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Ill Wind for Washington Grapes?

Chlorophenoxy Issue Won't Drift Away

Dr. Vincent R. Hebert, Analytical Chemist, WSU

Pacific Northwest agriculture is highly diverse—Washington alone produces nearly 300 different crops. While crop diversity is a good thing economically, it can sometimes lead to concerns between neighboring growers, especially when it comes to inadvertent pesticide drift.

For over fifty years, a drift controversy has existed between wheat growers and grape growers. Chlorophenoxy herbicides including 2,4-D (2,4-dichlorophenoxyacetic acid) and MCPA (4-chloro-2-methylphenoxyacetic acid) and certain carboxylic acid herbicides including dicamba (3,6-dichloro-o-anisic acid) are highly effective in controlling broadleaf weeds in wheat and other cereal grains. Unfortunately, plants other than broadleaf weeds are negatively impacted by these compounds. Grapes are one of the most sensitive plants for expressing chlorophenoxy and benzoic acid herbicide damage. In Washington State, Concord and wine grape vineyards have sustained severe chlorophenoxy-type damage over the years. Yet use of these herbicides is carefully regulated, and the vineyard damage doesn't seem to correlate with local (adjacent field) use of these products. So where is the ill wind coming from?

Chlorophenoxy History

The chlorophenoxy herbicides have been around a long time and are among the most thoroughly investigated families of chemical compounds in the world with 2,4-D receiving most of the research attention (7). While widely touted as being one of the greatest discoveries in weed science in the twentieth century (4,7), their mechanism of action is still not completely understood, even sixty years after their discovery. What is known is that they are capable of mimicking naturally occurring plant chemicals such as indole-3-acetic acid (IAA) and other plant auxins. Auxins promote root initiation, cell elongation, xylem differentiation, and apical dominance. Phenoxy herbicides act as potent plant auxins, rejuvenating old cells, overstimulating young cells, attenuating growth in girth, retarding apical development, and disrupting nutrient transport.

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Simply put, this herbicide class kills broadleaf plants by drastically interfering with their normal physiology and growth.

The problem, especially for grape and cotton growers, is that this effective class of herbicides can also cause great damage to off-target plants. Extremely low concentrations have been shown to cause damage to Concord and wine grapes. Damage is especially severe when vines are exposed in the spring from late April through early June, during bud-break through bloom growth stages.

Local, Regional, or Long-Range?

Starting in the early 1950s, the chlorophenoxies were being blamed throughout the western United States for recurring damage to Concord and wine grapes. The vineyards claiming damage were in close proximity to fields of cereal grains that had been treated with aerial 2,4-D dust formulations. These formulations were cheap and effective at delivering the phenoxy herbicide to the target weed, but the dust tended to remain airborne for quite some time due to its small particle size.

Drs. Norman Akesson and Wesley Yates, two agricultural engineers from the University of California at Davis, performed pioneering work in estimating drift. They found that, under a light, sustained wind, dust particles measuring 10 to 20 microns could travel approximately one mile horizontally for every ten-foot vertical drop (3). It was not, therefore, surprising to observe severe damage to grape vineyards within a fifteen-mile radius of an aerial cereal field application.

Localized damage to both grape and cotton production in the western United States from these aerial dust applications resulted in nine damage cases reaching as high as the appellate courts from 1952 to 1953. Decisions usually placed the financial responsibility on the aerial applicator (3).

Although subsequent use restrictions on aerial 2,4-D dust applications reduced the frequency of localized damage, drift problems continued to persist in the Pacific Northwest. Altered formulations (volatile isopropyl, butyl and lower-volatile butoxyethyl and isooctyl ester formulations and non-volatile 2,4-D salts) reduced local drift problems, but may have contributed to a different damage pattern. Where local drift tended to result in intense damage at the field edge that lessened along the wind gradient, more uniform vineyard damage was now being observed. This seemed indicative of long-range or general air mass contamination (10).

Meteorological Connection?

From the early 1970s through 1980, a team of atmospheric scientists from the Air Pollution Research Section of the College of Engineering at Washington State University tried to find an explanation for this generalized air mass 2,4-D plant damage pattern (1, 2, 5, 8, 9). The team gathered data on pesticide use, meteorological conditions, vineyard damage, and airborne 2,4-D concentrations across a principal wind trajectory in wheat- and grape-growing districts of central Washington. This extensive field and laboratory research effort did not show correlation between local pesticide use and grape damage. Instead, a relationship seemed to exist between plant damage, increased airborne 2,4-D concentrations, and weak prefrontal activity (a meteorological condition characterized in this region by mid-level cloudiness and light southerly surface winds) from regional nonpoint sources estimated to be as far as 10 to 50 miles away.

As a result of this information, the Washington State Department of Agriculture (WSDA) placed restrictions on the agricultural use of volatile 2,4-D esters in Washington State starting in 1974. The less volatile 2,4-D formulations such as the butoxyethyl esters were less restricted, with applications allowed in certain inland counties up to May 16 of the growing season. In counties along the Columbia River, WSDA timing restrictions on the use of ester formulations can take effect as early as April 5.

From the early to late 1980s, chlorophenoxy drift problems attracted little investigative attention although it might be incorrect to conclude that damage

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to grape vineyards was not occurring. Banning the use of volatile 2,4-D esters and placing restrictions on the timing of low volatility ester formulations were no doubt effective in minimizing drift damage.

Reports of chlorophenoxy herbicide damage to grapes began resurfacing in 1988, with a greater number of WSDA investigative reports appearing from 1997 to the present. Much of the notable 2,4-D grape damage symptoms were reported along the Columbia River corridor in the area of newly established vineyards from the Alder Canyon area eastward into the Walla Walla Valley in central Washington. Another meteorological explanation for these regional episodic damage events began to be considered: temperature inversions (see sidebar).

Because of the increased risk to grape vineyards from widespread regional drift, WSDA prohibits the aerial application of chlorophenoxy herbicides during temperature inversions. But air masses and meteorological conditions don't respect political boundaries, and there has been concern that chlorophenoxy herbicides may be drifting across the Columbia River from northern Oregon during atmospheric inversions, thereby causing inadvertent damage to this grape-growing region.

While the source or sources for the continued and severe chlorophenoxy-like damage to Alder Canyon grapes still remains a mystery, the allegation of regional or directional inversions emanating from northern Oregon and affecting the Alder Canyon vicinity in Washington has some scientific support. Comprehensive models indicate directional transport during an inversion could occur from the Oregon border northward towards the Alder Canyon region from late April to May, a time when vineyards are most susceptible to chlorophenoxy herbicide plant damage (6, 9, 10). Furthermore, indicator or sentinel plants positioned throughout the central Washington counties of Benton, Franklin and Klickitat, have identified the Alder Canyon region as a "hot spot" for herbicide-damage symptoms not attributable to any known local pesticide application (6).

Temperature Inversions

The temperature structure of the lower troposphere is usually warmer near the ground and cooler as you go higher. This tends to be true throughout the year. During these typical conditions, the natural tendency for warm air to rise and cold air to sink results in a continuous state of turbulence, which mixes the air and results in dilution of particulate matter, including pesticides. Less frequently, this structure reverses—cooler air lies closer to the ground with warmer air above. This is known as a "temperature inversion" and can occur throughout the year in the central Washington grape-growing region. Under these more stratified conditions, the typical vertical turbulent mixing can cease. Airborne particles stay suspended and undiluted, allowing for the horizontal transport of airborne pollutants at high concentrations in the air mass over appreciable distances.

Hope for Resolution?

Grape vineyards, especially in regions of mixed cereal and minor crop production, have historically been exposed to phenoxy-type herbicides, presumably from a combination of local, regional, and long-range transport. The combined efforts among affected grape and cereal grain commodity groups, regulatory agencies, and land grant universities have significantly reduced the severity and number of reported chlorophenoxy damage occurrences over the past fifty years. Banning dust and volatile ester formulations, restricting the timing of low volatile ester formulations, and prohibiting applications when drift is likely have all helped to minimize the damage to grapes. Unfortunately, episodic damage remains severe enough to cause massive economic losses to the grape industry. During the last two growing seasons, phenoxy-like wine grape injury seriously affected production in vineyards along the Columbia River corridor in south central Washington. One vineyard in

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this area reported a reduction in yield that resulted in a $290,000 loss of revenue due to alleged phenoxy-like symptoms occurring in May and June of 2000 (11).

The chlorophenoxy herbicides are important agri-chemical tools for managing broadleaf weeds in wheat and cereal grains. To minimize future off-target damage to sensitive crops, all stakeholders must continue to work together. Cooperation among commodity grower groups and policy harmonization between the Oregon and Washington departments of agriculture is vital. Meanwhile, the land grant universities must continue and expand research to identify potential sources of local, regional, and long-range transport of chlorophenoxy herbicides.

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Puyallup Pre-License Course April 17-19

Washington State University provides training for pesticide applicators who are preparing to take the licensing exam. The course focuses on laws and safety, weed control, and insect and disease control; it does not cover seed treatment, stored grain, PCO, or other subjects. See a description of each day's program on the Internet at **http://pep.wsu.edu/education/plt.html** or go directly to the April course sign-up form at **http://pep.wsu.edu/education/plt/aprpuy.html**. Course fees are $35 per day if registration is postmarked on or before April 3; $50 per day after. Study materials are also available through this website, and reading them is a prerequisite for the course. For further information, call (509) 335-2830.

Invertebrate Pathology Field Manual Available

In today's regulatory climate, emphasizing integrated pest management (IPM) and reduced use of organophosphate and other conventional chemical insecticides, microbial control agents (MCAs) stand to play an increasingly important role in pest control.

A recently published field manual will provide researchers and IPM practitioners with techniques and practical guidance for the study and optimal use of MCAs in a variety of settings.

The *Field Manual of Techniques in Invertebrate Pathology: Application and Evaluation of Pathogens for Control of Insects and Other Invertebrate Pests*, edited by Lawrence A. Lacey (U.S. Department of Agriculture) and Harry K. Kaya (University of California at Davis), is intended as a reference tool for academic and government researchers, graduate students and industry personnel involved in research and development of microbial insecticides as well as a practical, hands-on guide for IPM practitioners and organic growers who wish to apply microbial insecticides.

Field Manual of Techniques in Invertebrate Pathology: Application and Evaluation of Pathogens for Control of Insects and Other Invertebrate Pests

by Lawrence A. Lacey and Harry K. Kaya

published by Kluwer Academic Publishers (http://www.wkap.nl/)

Hardbound, 932 pp., $334.00
ISBN 0-7923-6269-1

While the new field manual stands alone as a reference tool, it can also function as a companion to the laboratory volume *Manual of Techniques in Insect Pathology* (L. Lacey, ed., Academic Press, **http://www.apnet.com/**, ISBN 0124325556, 1997, $135.00). The field manual and the manual of techniques together complement the textbook *Insect Pathology* by Y. Tanada and H. Kaya, which is also available through Academic Press (ISBN 0126832552, 1992, $135.00).

The field manual is designed for the study and evaluation of entomopathogens in a diverse array of agroecosystems, managed forests, lentic and lotic aquatic habitats, and domestic and other situations in which insects are pests. The contents of the book include descriptions of practical methodology for evaluation of the impact of naturally occurring insect pathogens; pathogens that have been inoculated into specific habitats as classical biological control agents; and pathogens that are used as microbial insecticides (inundative application). Chapters on the theory of microbial insecticide application, experimental plot design, statistical analysis, and the type and calibration of application equipment are intended to supplement chapters on application in specific systems and to provide scientific guidelines for the rigorous examination of the practical value of entomopathogens. The manual takes a "how-to" approach, but also includes pertinent literature review.

The manual comprises thirty-eight chapters in ten sections. Topics include theory and practice of MCA utilization, design and conduct of experiments, and equipment and strategies for application. The major pathogen groups (virus, bacteria, protozoa, fungi, and nematodes) are outlined, and the special considerations inherent in field implementation are discussed. Readers will find specific, step-by-step instructions on inoculum handling and efficacy assessment. Additional topics include special consideration for evaluation of Bt transgenic plants, resistance to insect pathogens and strategies to manage resistance, and guidelines for evaluating effects of MCAs on nontarget organisms.

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Using Beneficial Nematodes for Crop Insect Pest Control

Dr. Carol A. Miles and Caitlin Blethen, WSU, and Dr. Randy Gaugler, Rutgers University

Nematodes are non-segmented, elongated roundworms that are colorless, without appendages, and usually microscopic. “Non-beneficial” nematodes cause damage to crops and other types of plants. “Beneficial” nematodes cause damage to soilborne insect pests, yet are not harmful to humans, animals, plants, or earthworms, and can therefore be used as biological control organisms. Beneficial nematodes can be classified as “entomopathogenic” (causing disease within an insect) or “insecticidal” (ability to kill insects).

Various species of beneficial nematodes can be used to control a wide range of insect pests including a variety of caterpillars, cutworms, crown borers, grubs, corn root worm, cranefly, thrips, fungus gnat, and beetles. Nematodes from the families Steinernematidae and Heterorhabditidae have proven to be the most effective as biological control organisms (9). As they live in the soil, they are more effective in controlling soilborne insect pests than in controlling insects in the leaf canopy.

The keys to successful pest control with beneficial nematodes are:

❶ understanding their life cycles and functions;

❷ matching the correct nematode species with the pest species;

❸ applying them at the right time;

❹ using them under appropriate environmental conditions (temperature, soil moisture, sunlight); and

❺ applying them prior to or after other pesticide applications.

Beneficial Nematode Life Cycle

The life cycle of most nematodes includes an egg stage, four juvenile stages, and an adult stage. The third juvenile stage of beneficial nematodes is referred to as the “infective juvenile"’ or “dauer” stage. The infective juvenile is capable of surviving in the soil; its sole function is to locate, attack, and infect an insect host (11). Under optimal conditions, it takes three to seven days for steinernemadtids and heterorhabditids to complete one life cycle inside a host from egg to egg.

Many species of beneficial nematodes occur naturally in the Pacific Northwest, including the *Heterorhabditis marelatus. Heterorhabditis marelatus* has been shown to control some crop insect pests (2) and has just become commercially available. It is unknown whether introduced species of beneficial nematodes will overwinter in the region and successfully colonize insect hosts in subsequent years.

How Beneficial Nematodes Control Insect Pests

An understanding of host-finding strategies enables the user to properly match nematode species to pest insects (4). Infective juvenile beneficial nematodes locate their hosts in soil by means of two strategies, “ambushing” and “cruising” (5). Ambushers remain stationary, standing on end and attacking more mobile, surface-dwelling hosts, while cruisers move around more, locating sedentary and slow-moving hosts by sensing their byproducts. Various species are identified as ambushers, cruisers, or a combination in the “Nematode Characteristics” sidebar on the facing page.

Generally, several nematodes will infect a single insect host, penetrating the insect’s body cavity, usually through natural body openings including the mouth, anus, or breathing pores (spiracles). Heterorhabditids can break the outer cuticle of the insect using a dorsal “tooth” or hook. Once inside the body cavity of the host, the infective juveniles release bacteria that live symbiotically within the nematode’s gut. The nematode-bacterium relationship is highly specific: only *Xenorhabdus* spp. bacteria co-exist with steinermatids, and only *Photorhabdus* bacteria co-exist with heterorhabditids. Once released into the host, the bacteria multiply quickly and under optimal conditions cause the host to die within 24 to 48 hours. The insect larva is killed by the bacteria and not by the nematode.

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After a few days inside the host, nematodes mature to the adult stage, producing hundreds of thousands of new juveniles. These progeny may undergo several life cycles within a single host. When the host has been consumed, the infective juveniles, armed with a fresh supply of bacteria, emerge from the empty shell of the host, move into the soil, and begin the search for a new host. Under ideal conditions, steinernematids emerge six to eleven days after initial infection and heterorhabditids emerge twelve to fourteen days after initial infection (10). Duration of infective juvenile survival in soil is unknown.

Using Beneficial Nematodes

Over thirty species of beneficial nematodes have been identified. Eight species have been commercialized and seven (described in the sidebar) are currently available in the United States. (See related information on an eighth species, page 11.) Table 1 (page 8) matches species with the pests they have been shown to control on various crops.

Beneficial nematodes are living organisms requiring careful handling to survive shipment and storage. They are available from large-scale commercial laboratories and from cottage industry suppliers. The quality of nematodes in commercial products varies greatly (6): shipments can contain lower numbers of nematodes than claimed or species of nematodes inconsistent with the product label. Websites with lists of beneficial organism suppliers can be found at **http://www2.oardc.ohio-state.edu/nematodes/nematode_suppliers.htm**, **http://www.ianr.unl.edu/pubs/insects/nf182.htm**, and **http://www.cdpr.ca.gov/docs/ipminov/bscover.htm** or **/bensuppl.htm**. Beneficial nematodes can also be purchased through gardening mail-order catalogs and at some local agricultural and nursery supply stores.

Beneficial nematodes have a short shelf life. It is advisable to order them just three to four days prior to application, have them shipped by overnight delivery, and apply them within a day or two after arrival. They should be stored in their shipment containers under refrigeration until ready for use. The storage life of

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Nematode Characteristics

(adapted from references 1 and 4)

Steinernema carpocapsae. An ambusher type, it is most effective against highly mobile surface insects such as webworms, cutworms, armyworms, girdlers, and wood borers. Most effective at soil surface temperatures between 70 and 85°F. Can be formulated in a partially desiccated state in clay granules to provide several months of room-temperature shelf life.

S. feltiae. Combines ambusher and cruiser strategies and attacks immature fly larvae (dipterous insects) including mushroom flies, fungus gnats, and crane flies. Maintains infectivity at low soil temperatures, even below 50°F. Has relatively low stability in formulation and a short shelf life.

S. glaseri. A large cruiser type that attacks white grubs and other beetle larvae, particularly scarabs. Expensive and difficult to produce and manage due to its tendency to "lose" its bacterial symbiont. Highly active and robust infective juveniles are difficult to contain within formulations. Additional work needed for commercialization.

S. riobravis. Combines ambusher and cruiser strategies, and attacks corn earworms, citrus root weevils, pink bollworms, and mole crickets. Isolated from Rio Grande Valley of Texas. Maintains infectivity at soil temperatures above 95°F and in semi-arid conditions.

Heterorhabditis bacteriophora. A cruiser type nematode that attacks caterpillar and beetle larvae including root weevils, particularly black vine weevil. Most effective in warm temperatures, above 68°F. Infective juveniles persist only a few days in the soil. Currently has poor stability in formulation and a short shelf life. Additional work needed for successful commercialization.

H. marelatus. A cruiser type nematode that attacks beetle larvae including white grubs and root weevils. Isolated from the Oregon coastal region. Active at cool soil temperatures, 50 to 55°F. Newly available.

H. megidis. A large cruiser type nematode that has been effective in controlling black vine weevil larvae. Has not been widely researched or tested for insect control. Isolated in Ohio, researched and developed in Europe, and now available in the United States. Currently has poor formulation stability and a short shelf life.

(See also information on new **S. scapterisci***, page 11.)*

Using Nematodes, cont.

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TABLE 1

Current use of Steinernema and Heterorhabditis nematodes as biological control organisms (Adapted from references 6 and 12).

Crop	Insect Pest	Nematode Species
Artichokes	Artichoke plume moth	*S. carpocapsae*
Berries	Root weevils	*H. bacteriophora, S. glaseri, H. marelatus*
Cranberries	Root weevils	*H. bacteriophora, S. carpocapsae*
	Cranberry girdler	*S. carpocapsae, H. bacteriophora, H. marelatus*
	Hoplia grub	*H. bacteriophora*
	Cranberry rootworm	*H. bacteriophora*
Mint	Mint root borer, root weevils, mint flea beetle	*S. carpocapsae*
Landscape ornamental trees and shrubs	Borers	*S. carpocapsae*
Mushrooms	Sciarids	*S. feltiae*
Ornamentals	Root weevils	*H. bacteriophora, H. megidis, H. marelatus*
	Wood borers	*S. carpocapsae, H. bacteriophora*
	Fungus gnats	*S. feltiae*
Turf	Scarabs	*H. bacteriophora*
	Billbugs	*H. bacteriophora, S. carpocapsae*
	Armyworm, cutworm, webworm, cranefly	*S. carpocapsae*
Vegetables – root and cole	Root maggots, cutworms, armyworms	*S. carpocapsae*

nematodes is species- and formulation-dependent. Specific storage instructions will be included with the nematode shipment.

Table 2 is a summary of storage times for beneficial nematodes in different formulations. Note that storing nematodes under refrigeration will increase their shelf life, but their infectivity will decrease the longer they are in storage. When the storage life has expired, expect 70 to 100% mortality of the nematodes (8).

Beneficial nematodes can die if they are applied to soils that are too dry, too hot, or too cold, or if they are exposed to ultraviolet (UV) light from the sun. Nematodes live in the water-filled spaces between soil particles. They need water to move and to successfully locate a host; at the same time they need oxygen to survive. Heavy clay soils hold water well, but may contain too little oxygen and may restrict nematode movement. Sandy soils must be irrigated to maintain the water-filled spaces.

Soil temperatures between 77° and 82°F are ideal for applying any nematode, but the species vary in their tolerance (e.g., *S. feltiae* can be effective at 57°F while *S. riobravis* can be effective at 95°F). In general, soil temperatures greater than 85°F can decrease the efficacy of some nematode species while soil temperatures less than 50°F can immobilize others at the soil surface, where they are exposed to UV light that can kill them.

Nematodes should be applied late in the day or on a cool, overcast day, when light and temperatures are low. Apply them to moist soil, following either a rainfall or irrigation. The soil can also be irrigated after nematodes have been applied. This washes them into the soil and decreases soil surface temperatures. Do not over-irrigate, as saturated soil will impede nematode activity due to lack of oxygen.

Nematodes should be prepared for application no earlier than one hour prior to field application. If nematodes are in a liquid suspension, shake the shipment container well and pour the liquid into the application container (e.g., tank, backpack sprayer, or watering can). Rinse the shipment container twice with cool water (approximately 60°F), and pour the rinse water into the application container. If nematodes are on a sponge, soak the sponge in one gallon

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of cool water for ten minutes, then pour the water into the application container. Rinse the sponge several times, pouring the rinse water into the application container after each rinse. If nematodes are in vermiculite, add the vermiculite-nematode mixture directly to water in the application container and stir until dispersed. Once the nematodes have been mixed with water, agitate the mixture every five minutes to keep the nematodes in suspension and supplied with oxygen.

TABLE 2

Expected storability of some commercially available formulations of beneficial nematodes (adapted from reference 7).

Formulation	Nematode Species	Storage (Months)	
		Room Temp.	Refrigerated
Liquid concentrate	*S. carpocapsae*	5 to 6 days	12 to 15 days
	S. riobravis	3 to 4 days	7 to 9 days
Sponge	*S. carpocapsae*	0	2 to 3
	H. bacteriophora	0	1 to 2
Vermiculite	*S. feltiae*	0	4 to 5
	H. megidis	0	2 to 3
Alginate gels	*S. carpocapsae*	3 to 4	6 to 9
	S. feltiae	1/2 to 1	4 to 5
Flowable gels	*S. carpocapsae*	1 to 1-1/2	3 to 5
	S. glaseri	0	1 to 1-1/2
Water dispersible granules	*S. carpocapsae*	4 to 5	9 to 12
	S. feltiae	1-1/2 to 2	5 to 7
	S. riobravis	2 to 3	4 to 5
Wettable powder	*S. carpocapsae*	2–1/2 to 3-1/2	6 to 8
	S. feltiae	2 to 3	5 to 6
	H. megidis	2 to 3	4 to 5
Nematode wool	*H. bacteriophora*	21 days	unknown

Read the product label for specific application instructions. Nematodes that are formulated with vermiculite may be best applied as a granular product. Other formulations can be applied using standard liquid pesticide, fertilizer, and irrigation equipment with pressures of up to 300 PSI. Electrostatic, fan, pressurized, and mist sprayers can be used. If tanks are agitated through excessive sparging (recirculation of the spray mix), or if the temperature in the tank rises above 86°F, the nematodes will be damaged. Irrigation systems may also be used for applying most species; however, high-pressure recycling pumping systems are not good delivery systems (14). Calibrate equipment to ensure appropriate application rate. An excellent overview of sprayer equipment, including calibration, is provided in WSU's *Private Applicator Pesticide Education Manual* (13).

Remove all screens smaller than 50-mesh from the spray or irrigation equipment to allow nematodes to pass through the system. Check spray nozzle orifices for clogging during application. Direct spray nozzles at the soil to maximize the number of nematodes being applied directly to the soil. A large spray volume is ideal. Volumes of 2 to 6 gallons of water per 1000 square feet (87 to 260 gallons per acre) are recommended on most nematode labels (14). The water in the spray will wash the nematodes from plant surfaces into the soil. Lower volume spray applications of 0.5 to 1.0 gallon per 1,000 square feet (20 to 45 gallons per acre) can be used if the area or field is irrigated prior to and immediately following nematode application. Overhead irrigation following nematode application or application during a rainfall will wash the nematodes from plant surfaces into the soil. If the spray droplets are allowed to dry prior to this irrigation, the nematodes will be exposed to UV light and will die while still on the plant surfaces.

Use equipment that is clean and free of pesticide residues. Also, do not mix nematodes with nitrogen fertilizers, particularly urea (8). Although there is evidence that nematodes are tolerant to many herbicides and fungicides, they are sensitive to certain insecticides and nematicides. Refer to the nematode product label for specific listings of chemicals that are

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lethal to beneficial nematodes. To check that live nematodes are being applied to the soil, set pans or containers on the soil surface prior to application. Immediately after application, use a hand lens (15X) or a microscope to check the liquid in the pans or containers for live, moving nematodes.

Before applying any biological control, including nematodes, read the product label for specific application instructions. A broadcast application rate of one billion nematodes per acre is generally recommended to control most soil insects. For smaller areas, the recommended application rate is 250,000 nematodes per square meter. If nematodes are banded (applied in a band beside the crop row), a lower rate may be applied. Research at the University of Florida has demonstrated that a rate of up to 200 million nematodes per acre applied in a band provided effective control of root weevil in citrus orchards (3). More research is needed to determine specific rate responses for each species of beneficial nematode in various cropping systems to control specific pests.

Beneficial nematodes have been released extensively in the field with negligible effects on nontarget insects, therefore they are regarded as exceptionally safe to the environment. Still, like all biological control organisms, they are considered a pesticide. They are exempt from federal pesticide registration under Section 25(b) of the Federal Insecticide Fungicide Rodenticide Act (FIFRA), but they must be registered with the Washington State Department of Agriculture (WSDA) prior to distribution. Questions regarding pesticide registration should be directed to the WSDA Pesticide Division (360-902-2030).

On-Line Nematode Resources

Several Internet sites provide more detailed information about beneficial nematodes. The Sustainable Agriculture Research and Education (SARE) Entomopathogenic Nematode Website at **http://www2.oardc.ohio-state.edu/nematodes** provides a comprehensive bibliography of research literature and access to a panel of nematode authorities who will respond to questions. The Gaugler Laboratory–Rutgers University at **http://www.rci.rutgers.edu/~nematode/** includes a slide collection, list of publications, and summaries of current projects including production, behavioral and developmental ecology, and genetic engineering of entomopathogenic nematodes. Oregon State University's Research on Entomopathogenic Nematodes site at **http://www.bcc.orst.edu/~jiel/** offers links to abstracts of recent publications, images of insect pests infested with nematodes, images of morphological characters of nematodes, and a table showing phylogenic relationships among nematodes. The University of Nebraska site, "Nematodes as Biological Control Agents of Insects," at **http://ianrwww.unl.edu/ianr/plntpath/nematode/wormepns.htm** includes discussion of the culture, storage, and transport of steinernemadtids and heterorhabditids. Finally, Midwest Biological Control News' site at **http://www.entomology.wisc.-edu/mbcn/mbcn.html** provides current and back issues of their newsletter along with an alphabetical index of biological control-related articles.

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Mole Cricket Nematode Shows Promise

The mole cricket has been a recognized agricultural pest in Florida since the 1930s. Originally controlled with arsenic baits and DDT, its management with softer pesticides has been less than successful.

In the 1980s, University of Florida (UF) Institute of Food and Agricultural Sciences (**http://ifas.ufl.edu/**) researchers identified a nematode from Brazil as a mole cricket parasite. The nematode species, *Steinernema scapterisci,* has proven nearly 100 percent effective against mole cricket within forty-eight hours of entering the host. UF holds three patents on use of this nematode for pest control.

The mole cricket causes about $94 million in damage to Florida turf and pastures annually by feeding on the roots and seedlings of grasses and by loosening the soil. It also impacts other crops including ornamentals and vegetables. Cost efficiency of controlling mole crickets with nematodes is not yet known.

MicroBio, a biotech firm owned by Iowa-based Becker Underwood, Inc., has obtained exclusive rights for commercial production of this nematode. It should be available later this year under the name Nematac S. MicroBio can be found on the Internet at **http://www.microbiogroup.com/**.

How Do You Spell Cool? P-N-N

An Update on the Pesticide Notification Network

Jane M. Thomas, Pesticide Notification Network Coordinator

It still happens—even after four years. When people ask me what the Pesticide Notification Network (PNN) is, I reply that it is "this cool thing that WSU and the WSCPR do for Washington agriculture…" (Can you tell I'm just a little proud?) Given the chance to talk about the PNN I can go on (and on, and on); no wonder I don't get asked too often.

The PNN informs pesticide users about changes in the status of ag pesticides.

Here's how it started. When the Washington State legislature passed House Bill 1009 in 1995, it created the Washington State Commission on Pesticide Registration (WSCPR). At the same time, it directed the Commission to provide a program for tracking the availability of effective pesticides for minor crop and emergency uses in Washington. The PNN is the result of this mandate. Washington State University (read: "Jane M. Thomas") has operated the PNN since it began in early 1997. Over time, the PNN's functions and output have expanded to include variations on the original theme.

Pesticide users must stay current with any changes affecting the pesticides they might use. The purpose of the PNN is to inform Washington pesticide users when changes take place in the status of agricultural pesticides (e.g., label changes, changes in registration status). The PNN operates on two planes: active distribution of information and passive posting of information to a web page.

Active Info: PNN Distribution

When a change takes place affecting a pesticide of interest to any of the diverse agricultural producers in Washington State, the PNN passes the information along to a targeted list of recipients representing a broad cross-section of these growers. These PNN contacts (mostly commodity/commission groups, grower groups, and WSU Cooperative Extension personnel) then pass the information along to the pesticide users that they represent. The PNN list currently numbers over one hundred fifty and represents thousands of growers.

Each PNN notification is targeted to the appropriate recipient(s) based on the crop/usage site and the type of pesticide being discussed. This way an ***entomologist*** conducting research on ***tree fruit*** will receive only information about ***insecticides*** registered for use on ***tree fruits*** while the Washington ***Blueberry*** Commission receives all notifications relating to pesticide use of ***any*** kind (herbicide, insecticide, fungicide) on ***blueberries***.

I can just hear you pondering "How can you do this wonderful thing?" The answer is—I don't know. Some really smart programmer guy set up the system and although he is long gone the thing continues to work. Knock on wood.

Secret Sources

PNN info comes from a variety of sources: WSDA, ODA, Federal Register, and registrants.

Before I move on to explain the passive (web-based) part of the PNN, I'll digress a moment. By now you have become fascinated (they always do) and are probably yearning to ask, "Jane, dear, please tell us what your sources are for the valuable information you distribute on the PNN."

Because our office also operates the Pesticide Information Center On-Line (PICOL) Label Database (**http://picol.cahe.wsu.edu**), we receive boxes (and boxes and boxes) of registration material from the Washington State Department of Agriculture (WSDA). As Charlee Parker, the PICOL data entry person, goes through the paperwork, she separates out the new and revised labels for commercial agricultural

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PNN? Cool! cont.

Jane M. Thomas, Pesticide Notification Network Coordinator

products. These she sets aside for my review. In fits and starts during the year I go through this stuff and summarize what is being done: WSDA has registered a new herbicide for use on X, Y, and Z crops or Dow has revised the label for its product X and apple use directions have been removed. WSDA also sends me each Section 18 and Special Local Needs (SLN) registration as it is issued or amended.

While this registration material comprises the nuts and bolts of the PNN information, that's not all there is to the system. As an avid reader, I sit down each month and review the *Federal Register.* Yep, you guessed it…this is ***really*** a chore and the part of the process of which I am least fond. But I take the long view. I believe that this self-sacrifice and discipline has been good for me, as evidenced by the fact that I haven't recently been arrested for a juvenile crime. (Just ignore the forty-five-year old woman behind the curtain.) The *Federal Register* is the source for all the notifications dealing with items such as proposed manufacturers use deletions and product cancellations, risk assessments, publication or revision of EPA guidance documents, and reregistration eligibility decisions (REDs).

WSDA personnel and individual registrants are also sources of information for the PNN. Over the last year, these sources have been responsible for PNN notifications on a wide variety of topics including

- a request for input on whether or not a certain Section 18 was needed on canola;
- information on WSDA's new Section 18 Compliance Project;
- summaries of the upcoming regulatory changes ahead for diazinon and chlorpyrifos;
- notice regarding future supplies of Surflan; and
- new WSDA rules requiring Section 18 labels.

All of these sources feed the information flow of the PNN. In 2000, the PNN distributed 344 notifications using a record 11,335 e-mails, faxes, and letters. When you look at the numbers (as some of us are wont to do), you begin to see the PNN's potential.

Passive Info: The Web Page

The PNN notifications discussed above are all summarized on the web page, **http://www.pnn.wsu.edu**. Here, web surfers can see the product name, date, crop/usage site, and the subject of any PNN notice since mid-1999. Should a viewer find something of interest, the full text of each notification is available at the click of the mouse. The web page also contains listings of Washington Section 18s and SLNs (linked to electronic copies of these labels where available). Finally, a table summarizing Oregon SLN information is also available on this web page.

The PNN web page is a newer component of the total PNN service. It underwent a major revamp in September 1999 to include the amount of information it provides today. Over the past year, it has been accessed 2170 times, and interest seems to be growing.

So check out the PNN on the web. If the notifications look like something that would be useful to you, let me know and I'll get you signed up as a PNN contact so you can receive notifications directly. But why not just ask me my opinion of the PNN. Is it good? Is it great? I just think it's cool.

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Her Royal Highness the Queen Bee of Labels cordially invites you to check out the very cool PNN (Pesticide Notification Network) on-line at URL:

http://www.pnn.wsu.edu

Pesticides and Salmon, Part 2: Animals in Drag?

Dr. Allan S. Felsot, Environmental Toxicologist, WSU

"Something's bending gender of Reach salmon," blared the headline of my local newspaper. "Chemicals suspected—not radiation—in Chinook males' development into breeding females (20)." It was just a matter of time before hormone mimics, a.k.a. endocrine disrupters, were implicated as one of the many factors for decline of the wild salmon. Transsexual salmon can grab one's attention as easily as flamboyantly costumed streetwalkers in a New Orleans Mardi Gras parade. If these sexual shenanigans are true, it could mean a prolonged Lent for wild salmon populations.

Just the Facts, Ma'am

The progenitor of the news about "salmon in drag" was a piece of research published in the January 2001 issue of *Environmental Health Perspectives*. A team of scientists from the University of Idaho, Washington State University, and the Battelle Pacific Northwest National Laboratory collaborated on research we will hereinafter call the UI study (22). They reported that over 80% of the female Chinook salmon collected from the Hanford Reach (a free-flowing stretch of the Columbia River bordering the Hanford Nuclear Reservation) carried a piece of DNA known as a genetic marker that was uniquely characteristic of the male's Y chromosome. Thus, these phenotypic female (i.e., female-appearing) fish were really genetic males masquerading as females.

Such a drag show on the Hanford Reach could have dire consequences for the salmon population. The female-appearing males are capable of normal reproduction as females, but therein lies the potential long-term trouble for salmon populations. Genetic females can only produce eggs containing an X chromosome. Genetic males with female reproductive organs can produce eggs contain either an X or Y chromosome, the same as the possible sex chromosomes contained in sperm. When a Y-containing egg is fertilized by a Y-containing sperm, an abnormal YY male embryo is produced. Under normal circumstances, a fertilized egg would have a 50% chance of becoming a female. However, fertilization of Y-containing eggs will always produce males. The worst-case scenario is that too few females would be produced to sustain the population.

Hatchery-reared fish were compared to fish collected at the Hanford Reach. No female-looking fish that were reared at the upstream Priest Rapids Hatchery on the Columbia River or at the Dworshak National Fish Hatchery on the Clearwater River in Idaho contained genetic evidence of "maleness." Because the only factor differing between the hatchery-reared fish and the wild fish was the location of spawning habitat, the UI study concluded that something related to the Hanford Reach was causing sex reversal of developing fish.

The Four Hypotheses

So how did the conclusion that something is causing sex reversal become translated by the media to "chemicals suspected"? Once researchers make an observation, they immediately construct hypotheses that seem plausible explanations for a phenomenon. When you offer the media a smorgasbord of four hypotheses, as the UI study did, reporters are going to jump on the sexiest one without regard to its validity. Sound science, however, demands a fair hearing of all plausible possibilities.

Jumping Chromosome Pieces. Phenotypic females may contain the male DNA marker because there has been a chromosomal translocation of a piece of the Y chromosome to a non-sex chromosome during sperm development. However, the researchers dismissed this possibility with the explanation that female fish returning to the Priest Rapids Hatchery were "genetically indistinguishable" from the wild fish spawning in the Hanford Reach. Female fish returning to the hatchery did not contain the male genetic marker, therefore a translocation is unlikely.

Radioactive Exposures. The Hanford Nuclear Reservation's historic love affair with the processing and disposal of radioisotopes for nuclear weapons made radiation-induced sex reversal an obvious choice. However, excessive radiation causes sterility, not effects on sexual development. The levels of

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radioactivity occurring in the Columbia River were deemed too low to cause any effects. Thus, the second hypothesis drowned for lack of evidence and relevance.

Water Temperature Fluctuations During Embryonic Development. Fish and reptile gender can be determined by environmental temperature during embryonic development. Hydroelectric dam operations, which occur upstream of the Hanford Reach, are known to cause water temperature fluctuations from 2 to 6°C at the Reach. Thus, the UI researchers suggested sex reversal may have been caused by timely water temperature fluctuations during incubation of the redds (spawning grounds containing eggs with developing embryos).

The salmon appeared to be female, but were genetically male.

Temperature-dependent sex determination has been well described in a handful of species, but whether low or high temperatures cause males or females to develop is not so easily generalized. For example, alligators tend to develop into females at cooler temperatures (1), but turtles tend to develop into males (25).

The UI study cited a number of papers supporting temperature as being an important factor in fish gender determination. However, three of the cited papers indicated that females of three different species were favored at lower temperatures (24, 30, 34), and one paper showed that females of yet another species were favored at higher temperatures (23). Sockeye salmon gender can be changed by a temperature shift during embryonic development (3), but specific effects on Chinook salmon presently seem unknown.

Exposure to Chemicals that Mimic Sex Hormones. It has been known for some time that sex ratio can be skewed to produce more females by exposing developing embryos or newly hatched fish to sex hormones like estrogen. Indeed, some hatcheries may purposefully use estrogen to manipulate fish sex ratios to increase production of females (8, 33).

In wildlife studies, estradiol, the naturally occurring estrogen, can reverse the sex of reptiles developing at male temperatures (1). However, only a small handful of studies have suggested that non-hormone environmental contaminants can actually reverse sex as opposed to affecting sexual development.

Despite the weak evidence that anything other than sex hormones can cause complete sex reversal, the researchers in the UI study left no stone unturned and finally got around to implicating pesticides as one possible type of "environmental estrogen." The Columbia River contains pesticide levels between 1 and 6 parts per trillion (ppt). But pesticides were an unlikely smoking gun because the researchers concluded "no information exists to show that the measured concentrations of these compounds can effectively cause sex reversal in any fish species." But the Priest Rapids Hatchery fish were supposedly reared in clean (i.e., non-pesticide contaminated water), and the females did not contain the male marker DNA; therefore, the UI team concluded that pesticides "remain valid candidates for causing the effects reported."

The media latched on to this final hypothesis like ticks on a dog. Newspaper reporters who don't make time for background reading are stuck with an uncritical acceptance of whatever the interviewee tells them. Thus, the story of sexually confused salmon was headlined to give the impression that chemical causes are the best hypothesis to explain mistaken sexual identity in the Hanford Reach salmon.

Pesticides: Guilt by Omission

Lack of evidence in the published literature led the UI team to quickly dismiss radioactivity exposure as a cause of phenotypic changes in gender. Despite their

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own words that pesticide concentrations were too low to affect fish sex, the UI team was not ready to ignore pesticides for lack of evidence.

But there was plenty of evidence suggesting that pesticides were not likely to be capable of causing sex reversal in salmon or related species. For example, by the time the UI team had submitted its paper to the journal for consideration of publication, Oregon State University (OSU) researchers had reported in the same journal nearly six months earlier that DDE (the environmental breakdown product of DDT) failed to alter sex ratios of rainbow trout and Chinook salmon (2). The OSU team made their observations after directly injecting DDE into embryos of rainbow trout and Chinook salmon and then histologically examining the gonads of six-month old fish. Furthermore, sex hormone levels in plasma and other morphological indicators of sexual development were unchanged by DDE treatment. DDE is known to have anti-androgenic (i.e., antagonistic to the effect of testosterone) properties, causing feminizing effects in rats (17).

There is very little evidence that pesticides can cause sex reversal.

Two years prior to the publication of the UI study, a different group of researchers at the UI published a study in which male rainbow trout were fed methoxychlor throughout early development prior to sexual differentiation (18). While methoxychlor is a pesticide known from both test tube (in vitro) and whole animal (in vivo) studies to bind to the estrogen receptor and cause feminization of male development, sexual differentiation and testicular development were unaffected by methoxychlor in this study. Considering that the trout sperm for the earlier study came from the office of a Washington State University researcher involved in the later study, it is unfortunate that the methoxychlor study was not mentioned in recent discussions.

Pesticides Are Weak Hormone Mimics

Lest you think I am displaying my own bias in selectively reporting the literature, there are plenty of other studies that could (or should) have been discussed to determine the validity of the hypothesis that environmental contaminants cause sex reversal. In fact, very few experimental studies have actually shown sex reversal from exposure to non-hormone chemicals. The most notable experimental study supporting the hypothesis involved the application of PCBs directly to turtle eggs grown at male-producing temperatures (5). The resulting hatchlings were overwhelmingly female.

To date, only one pesticide has been experimentally shown capable of causing sex reversal in fish. When o,p′-DDT, a minor isomer in the DDT formulation, was injected into fertilized embryos of medaka fish at an egg concentration that was one-half of lethal levels, all male embryos were sex reversed to females (8). Furthermore, these genetic males were grown to maturity and found to be fully reproductively functional as females.

Another highly cited study found feminization of gull embryos after directly injecting DDE into eggs (11). Note, however, that feminization is distinct from sex reversal. Sex reversed males are reproductively functional. Feminization results in abnormal development of male reproductive tissue that has female morphological characteristics. However, feminized males are not reproductively competent females.

Other studies have supposedly proven effects of pesticide contaminants on sexual differentiation, but they are essentially epidemiological in nature. That is to say, there is an association (not to be mistaken with causation) of sexual abnormalities in animals collected from the wild with the presence of a mixture of environmental contaminants. Thus, Florida alligators from a lake impacted by a waste pesticide spill have

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smaller than normal penises (but no sex reversal) (12), and turtles have lower body shells more akin to females than to males (but have normal penises) (6).

Other sex reversal studies in animals have shown that masculinization rather than feminization is a possible outcome. Female marine mollusks exposed to tributyltin, an antifouling paint used on boats and ships, develop a pseudopenis in a condition called imposex (15, 32). At sites contaminated by PCBs and dioxins, sex ratio in populations of cricket frogs was skewed to male (27). Fish downstream of kraft mill paper bleaching plants exhibit sex ratios favoring males rather than the normal ratio slightly dominated by females (19). The hypothetical culprit in these cases is believed to be phytosterols, natural plant biochemicals released during the pulping process, not synthetic chemicals.

Plenty of experimental studies have shown no pesticide-related effect on sex reversal or any effect on male sexual differentiation. For example, separate studies of two different turtle species concluded that DDE did not alter sex of eggs incubated at male producing temperatures (25, 26). Atrazine and 2,4-D, two pesticides definitively found in waters of the Pacific Northwest, were painted on alligator eggs that were incubated at male-producing temperatures (4). Neither pesticide caused sex reversal to females as did the natural estrogen, nor were sex hormone levels and associated enzyme activities altered.

An increasing number of studies are showing that male fish can be induced to produce the egg developmental protein called vitellogenin when exposed to sufficient levels of estradiol or a surfactant degradation product called nonylphenol (14, 16, 31). Normally, only females produce vitellogenin as it is necessary to provide the egg with nourishment. Males contain the gene that codes for vitellogenin synthesis, but it is normally nonfunctional.

In the field, fish near sewage treatment plant discharge sites have been found with abnormally high levels of vitellogenin (28). Pesticide-impacted natural waters have not been associated thus far with vitellogenin induction in male fish. However, in the laboratory, o,p′-DDT and methoxychlor, but not endosulfan, have induced vitellogenin production in male fish (7, 14, 21). Nevertheless, vitellogenin production in males is not sex reversal nor an adverse reproductive effect but only a biomarker of exposure.

One other measure studied to determine if pesticides (and other contaminants) affect sexual development is the gonadosomatic index (GSI). The gonads of fish are surgically removed, weighed, and then compared to the whole body weight to calculate the index. A comparatively smaller index indicates that gonad development has been affected, presumably by some hormonally active agent. Estrogens and nonyphenol have definitively been shown to reduce gonadosomatic index. Thus far, data suggest that o,p′-DDT may be the only pesticide that can alter the GSI (21). Methoxychlor can induce vitellogenin production in rainbow trout but thus far seems unable to alter the GSI (33).

In summary, the evidence that modern pesticides can cause sex reversal or even feminization of fish is very weak. To date, only one isomer of the long-banned DDT has been shown capable of sex reversal, and as might be expected, it can induce vitellogenin production and alterations in gonad development. Methoxychlor, which is a biodegradable analog of DDT with very limited use in the United States, can induce vitellogenin production, but seems incapable of sex reversal and feminization of male gonads.

Finally, bear in mind that pesticides at sufficiently high concentrations can seriously harm individuals in a

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See also Dr. Felsot's "A Skeptic's Guide to the Hazard Assessment of Pesticides on Salmon," page 19.

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population. Whether the population as a whole suffers, however, is another matter. Population-level effects will depend on age structure (proportion of juveniles to adults) and whether the individuals affected are reproductively active or not (29). Based on our current knowledge of pesticide hazards to fish, pesticide concentrations in Pacific Northwest waters are just too low to blame them for harm to salmon populations (9, 10). Don't be misled by red herrings; they only detract from our understanding of significantly more important factors influencing the dynamics of salmon populations.

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...continued on page 20

Animals in Drag, cont.

Dr. Allan S. Felsot, Environmental Toxicologist, WSU

A Skeptic's Guide

to the Hazard Assessment of Pesticides on Salmon

Amidst the cacophony of published studies purporting that pesticides spell the doom of salmon populations, a few thoughtful questions might serve to help make sense of the noise.

Is the study in vitro or in vivo?

In vitro studies usually use unrealistically high doses or doses given in one sudden exposure. Such exposures overwhelm the normally protective effects of whole body distribution, metabolism, and excretion.

Is the study mechanistic or regulatory?

Mechanistic studies seek to understand or identify the nature of a hazard or the mechanism of its toxicity. Dosing is designed to cause an effect and is almost always not environmentally realistic. Regulatory studies seek to establish the lowest dose causing an effect (LOEL) and a dose not causing the effect (NOEL). Nevertheless, the NOEL for most pesticides is still substantially above environmental concentrations in water.

Is the study generating a hypothesis or validating one?

Hypotheses are generated from some set of observations about a phenomenon and seek to explain it. However, hypotheses need to be validated with experimentation having proper controls.

Did the study objectively review both the pros and cons of its hypothesis?

A researcher proposing a hypothesis should thoroughly analyze the scientific literature to obtain the likelihood his hypothesis is valid. Ideally he will explain the good and bad points about the hypothesis. Be wary of articles that propose a hypothesis but do not review the literature to indicate its likely validity.

Is the study epidemiological?

Epidemiological studies of chemicals can only show that the incidence of a disease is *associated* with one or more factors. Such studies are incapable of proving that the factors *caused* the disease.

Were exposures directly measured or inferred from environmental contamination levels?

Often, researchers observing some abnormal feature among individuals in a population will also measure environmental contaminants in the habitat or occasionally in sampled tissues from a limited number of individuals. However, endocrine disruption leading to altered sexual development is likely to have taken place during embryonic development (13). Thus, environmental residues and tissue concentrations in juveniles and adults are likely poor predictors of the effects of hormone mimics.

Animals in Drag, cont.

Dr. Allan S. Felsot, Environmental Toxicologist, WSU

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First Annual Precision Forestry Symposium

The First International Precision Forestry Symposium will be held on the campus of the University of Washington in Seattle June 17 through 19, 2001. The University of Washington's College of Forest Resources, in collaboration with the College of Engineering, created the Precision Forestry Cooperative under the umbrella of the Advanced Technology Initiative (ATI). The symposium is sponsored by the University of Washington College of Forest Resources' Precision Forestry Cooperative and supported by the American Society for Photogrammetry and Remote Sensing and the USDA Forest Service.

Emerging technologies and innovative applications are affording natural resource professionals opportunities unimagined in the recent past. This conference will offer perspectives on these advances. Topics will include remote sensing, tree measurement, automated systems, monitoring, road design, and decision support systems. Featured speakers include Rex McCullough, Weyerhaeuser Company USA; Fran Pierce, Director of the Washington State University Center for Precision Agricultural Systems; and Gero Becker, University of Freiburg, Germany. Optional activities include a Lake Washington dinner cruise the evening of Monday, June 18, and a day-long tour of Washington State Department of Natural Resources' Capital Forest in Chehalis (the latter limited to 80 attendees).

The basic conference fee is $295 before May 1, 2001. For more information, phone (206) 543-0867, e-mail **ForestCE@u.washington.edu** or point your Internet browser to **http://www.cfr.washington.edu/outreach/prefor/index.html**.

New On-Line Environmental Health Curriculum

Environmental Health in Family Medicine is a set of teaching and learning modules based on clinical cases. Topics covered include lead, indoor air quality, outdoor air quality, pesticides, water quality, and persistent organic pollutants. Each module is co-authored by a family physician and an environmental health specialist, and all modules have been peer-reviewed.

Each module, or the entire curriculum as a whole, can be viewed or downloaded in Portable Document Format (PDF) from the Internet URL **http://www.ijc.org/boards/hptf/modules/content.html** or can be ordered free of charge on CD-ROM.

Health professionals including family physicians, emergency physicians, nurses, and nurse practioners may find these tools useful for their own information or as teaching tools. The presentation of material emphasizes the three skill sets considered core to family medicine and other primary care settings: taking an exposure history, knowledge of resources, and risk communication.

This resource is made available by the Health Professionals Task Force of the International Joint Commission (IJC). The IJC was established by the 1909 Boundary Waters Treaty between the United States and Canada in recognition that the environment and human health of each country is affected by the other's actions with respect to lake and river systems along the border.

2001 Pesticide Container Recycling Schedule

Washington Pest Consultants Association

DATE	TIME	LOCATION	SPONSOR	CONTACT	PHONE
4/23	10a-1p	Pasco	Air Trac	Gerald Titus	509-547-5301
4/24	8a-11a	Eltopia	Wilbur Ellis	Vern Records	509-297-4291
	1p-3p	Eltopia	EA WA Spray Svc	Willis Maxon	509-297-4387
4/25	8a-10a	Pasco	Pfister Crop Care	Steve Pfister	509-297-4304
	1p-3p	Connell	B&R Crop Care	Chris Eskildsen	509-234-7791
4/26	8p-10p	Othello	Conner Flying Inc.	Mark Conner	509-488-2921
	1p-3p	Royal City	Cenex	Ted Freeman	509-346-2213
4/27	8p-10p	Bruce	Simplot	Chuck Spytex	509-488-2132
	1p-3p	Othello	B&H Chemical	Larry Hawley	509-488-6576
5/1	8a-11a	Mount Vernon	Wilbur Ellis	Marty Coble	360-466-3138
5/2	8a-11a	Conway	Cenex/Tronsdal Air Svc.	Will Cox	360-445-5015
				Kevin Belisle	360-661-0422
	12p-2p	NE Seattle	WA Tree Service	Ron Angle	206-362-9100
5/3	8a-11a	Puyallup	WSU Res Stn	Roy Jensen	253-445-4517
	8a-10a	Tacoma	Wilbur Ellis/DOT	Randy Knutsen	253-351-6591
				Dave Patterson	253-589-7255
5/4	8a-10a	Centralia	Lewis County Public Works	John Prigmore	360-740-1193
	8a-10a	Vancouver	WSU Res Stn	Martin Nicholson	360-576-6030
	1p-3p	Chehalis	Farm & Forest Helo Svc	Dan Foster	360-262-3197
	3p-4p	Morton	DOT	Craig Robbins	360-496-5516
5/14	9a-11a	George	Dependable Spray	Ceourt Rylaarsdam	509-785-2061
	1p-3p	Quincy	Cobia Spray Svc	Jim Cobia	509-750-2888
5/15	8a-10a	Quincy	Wilbur Ellis	Dale Martin	509-787-4433
	1p-3p	George		Randy Wentworth	509-878-1565
5/16	8a-10a	Quincy	Quincy Farm Chem	Ron Turner	509-787-3556
	1p-3p	Quincy	Simplot	Butch Creameans	509-787-1571
5/21	8a-10	Waverly	Wilbur Ellis	Monte Bareither	509-283-2432
	1p-3p	Tekoa	McGregor Co	Charles Wedin	509-284-5391
5/22	8a-10a	Oakesdale	Wilbur Ellis	Jerry Jeske	509-285-4511
	1p-3p	Garfield	Cascade Flying Svc	Doran Rogers	509-635-1212
5/23	8a-10a	Palouse	Dale’s Flying Svc	Dale Schoeflin	509-878-1531
	1p-3p	Dusty	Dusty Farm Coop	Chris Crider	509-397-3111
5/24	8a-10a	Warden	Kilmer Crop Dusting	Terry Kilmer	509-349-2491
	1p-3p	Bruce	Cenex	Lori Anderson	509-488-5261
5/25	8a-10a	Othello	S Saddle Orchard	Mike Macy	509-539-5836
	2p-4p	Black Rock	Stemilt Orchards	Jim Taylor	509-830-4888
5/29	8a-10a	Walla Walla	McGregor Co	Gary Burt	509-529-6787
	1p-3p	Waitsburg		Terry Jacoy	509-337-6621
5/30	8a-10a	Pomeroy	Western Farm Svc	Jerry Wilsey	509-843-3491
	1p-3p	Dayton	McGregor Co	Jeff Bruce	509-382-4704
5/31	8a-10a	Prescott	Agri Northwest	Shawn Elder	509-547-8870
	1p-3p	Prescott	Broetje Orchard	Joe Shelton	509-749-2107
			Flat Top Ranch	Dave Hovde	509-547-9682

Washington Pest Consultants Association (WaPCA) has been involved in recycling plastic pesticide containers since the early 1990s. They organize an annual series of collection dates and sites, contracting with Northwest Ag Plastics to collect and granulate the plastic containers. This table shows April and May dates only; a full schedule of dates through October is available on-line at **http://pep.wsu.edu/waste/wapca.html**. Dates, times, and locations are subject to change; use the contact information to confirm. For general questions, or to host an event at your farm, business, or in a central location in your area, contact Clarke Brown at (509) 965-6809, Dave Brown at (509) 961-8524 (**dbrownwash@msn.com**), or the Northwest Ag Plastics office at (509) 457-3850. THERE IS NO FEE FOR THIS SERVICE.

CONTAINERS MUST MEET THESE CRITERIA:

- Rinsed—no residue
- Clean and dry, no odor
- Majority of foil seal removed from spout
- Half-pint, pint, quart, 1 gallon, 2.5 gallon, and 5 gallon containers accepted whole
- Hard plastic lids and slip-on lids removed
- Glue-on labels may remain
- For 30 and 55-gallon containers, call 509-457-3850.

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

Pest of the Month
Aphids

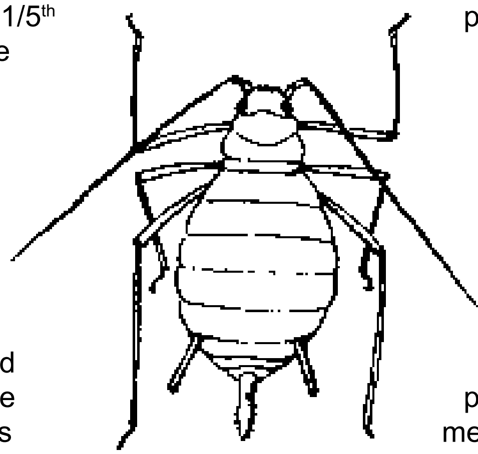
Page 23
Agrichemical & Environmental News
April 2001
No. 180

Jack Marlowe, President, Washington State Pest Control Association

Numerous species of aphids can be found throughout Washington State. These insects are members of the order Homoptera and have piercing/sucking mouth parts. They are active primarily during the months of April through October.

Description

In general, aphids are 1/25th to 1/5th inch in length. They are delicate insects with well-developed antennae. Most species comprise six segments. Adults are wingless or have two pairs of membranous wings depending on species and time of year. True aphids have a pair of cornicles or erect tubules on the top rear of the abdomen and a pointed caudal structure at the tip of the abdomen. Color varies between and among species.



STRAWBERRY LEAF APHID

Life Cycle and Habits

Aphids have a fascinating life cycle that includes both winged and wingless adult forms. They reproduce both through parthenogenesis (without the benefit or need for male insects) and sexually. Usually they overwinter as eggs on woody primary host plants, although some species overwinter as nymphs or adults. The insects undergo simple metamorphosis with egg, nymph (four instars), and adult stages. Generally, eggs hatching in the spring produce only wingless females. These females normally reproduce through parthenogenesis. Winged females are produced later in the spring, allowing for dispersal to other plant or crop types. Once the aphids disperse, they again produce wingless forms through summer. Winged males and females are produced in late summer/early fall, whereupon they breed and return to their primary host plant.

The insects feed by sucking plant juices. This can seriously effect the vitality of the host plant, causing damage to buds and fruiting bodies as well as leaving the plants weakened and susceptible to disease. Indeed, aphids are known to carry and transmit hundreds of viral diseases.

Aphids also play an important role as a food source for many ant species, including carpenter ants, odorous house ants, and argentine ants. The ants do not kill the aphids; on the contrary, they protect them from their natural predators. The ants feed on honeydew, a sugary waste product of the aphids.

Control

Aphids can be managed through the use of natural predators such as ladybugs. They can also be controlled through the use of insecticidal soaps, although this method is recommended for small applications of appropriately labeled products, mainly to houseplants and ornamentals. Systemic chemicals available to professional applicators and primarily aimed at ornamental plants can be very effective. Research has shown control results as high as 98% when combining soap with insecticide sprays, a rate greater than that achieved with either pesticide or soap alone (1).

Finally, using dormant oil sprays on woody primary hosts in late winter can greatly reduce spring populations of aphids. The oil smothers the overwintering eggs and/or insects, allowing new plant growth to develop in the spring unmolested. This also reduces the food supply for foraging ant species, especially around structures, and minimizes impact on non-target organisms.

*Jack Marlowe is the owner of Eden Advanced Pest Technologies (**http://edenpest.com**) and current President of Washington State Pest Control Association. He can be reached at **edenapt@olywa.net** or (800) 401-9935.*

REFERENCE

1. Funk, R. 1988. Davey's plant health care. Journal of Arboriculture 14 (12):285-287.

Federal Register Excerpts

Compiled by Jane M. Thomas, Pesticide Notification Network Coordinator, WSU

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

In the January 5 Federal Register, EPA announced the revocation of methyl parathion tolerances for the following crops: apples, artichokes, beets (greens alone), beets (with or without tops), birdsfoot trefoil forage, birdsfoot trefoil hay, broccoli, Brussels sprouts, carrots, cauliflower, celery, cherries, collards, grapes, kale, lentils, kohlrabi, lettuce, mustard green, nectarines, peaches, pears, plums (fresh prunes), rutabagas (with or without tops), rutabaga tops, spinach, tomatoes, turnips (with or without tops), turnips greens, vegetables leafy Brassica (cole), and vetch. In addition, EPA is amending the following tolerances: beans (amend to beans, dried), peas (amend to peas, dried) so that methyl parathion is not used on succulent beans and peas. Note that methyl parathion may still be used on lentils; however, residues on lentils are covered by the tolerance for peas, dried. (Page 1242)

In the January 10 Federal Register, EPA announced that it has received requests from Syngenta Crop Protection and Makhteshim Agan of North America, the companies that manufacture diazinon, to cancel their diazinon manufacturing-use product registrations. The companies have also asked EPA to amend their end-use product registrations to delete all indoor uses and the agricultural uses listed below:

♦ Indoor uses: Pet collars, or inside any structure or vehicle, vessel, or aircraft or any enclosed area, and/or on any contents therein (except mushroom houses), including food/feed handling establishments, greenhouses, schools, residences, museums, sports facilities, stores, warehouses and hospitals.

♦ Agricultural uses: Alfalfa, bananas, Bermuda grass, dried beans, celery, red chicory (radicchio), citrus, clover, coffee, cotton, cowpeas, cucumbers, dandelions, kiwi, lespedeza, parsley, parsnips, pastures, peppers, Irish potatoes, sheep, sorghum, spinach, squash (winter and summer), sweet potatoes, rangeland, strawberries, Swiss chard, tobacco, tomatoes, turnips. (Page 1977)

On January 25 EPA finalized the chlorpyrifos use deletions and product cancellations initially proposed in the November 17 Federal Register. These voluntary cancellations and amendments are the result of a memorandum of agreement signed by EPA and the basic manufacturers of chlorpyrifos on June 7, 2000. (Page 7753) (For a more detailed discussion of the chlorpyrifos actions see PNN notification 2000-283 on the PNN web page, http: www.pnn.wsu.edu.)

In the January 31 Federal Register, EPA announced that the revised risk assessment for diazinon was available for review and comment. The diazinon risk assessment, as well as other related documents, is available electronically at the following URL: http://www.epa.gov/pesticides/op/diazinon.htm. (Page 8400)

In the February 2 Federal Register, EPA announced that it was issuing an amendment to the Reregistration Eligibility Document (RED) for aluminum and magnesium phosphide. Specifically EPA is amending the risk mitigation measurers outlined in the original RED via a Memorandum of Agreement (MOA) reached between EPA and the phosphine registrants. The purpose of the MOA is to implement mitigation measures to meaningfully reduce risks and gather information to better characterize risks to workers and bystanders. The text of the entire agreement can be found at http://www.epa.gov/REDs. (Page 8790)

In the February 14 Federal Register, EPA announced that the preliminary human health risk assessment and related documents for atrazine are available for review and comment. Electronic copies of these documents are available at http://www.epa.gov/pesticides/reregistration/atrazine/. (Page 10287)

Tolerance Information

Chemical (type)	Federal Register	Tolerance (ppm)	Commodity (raw)	Time-Limited		
				Yes/No	New/Extension	Expiration Date
clopyralid (herbicide)	1/3/01 pg. 296	2.00	cranberry	Yes	Extension	12/31/03
Comment: This time-limited tolerance is being extended in response to EPA again granting Section 18s the use of clopyralid on cranberries for the control of lotus, Douglas aster, and clover in Oregon and Washington.						
myclobutanil (fungicide)	1/3/01 pg. 298	0.05	sugarbeet, roots	Yes	New	12/31/02
		0.70	sugarbeet, refined sugar			
		1.00	sugarbeet; tops, molasses, & dried pulp			
Comment: This time-limited tolerance is being established in response to the issuance of a Section 18 crisis exemption being granted for the use of myclobutanil to control downey mildew in Idaho sugarbeets.						
spinosad (insecticide)	1/9/2001 pg. 1592	4.00	alfalfa, forage & hay	Yes	New	12/31/02
		0.02	sugarbeet			
		10.00	sugarbeet, tops			
		0.25	sugarbeet, molasses			
		15.00	fat of cattle, goats, hogs, horses, & sheep			
		3.50	mbp of cattle, goats, hogs, horses, & sheep			
		0.60	meat of cattle, goats, hogs, horses, & sheep			
		0.30	poultry fat			
		7.00	grass, forage & hay			
Comment: These time-limited tolerances are being established in response to EPA receiving the following Section 18 exemption requests: Texas, New Mexico, Kansas and Oklahoma all requested the use of spinosad to control beet armyworm on alfalfa; California requested the use of spinosad on sugar beets to control armyworms; and Arkansas requested the use of spinosad to control armyworms in pastureland and rangeland.						
tebufenozide (insecticide)	1/10/01 pg. 1875	0.30	garden beet, root	Yes	New	12/31/02
		9.00	garden beet, top			
		15.00	sunflower			
		2.00	legume vegetable group			
		7.00	legume vegetable group, foliage			
Comment: These time-limited tolerances are being established in response to EPA granting Section 18 exemptions for the use of tebufenozide to control beet armyworm in California table beets and Texas legume vegetables and sunflowers.						
clopyralid (herbicide)	1/11/2001 pg. 2308	2.00	sugarbeet, roots	No	N/A	N/A
		3.00	sugarbeet, tops			
		10.00	sugarbeet, molasses			
Comment: With this action EPA is amending tolerances for clopyralid in sugarbeet roots and tops and is establishing a new tolerance for sugarbeet molasses.						

...continued on next page

Tolerance Information, cont.

Chemical (type)	Federal Register	Tolerance (ppm)	Commodity (raw)	Time-Limited		
				Yes/No	New/Extension	Expiration Date
carboxin (fungicide)	2/12/01 pg. 9770	0.20	onion, dry bulb	Yes	Extension	31-Dec-01
Comment: With this action EPA is re-establishing this time-limited tolerance. The tolerance is being re-established in response to EPA again granting a Section 18 exemption for the use of carboxin to control onion smut in California.						
clomazone (herbicide)	2/14/01 pg. 10196	0.05	cucurbit vegetable grou	No	N/A	N/A
		0.05	tuberous and corm (except potato) vegetable subgroup			
flutolanil (fungicide)	2/20/01 pg. 10817	0.20	potato	No	N/A	N/A
		0.30	potato, wet peel			
pendimethalin (herbicide)	2/22/01 pg. 11110	0.10	mint, hay	Yes	Extension	12/31/02
		5.00	mint, oil			
Comment: With this action EPA is re-establishing this time-limited tolerance. The tolerance is being re-established in response to EPA again granting a Section 18 exemption for the use of pendimethalin to control kochia and redroot pigweed in mint grown in Idaho, Oregon, and Washington.						

NW Consortium Presents 9th Annual

Food Safety Conference

May 30 - 31, 2001 • Best Western University Inn • Moscow, Idaho

Presented by the Northwest Food Safety Consortium, a group of faculty from Pacific Northwest universities who work on food safety education and research, this program to serves a wide audience of professionals who work on all aspects of food safety "from the farm to the table:" Cooperative Extension faculty, agricultural producers, food service managers, veterinarians, HACCP coordinators, food processors, clinical microbiologists, nutrition and health educators, food retailers, and public health professionals.

Topics this year include updates on the pathogens making news today; speculation on the pathogens of tomorrow (including a perspective on "mad cow disease"); a look at the role of water in food processing and food safety; practical discussion of Hazard Analysis and Critical Control Point (HACCP) implementation; and some alternative theories on antimicrobial resistance. Special attention will be given to the role of consumers in food safety—their perceptions and how best to educate them.

The Food Safety Farm to Table conference relies on support from the faculty and staff of the University of Idaho Cooperative Extension System and the Washington State University Cooperative Extension. For registration or more information, contact Ann Brelsford at WSU Cooperative Extension, P.O. Box 646230, Pullman, WA 99164-2921, (509) 335-2921, or annb@wsu.edu, or see the web page:

http://foodsafety.wsu.edu/farmtotable/