an effort to protect the body, cause smooth muscle contractions (for example, the gut walls), dilation of blood vessels, and constriction of the lung bronchia. Such effects manifest as the typical allergic symptoms of respiratory distress, running nose and stuffiness, swelling, and skin rashes.

If Bt proteins are not toxic, could they be allergenic? Tests can help determine this.

One way to determine whether food proteins are allergenic is to determine their digestibility using mixtures that simulate the environment of the stomach with its acid pH and enzymes. If a protein is unstable in this environment after a short contact time, then it has no potential for allergenicity. Food allergens are almost always proteins, and one common characteristic among them is their stability to digestion, as well as to heat (as in cooking) (6). Furthermore, the amino acid sequence of allergenic food proteins have been mapped out, and suspected allergens can be compared for similarities in structure. Finally, many protein allergens have a sugar molecule attached to them while they are partially transformed in a reaction known as glycosylation.

Most Bt proteins degrade rapidly in the stomach; while allergens are stable to digestion.

With the exception of the cry9C-containing hybrid of corn, all transgenic Bt proteins are rapidly degraded by the stomach environment and are unstable when heated (Table 1). The cry9C protein is stable to simulated stomach conditions, but it is not glycosylated and has not caused any adverse effects characteristic of immune system responses in mammalian studies. Furthermore, no part of its structure resembles known allergenic proteins.

Immune System Responses to Bt Sprays Exonerate Transgenic Bt Proteins

A recently published study showed that farm workers who picked vegetables that were sprayed with a commercial Bt formulation called Javelin exhibited positive responses to skin prick and antibody tests (2). The Bt formulation is a fairly complex mixture containing large amounts of spores, intact delta-endotoxin proteins, residual amounts of fermentation medium, bacterial cell wall debris, and vegetative (i.e., growing) Bt cells.

The experimenters prepared the Javelin in the laboratory to separate water soluble components, the Bt spores, and the Bt endotoxin protein. They then subjected the farm workers to skin prick tests, which are routinely used to test for allergic reactions to foods or other substances. Only the Javelin extracts representing the water soluble portions and the spores gave positive reactions. No significant positive reactions were noted with the delta endotoxin proteins. Test-tube-type studies with the IgE antibody confirmed that only the water soluble extracts and spores gave positive immune system reactions.

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The unique experimental design of the farm worker study allowed the authors to confidently conclude, "results of this investigation should partially allay recent concerns about the occurrence of possible adverse health effects in consumers after exposure to transgenic foods." Furthermore, "it is unlikely that consumers would develop allergic sensitivity after oral exposure to transgenic foods (e.g., tomatoes, potatoes) that currently contain the gene encoding this [the Bt] protein."

Exposure to Bt Proteins May Be Ancient

As the number of acres farmed by certified organic practices increases along with the acreage of Bt transgenic crops, no doubt we will be exposed to Bt protein. But transgenics or not, we already are exposed to Bt proteins. Indeed, our exposure may be ancient as well as unavoidable. Studies of the natural ecology of Bt show it is abundant in the foliage of numerous plant species, and its presence in the soil may result from washoff with rainfall (7, 12). Even more curious is the occurrence of Bt in stored grain that has not been specifically sprayed. Stored grain is commonly infested by moths and beetles that may be susceptible to naturally occurring Bt. Exposure to Bt by organisms feeding on the grain is confirmed by finding Bt spores in the feces of birds and rodents collected from the feed mill (8). Indeed, birds and rodents have been suggested as possible spreaders of the Bt spores. A recent study from Canada indicated that Bt can be detected occasionally on produce in grocery stores when no known aerial applications have taken place on the subject crops in the field (3).

Bt's ubiquity in the environment... suggests we have been exposed to it throughout history.

Still, some people will be concerned about the ubiquity of the Bt transgenic protein in whole fields of corn or cotton. But would the amount necessarily be any different than produced by applications of Bt spray? The mass of Bt endotoxin protein in a corn crop after spraying one commercial product may approach 14 grams per acre. The amount of protein in transgenic crops could be as low as 1.5 grams per acre or as high as 21 grams per acre (Table 2). Thus, the introduction of engineered protein into the environment doesn't seem to present an environmental burden any different than a single Bt spray.

Conclusions About Bt and Human Health

One argument that Greenpeace uses to warn us against transgenic foods is that the genes being transferred come from sources that have never been part of the human diet. The ubiquity of Bt in the environment, and its presence on fresh unsprayed produce and in stored grain suggests that we have historically been exposed to Bt proteins.

Greenpeace warns us by relating the story of allergenic soybeans produced after being engineered with a gene from Brazil nuts that directed increased synthesis of the essential amino acid methionine (10). But they do not emphasize that the researchers already knew that Brazil nuts contained an allergenic protein. Indeed, the purpose of the study was to determine whether transfer of the Brazil nut gene to soybean would express a protein possessing the same allergenic property. The researchers did not uncover anything unexpected but proved that transgenes from allergenic foods are still functional. FDA policy already mandates labeling of foods with genes from known allergenic foods (9).

I'm sure that Greenpeace staff bet that few internet surfers will seek out and read the original scientific studies they mention to validate their position. But they shouldn't be surprised that contrary perspectives abound among those who critically read the scientific literature.

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A perception exists that our regulatory system is broken and the EPA cannot be trusted. Take it from a rabid critic of EPA's risk assessments that prior to registering Bt transgenic crops, the agency already had in hand all of the studies addressing the health issues raised by Greenpeace and others. In Part III, I'll examine the remaining issues concerning environmental effects and resistance management.

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Protecting Our Insect and Mite Friends

Dr. David G. James, WSU Entomologist

Bad Bugs, Good Bugs, and IPM

Think of insects and mites in an agricultural context and you will think of pests—the (usually) small organisms that chew or suck the life out of crops, reducing quality and profits. But not all insects and mites are our enemies. Some bugs are most definitely our friends and we are increasingly recruiting them as valuable foot soldiers in our battles against their pestiferous cousins.

As this new century begins, the focus of crop pest management around the world has shifted, and will continue to shift, towards reducing pesticide inputs. Already we have made great advances in this direction but the greatest advances are likely yet to come. Integrated Pest Management (IPM) has become the catch cry of pest control specialists everywhere. Biological control is usually a part of IPM systems. This is where our foot soldier bugs come in….

Preserving and encouraging beneficial insects and mites is fundamental to IPM.

Biological Control: Two Kinds

Biological control of insect and mite pests is most often thought of in “classical” terms. Classical biological control involves importing an exotic predator or parasitoid to control an exotic pest. This is the kind of biological control that receives media attention. The first and possibly most famous classical biological control success involved the Australian cottony cushion scale insect, which threatened to destroy the Californian citrus industry early last century. Importation of an Aussie beetle predator by American entomologists saved the day (and the industry).

However, most biological control is truly natural. It occurs without fanfare, often unobserved or unrecognized. This type of biological control is referred to as “conservation biological control.” The existence of a successful biological control system of this type sometimes is recognized only when something disrupts it. Using a broad-spectrum insecticide (i.e., one that kills ALL insects and mites, good and bad, in a crop) is often a good way of disrupting, thereby exposing, a natural biological control system. For example, spider mites in many crops only become significant pests when their predators are killed. Large populations of spider mites are rarely found in natural or relatively undisturbed ecosystems like woodlands or parks.

Good Health for Good Bugs

Preserving and encouraging beneficial insect and mite populations in agroecosystems is a fundamental component of IPM. To do so, we need to know which pesticides the beneficials can tolerate and which they cannot. Armed with this information, we can develop IPM programs that are highly compatible with those insects and mites most beneficial to a particular crop.

Pesticides: Determining the Hazards for Good Bugs

At present, very little information on tolerance to specific pesticides is available for our beneficial bugs in Washington State. A new research program has been established at Washington State University Prosser to fill this information void, at least for the approximately twenty-five important beneficial bug species found in grapes and hops. Using laboratory bioassay techniques and procedures, researchers will examine each species of beneficial insect and mite for susceptibility to a range of commonly used pesticides (i.e., insecticides, miticides, fungicides). First, we will determine the toxicity of different pesticides to predators and parasitoids. We will also examine possible sub-lethal impacts of pesticides (such as suppression of reproduction) on beneficials. We will consider the possibility of positive effects of pesticides on beneficials as well. For example, a commonly used insecticide in Washington, imidacloprid (trade names: Admire, Provado) has been demonstrated to *increase* reproduction in one species of predatory mite (James 1997).

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Protecting Our Friends, cont.

Dr. David G. James, WSU Entomologist

Fungicides, the impact of which is often ignored, can also affect beneficial bugs, particularly predatory mites. For example, the use of lime sulfur and mancozeb for disease control was once a major impediment to biological mite control in Australian vineyards. Substitution of fungicides determined to be safe to predatory mites, such as wettable sulfur, copper, and some synthetics, resulted in commercially acceptable biological control of mites (James 1989, James and Whitney 1993, James and Rayner 1995). Perhaps research on predatory mites in Washington vineyards could result in a similar positive outcome.

Clearly, examining the individual susceptibilities of natural enemy species to different pesticides is an ambitious program. However, it is one that is crucial to the effective development of IPM systems in hops and grapes. We must learn more about the impacts of all chemicals used in crops, on the good bugs as well as the bad bugs. Armed with this information, we will be able to more effectively recruit and utilize our insect and mite friends as allies in the ongoing war against crop pests.

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8th Annual Food Safety Conference

The eighth annual "Food Safety Farm to Table Conference" will be held May 16 and 17, 2000, at the Best Western University Inn in Moscow, Idaho. The conference is co-sponsored by Washington State University Cooperative Extension and University of Idaho Cooperative Extension System. Topics will include:

Foodborne Pathogens of current interest including *Shigella* and *Listeria*

Organics Issues including compost pathogens and the latest on federal organics regulations

Fresh Produce Safety including sprouts and water issues

Biotechnology and GMOs including an overview and the latest on safety

Registration fee is $150 before May 1, $175 after; preregistration is required. Fee covers all meeting sessions, luncheons, and refreshment breaks. For a conference brochure or further registration information, contact Chris Eder at (509) 335-2954 or **cecps@cahe.wsu.edu**. Rooms at the conference hotel should be reserved by April 14; call (800) 325-8765 and ask for the Food Safety Conference special rate.

The Value of Section 18s

Jane M. Thomas, Pesticide Notification Network Coordinator, WSU

In the February 1999 issue of *Agrichemical and Environmental News*, Washington State University's Pesticide Information Center (PIC) attempted to summarize the value of Section 18s* to Washington agriculture. Using economic data from the Section 18 requests, we concluded that in 1998 alone, Section 18s were worth $443.2 million to Washington's agricultural industry. Dollar figures for Section 18s are typically comprised of avoided crop losses but may also include savings associated with not having to replant or rehabilitate acreage involved in severe pest infestations.

A year later, we find—not surprisingly—that Section 18s are still saving the industry money. The estimated dollar value of Section 18s issued in 1999 was $447.7 million, up $4.5 million from 1998.

While these numbers are interesting to compare and may even be impressive to toss around, be aware of some disclaimers:

❶ These are only estimates.

❷ If two Section 18s for the same use were issued in the same year, the estimated savings has been "double counted." (e.g., one Section 18 for Axiom DF on wheat was issued, with a May 1999 expiration date; another for the same product and crop was issued later, allowing for use into June of 2000.)

❸ PIC did not have usable economic data for every Section 18 request. Of the thirty-seven emergency and crisis exemptions on the books at the end of 1999, five had insufficient data pertaining to acreage or specific net revenue to allow for a calculation.

❹ Where economic values were given as a range, the lower value was always used in the total estimated value.

Given those caveats, those of you who find this number useful or even interesting can track this information on an ongoing basis via WSU's Pesticide Notification Network web page. You can get there through the PICOL (Pesticide Information Center On-Line) web page at URL **http://picol.cahe.wsu.edu**/, or directly by going to URL **http://www.tricity.wsu.edu/~mantone/pl-newpnn.html**. Once on the PNN web page, click on the Section 18 information and pull up the list for 2000. As we receive each Section 18 request, we calculate and post the estimated value. When a Section 18 is issued as either an emergency exemption or a crisis exemption the value is then added to the annual running total at the top of the page.

What all this really means is that we should take a minute to thank the growers, commodity/commission groups, WSU research and extension staff, WSDA, and, yes, even EPA. The people who work processing Section 18s are making a significant contribution to Washington agriculture. And that's no estimate!

*Jane M. Thomas is the Pesticide Notification Network (PNN) Coordinator for the Pesticide Information Center (PIC) at WSU. She can be reached at (509 372-7493 or **jmthomas@tricity.wsu.edu.***

*ED. NOTE: For the uninitiated, a "Section 18" is a temporary exemption of a pesticide from the full requirement of registration in the case of an emergency circumstance. This exemption derives its nickname from the section of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) that provides for it.

2000 Pesticide Container Recycling Schedule

Washington Pest Consultants Association

Washington Pest Consultants Association organizes an annual series of collection dates and sites for empty pesticide containers. The table below shows dates for April and early May only; watch upcoming *AENews* issues for more recycling dates in the months ahead. A full schedule through October is available in the electronic version of *AENews.* Dates and locations are subject to change; it may be wise to confirm with a telephone call before participating. Contact telephone numbers for specific events are given in the table below. For general questions, or if you are interested in hosting an event at your farm, business, or in a central location in your area, contact Northwest Ag Plastics representative Clarke Brown at (509) 965-6809 or David Brown at (509) 469-2550 or **dbrownwash@msn.com**.

CONTAINERS MUST MEET THE FOLLOWING CRITERIA:

• Rinsed—no residue remaining • Clean and dry, inside and out, with no apparent odor •
• Majority of foil seal removed from spout (small amount remaining on rim OK) •
• Half-pint, pint, quart, one and two-and-a-half gallon containers accepted whole •
• Hard plastic lids and slip-on lids removed • Five-gallon containers accepted whole if lids and bails removed •
• 30 and 55-gallon containers accepted whole if above criteria is met •

DATE	TIME	LOCATION	SPONSOR	CONTACT	PHONE
April 3	8a-11a	Bruce	Simplot	Mike Garza	(509) 488-2132
	1p-3p	Othello	B&H Chemical	Larry Hawly	(509) 488-6576
April 4	8a-Noon	Harrah	Husch & Husch	Allen Husch	(509) 848-2951
April 24	9a-11a	Quincy	Quincy Farm Chemical	Ron Turner	(509) 787-3556
May 1	8a-Noon	Walla Walla	McGregor's	Gary Burt	(509) 529-6787
	1p-3p	Waitsburg	McGregor's	Terry Jacoy	(509) 337-6621
May 2	8a-11a	Pomeroy	Western Farm Service	Jerry Wilsey	(509) 843-3491
	1p-3p	Dayton	McGregor's	Jeff Bruce	(509) 397-4704
May 3	8a-10a	Prescott	Agri Northwest	Shawn Elder	(509) 547-8870
	11a-2p	Prescott	Broetje's Orchard	Joe Shelton	(509) 749-2217
			Flat Top Ranch	Dave Hovde	(509) 547-9682
	3p-5p	Pasco	Air Trac	Gerald Titus	(509) 547-5301
May 4	8a-11a	Eltopia	Wilbur Ellis	Vern Record	(509) 297-4291
	1p-3p	Eltopia	Eastern Wa Spray Serv.	Willis Maxon	(509) 297-4387
May 5	8a-Noon	Connell	B&R Crop Care	Chris Eskildsen	(509) 234-7791
	1p-3p	Pasco	Pfister Crop Care	Steve Pfister	(509) 297-4304
May 8	1p-3p	Seattle	Washington Tree Service	Ron Angel	(206) 362-9100
May 9	8a-Noon	Mount Vernon	Skagit Public Works	Robin LaRue	(360) 336-9400
	1p-3p		Tronsdale Air Service	Kevin Belisle	(360) 661-0422
May 10	8a-11a	Port Orchard	Kitsap County Moderate Risk Facility Omega Pest Mgmt.	Niels Nicolaisen Todd Best	(360) 337-5781 (360) 373-4531
	2p-4p	Tacoma	Wilbur-Ellis Co. & DOT	Randy Knutsen Dave Patterson	(253) 351-6591 (253) 589-7255

"Our industry does not want pesticide containers to become a waste issue. If we take the time to clean and recycle these products, we can save money, show that the industry is responsible in its use of pesticides, and reduce inputs to the waste stream."

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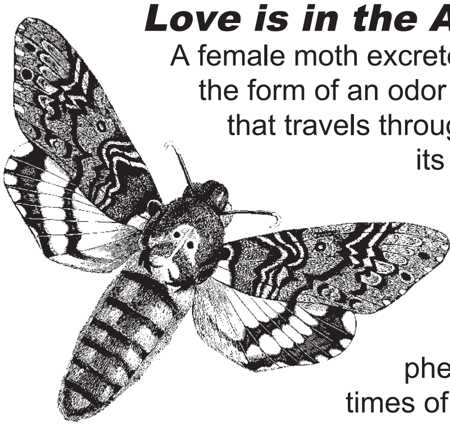
The Chemistry of Moth Pheromones

Dr. Douglas B. Walsh, WSU Entomologist

In the "chemical soup" of the environment, insects must locate food and shelter, avoid being eaten, and—for obvious reasons—boy must meet girl. For many lepidopterans (moths), success in finding a mate is achieved through the female's release of attractant chemicals that prove irresistible to males of her species. These attractant chemicals are known to science as "sex pheromones." The sex pheromone for a female moth must be able to rise out from the "background stink" of competing odors and convey the unambiguous message to males of her species, "I am here and I am ready for sex."

Love is in the Air



A female moth excretes pheromones in the form of an odor cloud or "plume" that travels through the air carrying its seductive message as it evaporates and dissipates. Typically, she will only produce and release pheromones at certain times of the day under specific environmental conditions. Release of pheromones during windy or rainy weather, for example, would prove unproductive. The shape and effective dispersal of the plume in the airstream is determined by factors including wind, temperature, vapor pressure, and topography.

Pheromone structures must remain fairly stable as they move through the air. Large molecules can prove unstable and too heavy to volatilize, while small ones can dissipate too rapidly. In keeping with this objective, moth sex pheromones have a very limited size range, containing between twelve and twenty carbons (see examples, Figure 1).

Love Potion Number Nine

We know a great deal about the chemistry of sex pheromones. They are metabolically derived from fatty acids. Codling moth pheromone's main component is (E,E)-8,10-dodecadien-1-ol, a primary alcohol consisting of a straight chain of twelve carbons with two conjugated double bonds. Other moth pheromones contain molecules that differ substantially in structure; some are epoxides, acetates, or aldehydes (Figure 1). The codling moth pheromone, also known as codlemone, is an excellent example of a successfully synthesized pheromone with commercial application in mating disruption (see *AENews* Issue 159, "Codling Moth: Serious Pest Provides IPM Model.")

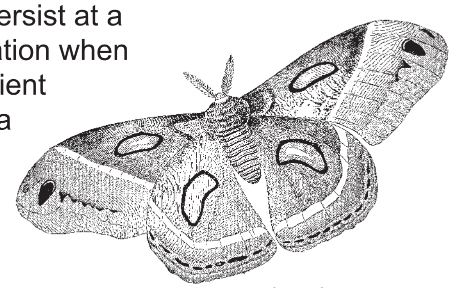
Only You

One might think that the female moths' limited range between twelve and twenty carbons for their pheromone structures would result in interspecific sensitivity among the thousands of moth species that release pheromones—i.e., moths of various species being attracted to one another's pheromones. In fact, pheromone chemists have determined that many pheromones consist of blends of two or more volatile chemicals that need to be emitted in exactly the right proportions to elicit the correct response from the appropriate male.

In addition to chemical structure differences between the various moth pheromones, there are substantial differences between species in the release rates and activity period of pheromones. For example, the codling moth pheromone evaporates about 7.5 times faster than that of the Pandemis leafroller (Figure 1).

The Nearness of You

Proximity is another factor in the success of pheromone attraction. While a moth pheromone plume can be huge, with detectable pheromones ranging from yards to miles from the point-source female, concentration of the attractant does decrease with distance from the female. To be effective, the sex pheromone must persist at a sufficient concentration when it reaches the recipient male moth to elicit a response.



In theory, the female silk moth

...continued on next page

Moth Pheromones, cont.

Dr. Douglas B. Walsh, WSU Entomologist

FIGURE 1

Codling Moth Pheromone
(E,E)-8,10-Dodecadien-1-ol
a.k.a. Codlelure; (8E,10E)-8,10-Dodecadien-1-ol; Codlemone; CheckMate Pheromone; Dodecadien-1-ol
$C_{12}H_{22}O$
Molecular Weight 182.3052
Alcohol

Pandemis Leafroller Pheromone
(E)-11-Tetradecenyl Acetate
a.k.a. (E)-11-Tetradecen-1-ol Acetate; Tetradecen-1-yl Acetate; Tetradecen-1-ol, Acetate, (E)-; Trans-11-Tetradecenyl Acetate
$C_{16}H_{30}O_2$
Molecular Weight 254.4118
Acetate

Silkworm Pheromone
(E,Z)-10,12-Hexadecadienal
a.k.a. Bombykal
$C_{16}H_{28}O$
Molecular Weight 236.2966
Aldehyde

Gypsy Moth Pheromone
(+/-)-cis-7,8-Epoxy-2-Methyloctadecane [29804-22-6]
a.k.a. cis-7,8-Epoxy-2-Methyloctadecane; 7,8-Epoxy-2-Methyloctadecane; Disparlure; Oxirane, 2-decyl-3-(5-Methylhexyl)-,cis
$C_{19}H_{38}O$
Molecular Weight 282.5086
Epoxide

Chemical structures, synonyms, and molecular weights of selected moth pheromones.

produces sufficient attractant to excite ten trillion male moths. But environmental factors, release rate, and proximity must align if the excitation response is to occur.

Come A Little Bit Closer

Finding himself within the active space of a pheromone plume, the male moth's initial long-range orientation is though anemotaxis—movement into the prevailing wind. As he gets closer, the male may orient himself toward the female by chemotaxis—movement toward the higher concentration of pheromone.

Once the male is in close proximity to the female, and the pheromone concentration has exceeded a threshold, genetically stereotyped responses are set in motion. A cascade of behavioral courtship behaviors begins. If the female deems him worthy, copulation will occur.

Next month, I will address the biological aspects of sex pheromones. Male moths detect pheromones via neural structures on their antennae called *sensilla*. These structures result in a marked difference in appearance, or *sexual dimorphism*, between males and females in many moth species.

Dr. Douglas B. Walsh is an Agrichemical and Environmental Education Specialist with WSU's Food and Environmental Quality Laboratory. His office is at the Irrigated Agriculture Research & Extension Center (IAREC) in Prosser, and he can be reached at ***dwalsh@tricity.wsu.edu*** *or (509) 786-2226.*

Noteworthy New Products

Dr. Douglas B. Walsh, Washington State IR-4 Liaison

A number of new pest control products have been introduced over the past several years, many of which exhibit reduced risk and may serve as viable alternatives for older pesticides. The partial list of herbicides below was compiled from the Interregional Research Project #4 (IR-4) Winter 2000 newsletter. A more complete product table, including more herbicides, plus insecticides, fungicides, nematicides, and plant growth regulators, can be seen in the electronic (on-line) version of this month's *Agrichemical and Environmental News* at **www2.tricity.wsu.edu/aenews**. We will print excerpts from these tables in upcoming issues as space allows. Further details on individual products can be found on the IR-4 website at **http://www.cook.rutgers.edu/~ir4/**. If you are interested in determining whether specific technologies could meet your crop protection needs, please contact me at (509) 786-2226 or **dwalsh@tricity.wsu.edu**.

Herbicide	Trade Name	Crop	Registrant	Chemistry	Pest Control Spectrum
alpha-metolachlor	DUAL MAGNUM	Registered: corn, beans, peas, potato, sorghum, onion, cabbage, peach. Pending: tomato, grass seed, sugar beets, carrot, spinach, rhubarb, asparagus. Potential: garden beets, turnip greens, gr. onion, broccoli, melons, caneberry, blueberry, pumpkin.	Novartis	Chloracetanilide	Same spectrum as metolachlor (DUAL)
BAS 615 H.			BASF	Isoindoldione	It is particularly active post-emergence on *Galium aparine,* among other broadleaf species, in small grains
Beflubutamid	UBH-820	Potential use on wheat, barley, rye, and triticale.	Ube Industries	Phenoxybutanamide	Post-emergence control of broadleaf weeds
Carfentrazone-ethyl	AFFINITY, AIM	Registered on field corn and wheat. Pending use on sorghum, potato, barley, sweet corn, and oats. Potential use on caneberry.	FMC	Aryl triazolinone	Numerous broadleaf weeds, including cocklebur and water hemp.
Clodinafop-propargyl	DISCOVER	Pending registration on wheat.	Novartis	Pyridylory-phenoxy propionate	Selective post-emergence of wild oats, annual grasses and other weeds
Dimethenamid	FRONTIER	Registered on dry beans, field corn, popcorn, seed corn, and grain sorghum. Pending use on dry bulb onion and garden beets.	BASF	Chloroamide	Annual grasses, broadleaf weeds, yellow nutsedge
Dimethenamid-P	FRONTIER X-2	Pending use on corn, potato, seed grass.	BASF	Chloroamide	Annual grasses, broadleaf weeds, yellow nutsedge
Flazasilfuron	MISSION	Unknown status on grape.	Zeneca & ISK	Sulfonylurea	Active against many grasses & broadleaf weeds w/ pre- and post-emergence activity at 50 g/ha
Florasulam	DE-570	Unknown status on wheat, barley, and oats.	Dow AgroSciences	Triazolopyrimidine sulfonanilide	Provides post-emergence of broadleaf weeds, particularly *Galium aparine*
Fluazolate	JV 485	Unknown status on wheat.	Bayer and Monsanto		Pre-emergence control of broadleaf weeds and grasses
Flucarbazone-sodium	EVEREST 70 WG	Pending use on wheat.	Bayer	Sulfonylamino-carbonyl-triazolinones	Manages wild oat and green foxtail, and certain broadleaf weeds
Flufenacet	AXIOM	Registered on corn and grass seed. Potential use on potato, tomato and onion.	Bayer	Thiadizole or oxyacetamide	Soil applied for annual grasses and some broadleaf weeds.
Flufenpyr-ethyl	S-3153	Pending registrations on corn. Potential use on snap bean, lima bean and dry beans.	Valent	PPO Inhibitor	Excellent control of velvetleaf and morning glories
Flumesulam	BROADSTRIKE	Registered on corn. Pending registrations on dry bean.	Dow AgroSciences	Sulfonamide	
Flumioxazin	VALOR 50 WD	Potential use on pome fruit, stone fruit, grapes, carrot and tomato.	Valent	N-phenylphthalimide derivative	Controls pre-emergence broadleaf with contact activity and residual soil activity
Fluroxypyr	STARANE F	Registered for wheat, barley, oats. Potential uses on spinach, tree crops, and bulb onion.	Dow AgroSciences	Picolinic acid	Post-emergence to control annual and perennial broadleaf weeds, including vol. Potato, Kochia and Nightshade
Flurtamone		Unknown status on wheat, barley, oats and pea.	Aventis		Pre- and early post-emergence for control of annual broadleaf weeds and some grasses.
Glufosinate	LIBERTY, RELY	Registered: apples, grapes, potatoes, field corn. Pending: sweet corn, canola, potato, sugar beet.	Aventis	Amino acid	Broad spectrum, non-selective
Halosulfuron	PERMIT	Registered on field and sweet corn and grain sorghum. Pending use on cucurbits. Potential use on snap/dry beans, asparagus, and potato.	Monsanto/ Gowan	Sulfonylurea	Controls nutsedge, velvetleaf, cocklebur, and other broadleaf weeds
Imazamox	RAPTOR	Pending use on edible legumes, and canola.	American Cyanamid	Imidazolinone	Pre- and post-emergence control of annual grasses and broadleaf weeds.
Isoxaflutole	BALANCE	Registered on field corn. Pending use on sweet corn, wheat and barley.	Aventis	Isoxazole	Soil applied for many annual grasses and some broadleaf weeds
Mesotrione		Pending use on field corn. Potential use on sweet corn.	Zeneca	Cyclohezanedione	Pre- and post- emergence management of annual grasses and broadleaf weeds, including sulfonylurea resistant weeds.
Oxadiargyl	TOPSTAR 80 WP	Potential use on vegetables and tree crops.	Aventis	Oxadiazol	Broad spectrum weed control, similar to oxidiazinon
Quizalofop-ethyl	ASSURE	Registered on canola, peppermint and spearmint.	Dupont		Post-emergence grass herbicide
Pelargonic Acid		Registered on all crops.	Dow AgroSciences	Biopesticide	Contact, non-selective
Pyraflufen-ethyl	ECOPART	Pending use on wheat and potato.	Nihon Nohyaku	Protox inhibitor	Post-emergence herbicide for general non-selective control of weeds or use as dessicant.

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Dear Aggie

Providing answers to the questions you didn't know you wanted to ask

In contrast to the usually more sober contributors to the Agrichemical and Environmental News*, Dear Aggie deals light-heartedly with the peculiarities that cross our paths and helps decipher the enigmatic and clarify the obscure. Questions may be e-mailed to Dear Aggie at* ***dearaggy@tricity.wsu.edu****. Opinions are Aggie's and do not reflect those of WSU.*

Dear Aggie:

I ran across the following in the February 23, 2000, Federal Register:

> ***"This regulation establishes time-limited tolerances for residues of the inert ingredient (herbicide safener) 3-dichloroacetyl-5-(2-furanyl)-2, dimethyloxazolidine, which is also known as furilazole (CAS Reg. No. 121776-33-8) in or on corn commodities (grain, forage, and stover), at 0.01 ppm."***

If inert ingredients are so darned inert, why do they need tolerances?

Inert Inquirer

Dear Inquirer:

A truly "inert" ingredient may not *need* a tolerance, but it might have one anyway. The reason can be found in CFR 40 Ch. 1 §153.125 (e):

> Designation of a substance as a pesticidally ***inert ingredient does not relieve the applicant or registrant of other requirements of FIFRA*** with respect to labeling of inert ingredients or submission of data, or from the requirements of the Federal Food, Drug, and Cosmetic Act ***with respect to tolerances*** or other clearance of ingredients. (emphasis added)

So, whether the registrant decided to apply for a tolerance or EPA decided to require one, the result will be an inert ingredient with an established tolerance.

That answers your direct question, but Aggie became fascinated by an additional, implied question: "When is an inert not inert?" or "Are safeners necessarily inert?" (If you weren't implying that, no matter. When Aggie becomes fascinated, it's "in for a penny, in for a pound.")

The crux of this matter is the definition of "inert," as opposed to "active." The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) clearly designates an ingredient "active" if it has direct pesticidal activity OR if it "has the ability to elicit or enhance" the pesticidal effect of another compound; in other words, if it's a "helper." A good example is that can of RAID® on your grocer's shelf. Check the label and you'll see a potent combination—an active pyrethrin insecticide and its (non-insecticidal, but technically "active") synergist, PBO (piperonyl butoxide).

Safeners are a special type of "helper" compound, acting to "safen" the activity of another compound so that the latter can be tolerated by a subject crop. For example, thiocarbamate and chloroacetamide herbicides are registered for use on corn and sorghum but are actually toxic to them. Safeners are added to the formulation to help these crops break down the toxic herbicide faster. (The safeners themselves may have direct herbicidal activity but only at very high doses.) It could be said that such safeners "elicit or enhance" the weed control effect of the primary compound. Interpreted thus, the law would consider safeners active ingredients, not inerts. In this light, your original question might have been whether the author of the Federal Register entry you cited was in error calling furilazole an "inert." Naturally, Aggie would not presume to make that accusation, and is relieved that was not the question you asked.

(Reference: Code of Federal Regulations 40, Subpart G, section 153.125, Criteria for determination of pesticidal activity; Devine et al. 1993, Physiology of Herbicide Action, PTR Prentice Hall)

...continued on next page

Dear Aggie, cont.

from page 15

Dear Aggie:

I heard the other day that the USDA has passed some rules regarding organic agriculture. Seems to me that I heard this about two years ago. Aggie, I'm getting the sense of déjà vu all over again. Am I losing my memory?

Been Here Before

Dear Been Here:

Aggie can't tell if you're losing your memory, but you have certainly heard this news story before. The USDA Agricultural Marketing Service released the first proposed rules for a national organic standard on December 16, 1997. The agency received 275,603 responses, an historical record. Nearly every response was adamantly against allowing, as the initial proposal did, the use of genetically engineered food, irradiation, and sewage sludge in organic agriculture and food processing. The second draft of the proposed rules eliminates these three bones of contention, with the interesting disclaimer by the USDA that there was no evidence of any adverse effects from any of the three practices. The recently released rules can still be commented upon, but USDA expects to have the final rule out by the end of the year. Who says the government doesn't reflect the will of the people? (*http://www.ams.usda.gov/nop/*)

PNN Update

Jane M. Thomas, Pesticide Notification Network Coordinator

The Pesticide Notification Network (PNN) is operated by WSU's Pesticide Information Center for the Washington State Commission on Pesticide Registration. The system is designed to distribute pesticide registration and label change information to groups representing Washington's pesticide users.

PNN notifications are available on our web page. To review those sent out in February, either access the PNN page via the Pesticide Information Center On-Line (PICOL) Main Page, **http://picol.cahe.wsu.edu/,** or directly, at **http://www.tricity.wsu.edu/~mantone/pl-newpnn.html**.

We hope that this new electronic format will be useful. Please let us know what you think by submitting comments to Jane Thomas at (509) 372-7493 or **jmthomas@tricity.wsu.edu**.

Federal Register Summary

In reviewing the February postings in the Federal Register, we found the following item that may be of interest to the readers of Agrichemical and Environmental News.

In the February 8 Federal Register, EPA announced that in accordance with an agreement reached with AgrEvo, the registrant is requesting both use deletions for its formetanate hydrochloride-containing insecticides and some product cancellations. (The product cancellations involve SLNs.) The proposed use deletions cover plum and prune use, as well as greenhouse grown ornamentals. (Page 6208)

In the February 11 Federal Register, EPA announced the availability of PR Notice 2000-1. This document clarifies EPA's policy with respect to the applicability of the "treated articles exemption" in 40 CFR 152.25(a) to antimicrobial pesticides. A copy of this document is available electronically at the following URL under the February 11 information: http://www.epa.gov/pesticides/. (Page 7007)

In the February 22 Federal Register, EPA announced that revised risk assessments were available for acephate and methamidophos. Electronic copies of both revised risk assessments can be accessed from the following URL: http://www.epa.gov/oppsrrd1/op/status.htm. Comments on these documents are due to EPA on or before April 24, 2000. (Page 8702)

On October 21, 1999, EPA reopened the comment period on the proposed rule "Standards for Pesticide Containers and Containment" to obtain comment on four specific issues. On December 21, 1999, EPA extend the comment period by 60 days until February 19, 2000. EPA is now reopening the comment period for an additional 30 days until March 20, 2000. (Page 9234)

Tolerance Information

Tolerance Information						
Chemical (type)	Federal Register	Tolerance (ppm)	Commodity (raw)	Time-Limited		
				Yes/No	New/Extension	Expiration Date
imidacloprid (insecticide)	16-Feb-00 pg 7737	0.20	sweet corn, fodder	Yes	New	31-Dec-01
		0.05	sweet corn, grain			
		0.10	sweet corn, forage			
imidacloprid to control flea beetles on sweet corn seed in Minnesota and Idaho. EPA has authorized the corn seed to be planted in states						
zinc phosphide (rodenticide)	23-Feb-00 pg 8872	1.00	alfalfa, forage and hay	Yes	Extension	31-Dec-02
Comment: This time-limited tolerance is being extended in response to EPA granting a Section 18 for the use of zinc phosphide to control voles in California alfalfa. This action also amends the tolerance, raising it from 0.1 ppm to 1.0 ppm. The amendment is necessary because the request is for a new use pattern.						