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Comments to: Catherine Daniels
WSU Pesticide Information Center
2710 University Drive
Richland, WA 99352-1671
Phone: 509-372-7495
Fax: 509-372-7491
E-mail: cdaniels@tricity.wsu.edu

The newsletter is on-line at
www2.tricity.wsu.edu/aenews,
or via the Pesticide Information
Center (PICOL) Web page at
http://picol.cahe.wsu.edu

Hard-copy subscriptions are $15 a
year. Mail check to above address,
ATTN: Sally O'Neal Coates, Editor.

Herbicide Tolerant Genes, Part 4

Withering Wildlife?

Dr. Allan S. Felsot, Environmental Toxicologist, WSU

A silent spring has become metaphor for ecological destruction by pesticides. Born forty years ago from the poetic pen of Rachel Carson, the idea grew and reached maturity with the banning of DDT in 1973. While there is no denying that Carson's book was a landmark event, the fact is that the spring never did go silent as she imagined. For example, the bald eagle (a putative tragic victim in DDT's heyday) seems to have made a comeback despite DDT's persistence.

Nonetheless, the idea of ecological destruction by pesticides has influenced public perception of crop protection technology, making every manmade chemical pest management tool out to be the twin sibling of DDT. DDT persists in the environment and accumulates in fatty body tissues. Pest management tools developed since the 1980s have neither of these traits. Glyphosate herbicide, for example, is a biodegradable non-accumulating synthetic amino acid. It has absolutely no chemical family relationship to DDT. Yet certain websites today assert that glyphosate poses enough ecological hazard and uncertainty to invoke the precautionary principle* (4).

Further stoking the herbicide hysteria, news reports this fall highlighted a study that concluded herbicide tolerant crops held the potential to destroy avian wildlife as we know it (or at least would like it to be) (29). Given the fact that the vast majority of herbicide tolerant crops are genetically engineered to resist the ravages of glyphosate, the world now has one more reason to despise Roundup Ready crops. Or does it?

A Little Perspective on the Big Picture

Before condemning glyphosate on the grounds of ecological disaster, let's put herbicide use in perspective. The vast majority of all herbicides are used on corn and soybeans: about 250 million pounds annually. Nearly every acre of these crops is treated (9). Much of this use is centered in the midwestern United States. In the southern tier of the country, cotton fields are treated annually with about 27 million pounds of herbicides.

**The so-called "precautionary principle" essentially holds that when any concerns or allegations, no matter how spurious, are raised about the safety of a product or activity, precautionary measures should be put in place and all burden of proof to the contrary should fall on the proponent of the allegedly unsafe product or activity.*

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Prior to the introduction of Roundup Ready beans, corn, and cotton, glyphosate had limited uses in crop production. For example, it was useful for “cleaning up” weedy, untilled fields before planting, especially if the alternative, soil cultivation, was going to promote soil erosion on sloping ground.

But now, with many farmers embracing Roundup Ready crops, closer to 45%, 20%, and 30% of the soybean, corn, and cotton acreage, respectively, are sprayed with glyphosate (9). Pertinently, other herbicides are still used, even in fields where glyphosate can be used. But overall, per acre glyphosate usage has gone up while other herbicide usage has gone down (9).

The bottom line is that the increase in glyphosate usage at what seems to be the expense of other herbicides has not introduced some new unknown risk on vast acreages of land. Mixtures of herbicides were historically used on nearly all bean, corn, and cotton acreage. Are people skittish about Roundup Ready crops because they fear farmers will become dependent on herbicides or because they believe herbicides are very dangerous to wildlife? Either way, the proper question is whether glyphosate introduces any unique hazards into a crop production system that embraced chemical weed control long ago.

Out to Get Glyphosate?

Glyphosate, like many other herbicides, has been saddled with the usual ecological laundry list: hazards to invertebrates, fish, birds, mammals, nontarget plants, and soil fertility. If glyphosate doesn’t kill an organism directly, it will alter the habitat to such a degree that wildlife populations will decline. Loss of biodiversity has become the new rallying cry.

OK, we’ll have to admit that glyphosate can do nasty things to most plant species. But its mode of action, inhibition of an enzyme only present in microorganisms and plants, is what makes it of low hazard to animals of all stripes. Does the fact that most plant species are susceptible to its toxic action make it any worse than wholesale dousing of a field with a herbicide that is only toxic to certain weeds and not others? Before answering, consider that herbicides are often used in mixtures so that the full spectrum of weeds in a crop can be controlled. Glyphosate may be doing the job of several herbicides.

If glyphosate will be replacing multiple other herbicides, questions about its direct and indirect effects on nontarget organisms are appropriate. So let’s examine some of the ecological claims against glyphosate, and by implication, herbicide tolerant crop technology in general. The hazards of glyphosate can be divided into directly toxic effects and indirect effects through alteration of habitat.

Ecotoxicological Risk Characterization of Direct Effects

Risk assessment is the currently accepted process for characterizing the likelihood that a chemical will have harmful effects on humans and the environment. Risk assessment consists of four integrated processes: hazard identification, dose-response characterization, exposure assessment, and risk characterization. To characterize the hazards of glyphosate, one would expose an organism to increasing doses or concentrations and then observe the response. The response (or toxicological endpoint) could range from death to severe organ pathology, or perhaps something more mundane like weight loss or enzyme changes in organs and blood.

If a series of low to high doses or concentrations are used in the hazard identification, then the relationship between dose or concentration and response can be determined for any toxicological endpoint. From this relationship, different parameters could be estimated, including the LD_{50} or ED_{50} and LC_{50} or ED_{50} (variously the dose [D] or concentration [C] that either kills [L for lethal] or causes harm [E for effective] to 50% of the test subjects). To be conservative in judgment about a pesticide’s ecological hazards, a risk assessor would want to focus on the response of the most sensitive organism (as determined by the magnitude of response for the most sensitive toxicological endpoint). Once the most sensitive organism is chosen from

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among an array of different species, the risk assessor then seeks the dose or concentration that causes no effect, either after a single exposure (acute toxicity) or after a daily lifetime exposure (chronic toxicity). While acute toxicity results in severe illness or death from an exposure close to the time of pesticide application, chronic toxicity represents effects on development, reproduction, behavior, and ultimately survival of the population.

The level of exposure causing no effect, the no-observable adverse effect level (NOAEL) or concentration (NOAEC), is either directly observed from experiments or estimated by dividing the acute LD_{50} or LC_{50} by a conservative safety factor of 5 (11). A safety factor of such magnitude represents one mortality out of a population of 10,000 (a probability of 0.0001). In the case of chronic toxicity, if a NOAEL or NOAEC has not been determined, a safety factor of 20 is applied to the LD/LC_{50}.

The directly observed or derived NOAELs and NOAECs are also known as toxicity reference values (TRVs) (11). They have been derived for glyphosate in a recently published comprehensive review of the worldwide ecotoxicology literature (Tables 1–3).

TABLE 1

Risk characterization for acute toxicity and exposure to glyphosate active ingredient following terrestrial uses of Roundup (adopted from 11)

Organism	Exposure Units[1]	Toxicity Reference Value (TRV)	Maximum Estimated Environmental Concentration (EEC)[2]	Hazard Quotient HQ[3]
Aquatic Organisms				
Microbes	mg/L	0.28	0.406	0.56
Plants	mg/L	0.08	0.406	0.52
Invertebrates	mg/L	0.5	0.406	0.21
Fish	mg/L	0.74	0.406	0.48
Amphibians	mg/L	0.74	0.406	0.25
Soil Organisms				
Microbes	mg/kg	16	15.1	0.94
Invertebrates	mg/kg	250	15.1	0.06
Terrestrial Organisms				
Birds (fruit/seed diet)	mg/kg/day	523	313	0.6
Birds (invertebrate diet)	mg/kg/day	523	313	0.6
Mammals (fruit/seed diet)	mg/kg/day	2,100	113	0.05
Mammals (invertebrate diet)	mg/kg/day	2,100	113	0.05
Mammals (foliage diet)	mg/kg/day	2,100	1,336	0.64

[1] **Exposure is to the isopropylamine salt of glyphosate (known as the active ingredient); glyphosate alone is called the acid equivalent. In Roundup, which is the formulated isopropylamine salt of glyphosate, 1 mg of active ingredient is equivalent to 0.75 mg of acid equivalents.**

[2] **The EEC was based on a Roundup application of 5 lbs AI/acre (5.6 kg AI/hectare).**

[3] **Hazard Quotient (HQ) = EEC/TRV; any ratio less than 1 indicates a reasonable certainty of no ecological harm.**

Lower Exposure = Less Risk

A well-known principle of toxicology is that at some dose or concentration all natural and synthetic substances will cause harm. Thus, to simply narrate the hazards of a chemical to an organism (for example, references 4 and 18) is not to tell the likelihood that the organism or its population will be affected in the environment. The next step of risk assessment, exposure assessment, crosses the bridge between hazard and risk.

Exposure can be characterized conservatively by starting with the known actual or maximum pesticide application rates on an area basis (e.g., the pounds of substance per acre) and calculating the resulting concentration, knowing the volume of soil or water on which the pesticide lands. For example, if the maximum permitted per-acre application rate of Roundup (the isopropyl amine salt of glyphosate) is 2.4 lbs. (equivalent to 2.68 kg/ha), the resulting Roundup concentration in the top 6 inches (15 cm) of soil will be 1.4 mg/kg (assuming a soil bulk density of 1 gram per cubic centimeter).

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Another conservative method for determining initial concentration is to examine the array of field studies and use the highest level reported. Estimated environmental concentrations (EECs) of glyphosate have been reported recently for both terrestrial and aquatic systems (Tables 1-3) (11). The concentrations for aquatic systems that are applicable to chronic exposure are conservatively higher than what the EPA used in its risk assessment of glyphosate.

Once the EECs are delineated for both acute and chronic exposures, risk can be characterized by the hazard quotient (HQ). The HQ represents the ratio of the EEC to the TRV for any particular organism and medium. When the ratio is 1 or less, exposure will be equal to or below levels that cause any kind of adverse effect. When the ratio is >1, adverse effects are possible but uncertain because the EECs are worst-case conditions not likely to occur over widespread areas. HQs are screening tools that can help determine if field studies are warranted to further measure exposure. However, if HQs are greater than 100, margins of safety inherent in the conservative assumptions behind the HQ are likely exceeded (11).

TABLE 2

Risk characterization for chronic toxicity and exposure to glyphosate acid following terrestrial uses of Roundup (adopted from 11).

Organism	Exposure Units[1]	Toxicity Reference Value (TRV)	Maximum Estimated Environmental Concentration (EEC)[2]	Hazard Quotient HQ
Aquatic Organisms				
Microbes	mg/L	0.28	0.0114	0.04
Plants	mg/L	0.08	0.0114	0.14
Invertebrates	mg/L	0.5	0.0114	0.02
Fish	mg/L	0.74	0.0114	0.02
Amphibians	mg/L	0.74	0.0114	0.02
Soil Organisms				
Microbes	mg/kg	5	2.6	0.52
Invertebrates	mg/kg	59.4	2.6	0.04
Terrestrial Organisms				
Birds (fruit/seed diet)	mg/kg/day	93	8.1	0.09
Birds (invertebrate diet)	mg/kg/day	93	8.1	0.09
Mammals (fruit/seed diet)	mg/kg/day	410	3	0.01
Mammals (invertebrate diet)	mg/kg/day	410	3	0.01
Mammals (foliage diet)	mg/kg/day	410	8.6	0.02

[1] **Exposure is expressed as glyphosate units without the associated isopropylamine (known as acid equivalents of glyphosate).**

[2] **The EEC was based on three Roundup applications and running the initial concentrations through a dissipation model that assumed a conservative half-life for glyphosate. The EEC represents the annualized mean concentration (the sum of the concentrations on each day of the year divided by 365).**

Based on the acute and chronic EECs and TRVs for Roundup and glyphosate in its acid equivalent form, the HQs for major groups of organisms are all below 1 (Tables 1,2). The estimations of hazard shown do not take into account that glyphosate will be used on fields with significant vegetative cover. Foliage will reduce glyphosate deposition on soil and consequently the movement in surface runoff, thereby further reducing exposure to soil and aquatic organisms. Thus, Roundup and its principle component, glyphosate, are highly unlikely to have any effects on populations and communities of terrestrial and aquatic organisms following crop use.

One noteworthy trait of Roundup is that the formulation surfactant, POEA (polyethoxylated tallowamine), is significantly more toxic to aquatic organisms than the glyphosate acid itself (Figure 1, page 6). If a three-foot deep, one-acre pond were accidentally oversprayed by a 2.4 lb. AI/acre application of Roundup, the initial concentration of glyphosate active ingredient mixed throughout the water column

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TABLE 3

Risk characterization for chronic toxicity and exposure to POEA surfactant following terrestrial uses of Roundup (adopted from 11).

Organism	Exposure Units[1]	Toxicity Reference Value (TRV)	Maximum Estimated Environmental Concentration (EEC)[1]	Hazard Quotient HQ
Aquatic Organisms				
Invertebrates	mg/L	0.1	0.005	0.05
Fish	mg/L	0.03	0.005	0.17
Terrestrial Organisms				
Mammals (fruit/seed diet)	mg/kg/day	16.5	1.4	0.09
Mammals (invertebrate diet)	mg/kg/day	16.5	1.4	0.09
Mammals (foliage diet)	mg/kg/day	16.5	4.2	0.25

[1] **POEA comprises about 15% of the formulation of Roundup. Roundup application rates are the same as in Table 2.**

would be 0.22 mg/L. The POEA concentration would be less than half this concentration because it constitutes only 15% of the Roundup formulation. Thus, even though acute toxicity of POEA is around 1.5 – 2 mg/L, the concentration from an accidental overspray is still at least five-fold less than the LC_{50}. The HQ analysis applied to POEA indicated that risk from chronic toxicity would also be nil (Table 3).

Backdoor Risk? The Scoop on Indirect Effects

Potential Effects on Soil Fertility The weight of evidence regarding ecotoxicity of glyphosate and the levels expected after application overwhelmingly suggests a remarkable level of safety for virtually all organisms tested. The only group of organisms that exhibit a NOAEC close to the EEC are soil microbes (Table 1, HQ of 0.94). Indeed, several laboratory tests of the effects of glyphosate on microbial processes have led some to speculate that nitrogen cycling and therefore soil fertility might be adversely affected (4). However, two problems with many of the microbial toxicity studies make them poor predictors of effects on soil fertility. First, many of the studies that have shown effects on nitrogen cycling processes have used liquid or agar laboratory cultures. Even so, a number of these studies concluded that field application rates would not adversely affect nitrification or other microbial functions (3, 7, 11, 12, 17, 23).

A second problem with the hypotheses that soil fertility might be affected is that after spraying, glyphosate would deposit on the soil surface. Glyphosate strongly adheres (sorbs) to the soil and does not leach (26). Indeed, it has almost no biological activity against plants when applied to soil. More importantly, glyphosate's lack of mobility makes it unlikely that microorganisms in the root zone would even be exposed. The soil surface, where the deposited glyphosate would remain, is highly susceptible to drying and high temperatures. Such conditions are not very microbe friendly anyway.

Potential Effects on Biocontrol A second indirect effect is adversity to beneficial predatory and parasitoid insects that could act as naturally occurring biocontrol agents. The International Organization for Biocontrol (IOBC) has tested numerous beneficial insect species (14). Glyphosate had very few adverse effects, but a few predatory beetles were found to be comparatively susceptible to glyphosate toxicity. However, these findings have almost no environmental relevance. The IOBC tests confines the insects to a glass surface completely coated with pesticide. The insects do not have a choice to move off the treated surface as they would on natural vegetation or on the soil surface. Furthermore, the glass surface does not mimic the sorptive nature of leaf and soil surfaces; sorption reduces the bioavailability of the pesticide for uptake by insects (8).

While the consensus of opinion is that glyphosate is extremely soft on insects (and other invertebrates) (6, 11), field studies have noted changes in abundance of beneficial insect populations following glyphosate applications. These changes range from minor to

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more severe depending on the remaining vegetative cover (1). Furthermore, such changes can occur after application of any herbicide or following hand weeding. In Roundup Ready soybeans, abundance of predatory insects was similar in herbicide-treated plots and hand-weeded plots (2). Predators were slightly more numerous in a conventional soybean plot treated with herbicides; however, this plot had greater vegetative cover than the glyphosate treated plot. These results suggest that anyone desiring to control weeds with a thorough hand-weeding or cultivation is just as likely to upset the "natural balance" as a herbicide application would.

Potential Effects on Wildlife Populations

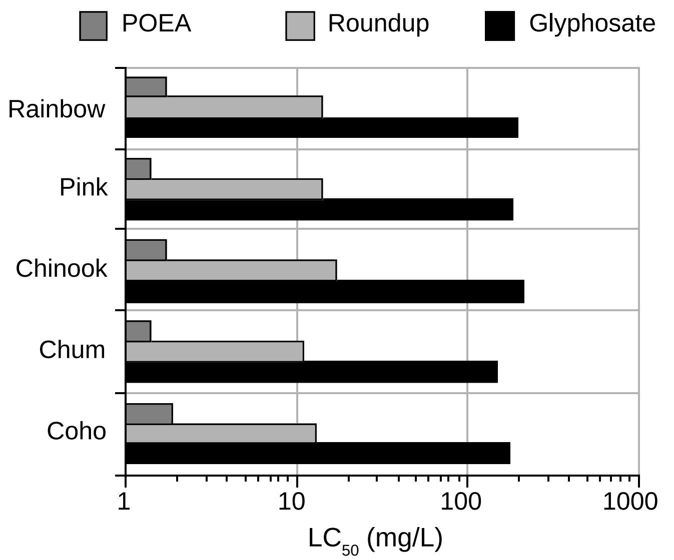
Drastic reductions in vegetative cover due to treatments with glyphosate have also been criticized for adverse effects on wildlife populations, including mammals, songbirds, and butterflies. Studies of forest clearcuts treated with herbicides have raised concerns that mammal and bird populations could be reduced by prolonged lack of vegetative cover (4). A careful review of these studies shows that species diversity is not affected, but the abundance of selected species may be altered temporarily until the vegetative cover is restored (5, 16, 20, 21, 22, 25). Clearcutting itself may be the principal factor affecting bird populations (16).

Like forest clearcutting, field tillage and harvesting greatly disturb habitat and are likely to alter faunal composition. Nevertheless, herbicide tolerant crops are being predicted to intensify an already severe population decline in songbirds, especially in the United Kingdom (29). Similarly, greatly improved weed control and the possible destruction of vestigial patches of milkweed are speculated to pose a great risk for monarch butterfly populations (27). Without the weed escapes that other herbicides supposedly allow, seed food sources will diminish and milkweeds will evaporate.

The supposed destruction of songbirds and butterflies rests on the faulty premise that efficiency of weed control will be vastly improved (10). Somehow glyphosate has been elevated to the status of a "super herbicide" capable of killing every plant in sight. Field studies in small plots of herbicide tolerant transgenic soybeans show that glyphosate treatments leave at least 2% of the plot areas covered with weeds (2). A 1999 random survey of Iowa landscapes for milkweed patches showed that 46% of cornfields and 57% of soybean fields contained easily discernible patches of milkweed (13). Given the tremendous area planted to herbicide tolerant crops in Iowa (9), one has to be skeptical about claims of super weed control. With regard to vegetation cover, one pertinent advantage of herbicide tolerant crops is that weeds can be left growing longer before the herbicide is used (10).

FIGURE 1

Acute toxicity of glyphosate acid, Roundup (containing glyphosate isopropylamine salt plus POEA surfactant), and POEA to four juvenile salmonid species and rainbow trout (based on 28). Shorter bars indicate greater toxicity.



What about the alleged silent spring in the United Kingdom? UK songbird populations have been declining since the 1970s, most likely due to intensification of agriculture and removal of refuge habitat (19). A recent report implicates both organic and conventional pasture production for silage instead of hay as a major factor in habitat loss for birds (15).

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Usage ≠ Hazard

The widespread use of millions of pounds of herbicides every year does not mean ecological danger is imminent. Atrazine, the most heavily used herbicide in corn production for thirty years running, is detected in nearly every surface water system in the world, yet a consortium of university scientists concluded that it posed no significant ecological risks (24).

We need more skeptical assessments of the claims about herbicides. Similarly, we should welcome periodic analysis and re-analysis of old and new data. The detailed independent reviews given to atrazine and glyphosate should be applied to any pesticide that has been on the market for awhile. But the analyses must critically examine each study to determine not only its merits, but also its applicability to characterizing probability of an effect in the environment. Distinctions must be made between studies designed to identify potential hazards and studies that address risks of the hazards ever being realized. Using this approach, concerns about increased glyphosate use may just wither away.

Dr. Allan Felsot is an Environmental Toxicologist with WSU's Food and Environmental Quality Laboratory. Parts 1, 2, and 3 of his "Herbicide Tolerant Genes" series can be found in the September ("Squaring Up Roundup Ready Crops"), November ("Giddy 'bout Glyphosate"), and December 2000 ("'Super-Weed' Myths and Kryptonite Remedies") editions of AE-News*, Issue No's 173, 175, and 176.*

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Canola Correction

An erroneous statement appeared in the article “Herbicide Tolerant Genes: ‘Super Weed’ Myths and Kryptonite Remedies” in *AENews* No. 176, December 2000. A paragraph on page 4 read:

> In Canada, three cultivars of herbicide-tolerant canola have been approved and commercially introduced. However, the cultivars tolerant to Pursuit (imazethapyr) or Liberty (bromoxynil) were derived by herbicide selection procedures, not genetic engineering. Only the RR canola is transgenic. The risk of gene flow is similar for all three cultivars, yet no herbicide-resistant weedy relatives have been reported where these tolerant cultivars are grown.

In fact, Canada has four systems of herbicide-tolerant canola, with many cultivars of each registered:

- Imidazoline tolerant (a.k.a. "Smart" system, or "Clearfield"); tolerant to Pursuit, Odyssey. Not transgenic but used biotech to select for the herbicide tolerance.
- Glyphosate tolerant (a.k.a. "Roundup Ready"); tolerant to Roundup. Transgenic method.
- Glufosinate ammonium tolerant; tolerant to Liberty. Transgenic method.
- Oxynil tolerant (a.k.a. "Navigator" system); tolerant to Compass, which is bromoxynil. Transgenic method.

AENews *thanks Murray Hartman, with the Government of Alberta, Canada, for providing this correction and additional information. Decision documents explaining breeding and safety are available through* **http://www.cfia-acia.agr.ca/**.

A Herbicide "Mode of Action" Primer

Dr. Rick Boydston, Weed Scientist, USDA

Herbicides can be classified in several different ways.

❶ Site of uptake in the plant (root vs. shoot).

❷ Degree of translocation within the plant (systemic vs. contact).

❸ Time of application (preplant incorporated, preemergence, postemergence).

❹ Chemical structure similarity (phenoxy vs. triazine).

❺ Mode of action (photosynthetic inhibitor vs. EPSP synthase inhibitor).

"Mode of action" is the sequence of events through which a herbicide kills a plant. Common herbicides used in Washington State are listed below according to their mode of action.

Acetyl CoA Carboxylase (ACCase) Inhibitors (Lipid Synthesis Inhibitors). This group includes the postemergence grass herbicides Achieve, Acclaim, Assure II, Fusilade, Hoelon, Poast, Prism, Select, and Whip. The ACCase enzyme is involved in synthesis of fatty acids in plants. Growth of the plant ceases soon after application. Grass plants slowly die about ten days to two weeks after application. About one week after herbicide application, when plants are still green, the tip of the grass shoot can be pulled out of the sheath and brown, dead tissue can be seen at the base of the removed segment. Wild oat populations that are resistant to ACCase inhibitors have been documented in the PNW.

Acetolactate Synthase (ALS) Inhibitors. Members of this group include the sulfonylurea ("su's") and imidazolinone ("imi's") herbicides. Examples are Accent, Ally, Amber, Battalion, Beacon, Escort, Finesse, Glean, Harmony Extra, Matrix, Maverick, Peak, Permit, and UpBeet (su's) and Assert, Pursuit, and Raptor (imi's). These herbicides inhibit the ALS enzyme involved in amino acid (valine, leucine, and isoleucine) synthesis. Biological activity of these herbicides is high at very low dosages. Initially plants turn chlorotic (yellow) in growing points. Susceptible plants die 1-2 weeks after herbicide application. These herbicides have both pre- and postemergence activity and resistant weeds (prickly lettuce, Russian thistle, and kochia) have developed rather quickly. Many herbicides in this group have long residual soil bioactivity and can present carryover problems in short crop rotations.

Microtubule Assembly Inhibitors. The dinitroaniline herbicides ("yellow herbicides") Treflan, Curbit, Prowl, Balan, Surflan, and Sonalan belong to this group. These herbicides bind to microtubule proteins involved in mitosis, resulting in inhibited cell division. They are normally incorporated preplant or applied preemergence to weeds to control many annual grasses and some small-seeded broadleaf weeds. Weed or crop injury often appears as stunted, short, stubby root growth and swollen, brittle stems.

Synthetic Auxins (Phenoxys, Benzoics, Picolinic Acids). This group includes 2,4-D, MCPA, MCPB, Banvel, Butyrac, Clarity, Garlon, Stinger, Curtail, Starane, and Tordon. The exact mechanism of action is not known, but it involves disruption of auxin (IAA) responses. These herbicides inhibit cell growth in meristematic regions but cause rapid uncontrolled cell division and malformed growth in other regions. These herbicides are generally applied postemergence for broadleaf weed control.

Photosystem II Inhibitors. These herbicides inhibit photosynthesis, the ability of plants to fix CO_2 into carbohydrates using energy from sunlight. They bind on a protein (D1) in photosystem II located in the chloroplast of the cell. I have grouped these into three categories based on their slightly different binding sites on the D1 protein.

Triazines and Uracils (e.g., Bladex, Princep, Aatrex, Caparol, Sencor, Velpar, Betamix, Pyramin, Hyvar, and Sinbar). Most are applied preemergence or early postemergence for broad-spectrum annual weed control. Triazine-

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Herbicide Primer, cont.

Dr. Rick Boydston, Weed Scientist, USDA

resistant and Sinbar-resistant weeds have been documented in Washington State, including biotypes of pigweed, lambsquarter, and common groundsel. Atrazine-containing products (Aatrex) and Hyvar and Sinbar have long residual soil bioactivity and can cause carryover problems to susceptible crops. Because of the extensive use of atrazine (Aatrex), it is sometimes found at very low levels in groundwater samples.

Benzothiadiazoles and Nitriles (e.g., Basagran and Buctril). These herbicides are applied postemergence for broadleaf weed control.

Ureas (e.g., Karmex and Lorox). These are applied preemergence or early postemergence for broad-spectrum weed control in trees, vines, carrots, and asparagus.

Photosystem I Inhibitors. These herbicides (bipyridiniums) inhibit photosynthesis in the plant chloroplast but inhibit in the PSI complex rather than the PSII complex mentioned above. Inhibition of photosynthesis in PSI results in lipid peroxidation and membrane disruption. Plants die rapidly after treatment and exposure to light. Gramoxone and Reglone are examples in this group. These herbicides are applied postemergence to weeds and are nonselective—they will kill exposed crops.

Lipid Synthesis Inhibitors (Not ACCase). Eptam, Ro-Neet, Far-Go, Sutan, Eradicane, and Avenge are members of this group. The mechanism of action is not well understood, but lipid synthesis is inhibited by these herbicides. The coleoptiles (emerging shoots) become swollen and fail to elongate, and usually seedlings do not emerge from the soil. Repeated use of several of these herbicides in the thiocarbamate group can lead to elevated populations of soil microorganisms that degrade the herbicide quickly so that the effective weed control period is reduced. Resistance to this herbicide family has developed in wild oat populations in the Pacific Northwest.

EPSP Synthase Inhibitors. Touchdown and Roundup or other glyphosate products inhibit this key enzyme in the shikimic acid pathway in plants. Synthesis of the amino acids tryptophan, tyrosine, and phenylalanine are inhibited by herbicides containing glyphosate. Susceptible plants die slowly, usually turning chlorotic (yellow) first. Glyphosate has no apparent soil activity and is applied postemergence for both annual and perennial weed control. Crops resistant to glyphosate have been developed which has led to wider use of this herbicide. Growers should rotate with herbicides having a different mode of action or use cultivation occasionally to prevent resistance development.

Glutamine Synthetase Inhibitors. These herbicides inhibit glutamine synthetase, which leads to accumulation of ammonia in the plant. This group includes Liberty, Rely, and Ignite herbicides, all containing the active ingredient glufosinate. These herbicides are applied postemergence for broad-spectrum weed control. Plant death is quicker than with Roundup but slower than with Gramoxone. Crops have been engineered that are resistant to Liberty herbicide.

Unknown Site of Action – Chloroacetamides. Lasso, Dual, Frontier, and Surpass are examples of this group of herbicides. The exact mode of action is unknown, but cell division is inhibited. These herbicides are applied preemergence to weeds and are absorbed by emerging plant shoots. They control annual grass and some small seeded broadleaf weeds. Yellow nutsedge is also suppressed by these herbicides.

Unknown Site of Action – Benzofuran. This group includes Nortron herbicide. It is applied preemergence and early postemergence for annual grass and some broadleaf weeds in sugarbeets and is absorbed by emerging shoots and roots.

Protoporphyrinogen Oxidase (Protox) Inhibitors. Goal, Milestone, Aim, and Spartan are members of this group of herbicides that inhibit the Protox enzyme leading to lipid peroxidation and membrane disrup-

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Herbicide Primer, cont.

Dr. Rick Boydston, Weed Scientist, USDA

tion. These herbicides have both preemergence and postemergence activity. Postemergence applications result in plants appearing water soaked, then necrotic; death follows in several days.

Carotenoid Synthesis Inhibitors. These herbicides, including Amitrole, Command, Evital, Solicam, Sonar, and Zorial, are known as "bleachers" because treated plants produce white foliage (sometimes termed "albino growth"). Carotenoids are compounds produced in plants that protect chlorophyll from being destroyed by light (photooxidation). Chlorophyll is the photosynthetic compound in plants giving them their green color. Once a plant's chlorophyll is destroyed, the plant appears white. Most of these herbicides are preemergence applied for broad-spectrum annual weed control in several tolerant crops.

Knowledge of a herbicide's mode of action can be useful in selecting and applying the proper herbicide in weed management programs. It can also prove useful in resolving problems with herbicide carryover or drift. Herbicides that inhibit different functions or enzymes in the plant often cause distinct injury symptoms.

Understanding various herbicides' modes of action is an important step toward anticipating resistance development and designing strategies to delay or prevent it. Herbicides with similar modes of action should be rotated or tank mixed with herbicides having different modes of action to prevent continuous selection of naturally occurring herbicide resistant weeds.

Dr. Rick Boydston is a Weed Scientist with the U.S. Department of Agriculture in Prosser. His office is located at the Irrigated Agriculture Research and Extension Center. He can be reached at (509) 786-9267 or ***boydston@tricity.wsu.edu****.*

IAREC: A Thumbnail Profile

While only 20% of Washington's agricultural acreage is irrigated, this acreage yields 70% of the state's farmgate value. Irrigated agriculture is big business for Washington State.

Washington State University's Irrigated Agriculture Research and Extension Center (IAREC) is headquartered in Prosser. IAREC encompasses nearly 1200 acres (about half in or near Prosser, and about half in Othello and Royal Slope), making it one of the nation's largest irrigated agriculture facilities. Eight academic departments are represented at the Prosser campus: Animal Science, Biosystems Engineering, Crop and Soil Science, Entomology, Food Science and Human Nutrition, Horticulture and Landscape Architecture, Plant Pathology, and Rural Sociology. It is also home to the Center for Precision Agriculture (**http://www.precisionag.prosser.wsu.edu/**) and to twelve U.S. Department of Agriculture scientists. The USDA has worked collaboratively with WSU since 1945, conducting research, serving as adjunct faculty, and mentoring graduate students. Information on USDA Agricultural Research Unit projects at Prosser can be seen at **http://www.usda.prosser.wsu.edu/**.

Commodities studied at IAREC include orchard crops (apples, cherries, and others), wine grapes, hops (largest program in United States), mint, asparagus, alfalfa, potatoes (and their rotational crops), small grains, vegetable/seed crops, and ornamentals. New and alternative crops are often first tested at IAREC. While emphasis over IAREC's 75-plus-year history has been largely on maximizing production, today's focus is turning toward environmental sustainability. For more information, contact IAREC Director and WSU Assistant Dean Arthur C. Linton at **alinton@tricity.wsu.edu** or (509) 786-2226, or see the IAREC web page at **http://www.prosser.wsu.edu/**

Which Pesticides Are Safe to Beneficial Insects and Mites?

Dr. David G. James, Entomologist, and Jennifer L. Coyle, Research Technician, WSU

In the April 2000 issue of *Agrichemical and Environmental News*, we introduced a new entomological and pesticide research program at Washington State University's Irrigated Agriculture Research and Extension Center in Prosser ("Protecting Our Insect and Mite Friends," Issue No. 168). This program aims to identify pesticides that are safe to endemic biological control agents in Washington's hopyards and vineyards, using a sensitive bioassay technique in the laboratory.

Currently, very little information is available on the toxicity of insecticides, miticides, and fungicides to the numerous species of predators and parasitoids that can occur in hops and grapes. Encouraging natural enemies to colonize and sustain themselves is an important element of integrated pest management (IPM). Natural enemies in vineyards and hopyards are important to Washington State and therefore are the focus of our research at WSU-Prosser.

Growers usually have a number of pesticide choices available for controlling the various insect, weed, and disease pests they face on a given crop. These different pesticides can have widely differing impacts on the beneficial insects pertinent to that crop, ranging from extremely harmful to completely safe. Knowing the impacts of specific chemicals on specific natural enemies in hops and grapes will provide an additional factor for growers to consider when choosing pesticides.

A large number of pesticides and a wide variety of beneficial insects affect the hop and grape industries. Washington State's hop and grape growers and processors, as well as the Washington State Commission on Pesticide Registration, have provided funding for the ambitious range of tests we have undertaken to review these many combinations.

Combinations Reviewed in 2000

There are many "friendly" bugs in hopyards and vineyards that need to be encouraged to stay and help provide control of pests like mites, aphids, mealybugs, and leafhoppers. We don't know the identity or importance of all these predators yet. Of those we know, we selected six to test in 2000: four predatory mites and two ladybugs.

The predatory mites were *Galendromus occidentalis, Neoseiulus fallacis, Amblyseius andersoni* and *Amblyseius* sp. near *tetranychivorus*. The first three are well-known predators of spider mites on grapes and hops as well as a number of other crops in the Pacific Northwest. The ladybugs were *Stethorus picipes* (a mite-eating ladybird) and *Harmonia axyridis* (multicolored Japanese ladybird).

TABLE 1

Safety ratings of selected pesticides against predatory mite species occurring in Washington hopyards and vineyards. (Not all combinations were tested.)

PESTICIDE	*Galendromus occidentalis*	*Neoseiulus fallacis*	*Amblyseius nr. tetranychivorus*	*Amblyseius andersoni*
Abamectin (M)	H	H	H	H
Cyhexatin (M)	H	H	H	
Propargite(M)	S	S	S	
Hexythiazoz (M)	S	S	S	
Fenpyroximate (M)		H		
Diazinon (I)		H		H
Imidacloprid (I)	H	H	S	
Pirimicarb (I)	H	S	MH	
Chlorpyrifos (I)	H	H	H	
Bifenthrin (I)	H	H	H	
Pymetrozine (I)	S	S		S
Myclobutanil (F)	S	S	S	

M = MITICIDE   I = INSECTICIDE   F = FUNGICIDE

S = SAFE = Less than 33% mortality expected when field rate used.

MH = MODERATELY HARMFUL = 33-66% mortality expected when field rate used.

H = HARMFUL = 66-100% mortality expected when field rate used.

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Safe to Beneficials, cont.

Dr. David G. James, Entomologist, and Jennifer L. Coyle, Research Technician, WSU

S. picipes is an effective predator of spider mites and *H. axyridis* is a voracious predator of aphids.

In 2000, we tested twelve insecticides, ten miticides, and one fungicide registered for use or being prepared for registration in hops and grapes.

Methodology

Cultures of the predatory mites were established in the laboratory and reared on spider mites. The ladybirds were obtained from unsprayed hopyards at WSU-Prosser and used in bioassays within twenty-four hours of collection.

Adult predatory mite females were individually selected and transferred from cultures to bean leaf discs using a fine bristle. For each pesticide, we used a single disc for concentrations equivalent to full, half, and one quarter of the recommended field rate when applied in 100 gallons of water per acre. An additional disc was used as a water-only control. Each test was replicated at least three times and data were combined to give results for about thirty individuals per concentration. Pesticides were applied in aqueous suspensions using a Precision Spray Tower with 2 mL of each concentration directly applied to predators on the leaf discs. Leaf discs were placed on saturated cotton wool in trays and each disc was supplied with spider mites as food for the predators. The predators were examined for mortality after twenty-four and forty-eight hours. All data were corrected for control mortality and tests were discarded if this mortality exceeded fifteen percent.

TABLE 2

Safety ratings of selected pesticides against two ladybird species occurring in Washington hopyards and vineyards.

PESTICIDE	*Stethorus picipes*	*Harmonia axyridis*
Abamectin (M)	H	H
Propargite (M)	H	S
Hexythiazox (M)	S	S
Fenpyroximate (M)	H	H
Bifenazate (M)	MH	MH
Milbemectin (M)	H	MH
Biomite (M)	H	S
Dicofol (M)		S
Fenbutatin-oxide (M)		S
Chlorpyrifos (I)	MH	H
Bifenthrin (I)	H	H
Thiamethoxam (I)	H	S
Diazinon (I)		H
Imidacloprid (I)	H	H
Pirimicarb (I)	H	S
Endosulfan (I)		S
Malathion (I)		H
Dimethoate (I)		H
Carbaryl (I)		H
Methomyl (I)		H
Pymetrozine (I)		S
Myclobutanil (F)	S	S

M = MITICIDE I = INSECTICIDE
F = FUNGICIDE

S = SAFE = Less than 33% mortality expected when field rate used
MH = MODERATELY HARMFUL = 33-66% mortality expected when field rate used
H = HARMFUL = 66-100% mortality expected when field rate used

Bioassays on ladybirds were conducted against early-mid stage larvae that were placed on grape leaf discs. Discs were placed on saturated cotton wool in small plastic cups. After application of pesticides (methodology same as for predatory mites), muslin lids were used to prevent larvae from escaping. Mortality of larvae was assessed after twenty-four hours.

Results

Test results are summarized in Tables 1 and 2, in which we assign arbitrary safety ratings for each chemical/natural enemy combination based on subject mortality. The miticides abamectin (Agri-Mek) and cyhexatin (Pennstyl) and the insecticides imidacloprid (Provado, Admire), chlorpyrifos (Lorsban), and bifenthrin (Brigade) were toxic to all the predators tested, while the miticides hexythiazox (Savey) and propargite (Omite), the insecticide pymetrozine (Fullfill), and the fungicide myclobutanil (Rally) were generally non-toxic to most species.

Implications

Spider mites are significant pests of hops and grapes in Washington. However, this should not be the case because these mites have a large and effective complex of natural enemies, which under 'normal'

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Safe to Beneficials, cont.

Dr. David G. James, Entomologist, and Jennifer L. Coyle, Research Technician, WSU

conditions prevents the occurrence of damaging populations. There are many crop ecosystems throughout the world that present ideal food resources for spider mites, but are not plagued by these pests, simply because sufficient numbers of predators exist within the crops to control them.

Our bioassay results indicate that many of the insecticides and miticides used in Washington grapes and hops are highly toxic to some of the natural enemies important in controlling mites. For example, Agri-Mek and Provado are the major chemicals used for mite and aphid control in hops. These compounds killed all the predator species we tested, even at half and quarter field rates. Provado is generally applied during June, when populations of *G. occidentalis, N. fallacis*, and *S. picipes* are increasing in hops, thus removing a significant component of natural control. The use of an aphicide, not toxic to the major predators, might delay the need to use a miticide. The use of a miticide not toxic to predators (e.g., Savey) might remove the need for a follow-up spray.

In grapes, mite predators will be adversely affected by applications of Lorsban and Admire for cutworm, leafhopper, and mealybug control. Once again, these applications are often made early in the season, destroying predator populations and likely making them ineffective as natural control agents for the rest of the season.

On the positive side, our bioassays indicated a number of chemicals to be safe to the predators we tested. Pymetrozine (Fullfill), a new aphicide, had low toxicity to the predatory mites we tested; its use in hops might overcome the problems outlined above. Savey and Omite appear to be safe to predatory mites, although Omite was toxic to the ladybird species *S. picipes*.

The next phase of our testing will include more fungicides used in hops and grapes. Rally, the only fungicide tested so far was virtually non-toxic to predators, but some impact was observed on egg laying in some species. Reduced reproductive potential or even sterility caused by fungicide exposure has been reported for some natural enemies.

Pesticide use can be tailored so that it not only provides effective control of pests, but also preserves predators and parasitoids. This is probably the single most important thing growers can do to increase biological control and reduce pesticide use in their crops. The information our bioassay program will generate in the coming years can be an important part of an integrated pest management process.

Dr. David James and Jennifer Coyle are with WSU's IAREC facility in Prosser. They can be reached at ***djames@tricity.wsu.edu*** *or* ***jcoyle@tricity.wsu.edu****, respectively, or at (509) 786-9280.*

WSDA Waste Pesticide Collection

The Washington State Department of Agriculture periodically collects waste agricultural and commercial grade pesticides from residents, farmers, business owners, and public agencies free of charge. The goal of this program is to properly dispose of unused or unusable pesticides, eliminating these as potential sources of contamination to the environment. Since disposal is complex, participants must register prior to an event to allow WSDA and the waste contractor to determine the types and amounts of pesticides that will be collected. To register, or for more information, contact WSDA at **(877) 301-4555.**

Collection Site Nearest City	Collection Event Date	Registration Deadline	Inventory to WSDA Deadline
Yakima	April 23 & 24	March 8	March 22
Pasco	April 25	March 8	March 22
Spokane	April 26	March 8	March 22
Oroville	May 15	March 27	April 9
Okanogan	May 16	March 27	April 9
Wenatchee	May 17	March 27	April 9
Mount Vernon	May 22	April 2	April 24
Puyallup/Tacoma	May 24	April 3	April 25

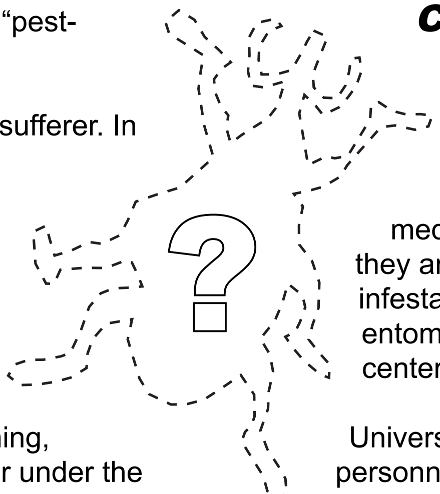
Pest of the Month

Delusory Parasitosis

***Agrichemical and Environmental News* Staff**

When is a pest not a pest? This “Pest of the Month” feature has dealt with a wide variety of pests, from insects everyone would agree are pestiferous (see “Yellowjackets,” *AENews* No. 173, Sept. 2000), to insects more beneficial than harmful (see “Ladybird Beetle,” *AENews* No. 174, Oct. 2000), to pests that aren’t insects at all (see “Rodents,” *AENews* No. 175, Nov. 2000). While *Agrichemical and Environmental News* in general deals with pests that are problematic on an economic scale, the fact is that the definition of “pest” is subjective. Stated differently, “pestiness is in the eye of the beholder.”

This month’s pest is truly defined by the sufferer. In fact, it’s not a “thing” at all, but a condition. Delusory parasitosis is a condition where a sufferer holds a belief that his or her body has been infested by parasitic insects which do not, in fact, exist.



Description

Individuals suffering from delusory parasitosis experience sensations of itching, pricking, tingling, creeping, or biting on or under the surface of their skin. By the time they present these symptoms to a professional, they are often exacerbated by self-inflicted irritations ranging from surface scratches to infections to residual effects of skin treatments. Since suffers believe insects are the cause of their discomfort, application of home remedies believed to have pesticidal properties are not uncommon.

Causes

Causes of delusory parasitosis may be physical, mental, or a combination. Any physical stimulus that causes a sensation of itching or tingling can be a catalyst. As dry, sensitive skin is particularly susceptible to these sensations, wintertime is prime time for the appearance of delusory parasitosis. While most of us experience dry skin and itching, even tingling or “crawling” sensations from time to time, we tend to rub or scratch briefly and move on. Delusory parasitosis sufferers focus on the sensation until it occupies their entire attention; they fixate on the irritation. Other physiological causes can include allergies, drug reactions, nutritional imbalances, exposure to various fibers and chemicals, and other medical and environmental conditions. Psychologically, touching, scratching, and rubbing are viewed as forms of self-assurance, while itching and tingling can be symptoms of stress, depression, and fatigue. It is not surprising that many who suffer from delusory parasitosis live alone and have limited social contact.

Control/Treatment

Delusory parasitosis is a medical condition, and should be handled by a medical professional. Ironically, those suffering from it are not inclined to present themselves to a medical professional. Instead, believing they are indeed suffering from an insect infestation, they bring their complaint to entomologists, pesticide information centers, and pest control professionals.

University, extension, and pest control personnel are not qualified to deal with the “pest” of delusory parasitosis. What should we do if confronted with a person complaining of these symptoms? First, determine whether an arthropod is involved. Thrips can be brought in on flowers and houseplants, mites can infiltrate structures from bird or rodent nests, and bedbugs and fleas are certainly arthropod pests that can be controlled. If no “bugs” are involved, the only ethical course of action is to refer the complainant to a medical professional such as a dermatologist. Whether the cause is a physical, non-entomological presence in the home or office, or whether these pests reside more in the sufferer’s head than on his or her skin, that determination is best left to the medical profession.

This article drew on delusory parasitosis information from several sources, most notably Dr. Nancy C. Hinkle’s article, “Delusory Parasitosis,” in American Entomologist, *Vol. 46, No. 1, pp. 17-25.*

Tolerance Information

Tolerance Information

Chemical (type)	Federal Register	Tolerance (ppm)	Commodity (raw)	Time-Limited		
				Yes/No	New/Extension	Expiration Date
fludioxonil	12/6/00	2.00	caneberries	Yes	Extension	12/31/01
(fungicide)	pg. 76169					
Comment: This time-limited tolerance is being extended because EPA has received a request to extend the use of fludioxonil to control gray mold on caneberries in Oregon and Washington due to the widespread development of pest resistance to previously-used standard fungicides.						
thiamethoxam	12/21/00	0.02	barley, grain	No	N/A	N/A
(insecticide)	pg. 80343	0.05	barley, hay			
		0.03	barley, straw			
		0.02	canola seed			
		0.02	meat and mbp of cattle, goats, hogs, horses, and sheep			
		0.02	sorghum: forage, grain, & stover			
		0.50	wheat, forage			
		0.02	wheat: grain, hay, & straw			
avermectin	12/21/00	0.05	spinach	Yes	Extension	12/31/02
(insecticide)	pg. 80333					
Comment: With this action EPA is reestablishing the tolerance for avermectin on spinach that previously expired 1/31/00. The tolerance is being reestablished in response to EPA again granting a Section 18 for the use of avermectin to control leafminers in California spinach.						
desmedipham	12/28/00	0.20	red beet, roots	Yes	Extension	12/31/01
(herbicide)	pg. 82291	15.00	red beet, tops			
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 exemption for the use of desmedipham to control broadleaf weeds in New York beets.						
cyprodinil	12/28/00	10.00	caneberries	Yes	Extension	12/31/01
(fungicide)	pg. 82288					
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of cyprodnil to control gray mold in caneberries grown in Washington and Oregon.						
fludioxonil	12/29/00	1.00	grapes	No	N/A	N/A
(fungicide)	pg. 82927	2.00	strawberries			
		0.20	onions, dry bulb			
		7.00	onions, green			
paraquat	12/29/00	0.05	artichoke	Yes	Extension	12/31/02
(herbicide)	pg. 82937					
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of paraquat to control weeds in artichokes in California.						
lambda-cyhalothrin	12/29/00	0.20	barley, bran	Yes	Extension	12/31/02
(insecticide)	pg. 82937	0.05	barley, grain			
		2.00	barley, hay & straw			
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of lambda-cyhalothrin to control Russian wheat aphid barley grown in in Wyoming, Montana, Idaho, and Colorado.						
difenoconazole	12/29/00	0.10	sweet corn, stover	Yes	Extension	12/31/02
(fungicide)	pg. 82937	0.10	sweet corn, forage			
		0.10	sweet corn (kernels plus cob with husks removed)			
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of difenoconazole to control fungal pathogens in Florida sweet corn seed crops.						

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Tolerance Information, cont.

Tolerance Information

Chemical (type)	Federal Register	Tolerance (ppm)	Commodity (raw)	Time-Limited		
				Yes/No	New/Extension	Expiration Date
fenbuconazole (fungicide)	12/29/00 pg. 82937	1.00	blueberries	Yes	Extension	12/31/02
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of fenbuconazole to control mummyberry disease in Georgia blueberries.						
sulfentrazone (herbicide)	12/29/00 pg. 82937	0.10 0.10	sunflower succulent bean seed without pod	Yes	Extension	12/31/02
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of sulfentrazone to control hophornbeam copperleaf in Tennessee cowpeas and lima beans and to control weeds in North Dakota sunflowers.						
imazamox (herbicide)	12/29/00 pg. 82937	0.05	canola	Yes	Extension	12/31/03
Comment: This time-limited tolerance is being extended in response to EPA again granting a Section 18 for the use of imazamox to control wild mustard in canola grown in Minnesota and North Dakota.						

Pesticide Applicator Training

Washington State University provides pre-license and recertification training for pesticide applicators. **Pre-license training** provides information useful in taking the licensing exam. **Recertification** (continuing education) is one of two methods to maintain licensing. (The other is retesting every five years.) Course registration (including study materials) is $35 per day if postmarked 14 days prior to the first day of the program you will be attending. Otherwise, registration is $50 per day. These fees do not include Washington State Department of Agriculture (WSDA) licence fees.

EASTERN WASHINGTON			WESTERN WASHINGTON		
Date	**City**	**Facility**	**Date**	**City**	**Facility**
PRE-LICENSING					
Feb. 6, 7, 8	Spokane	Valley Doubletree	Feb. 6, 7, 8	Kirkland	Lake WA Tech College
			Mar. 13, 14, 15	Puyallup	WSU Allmendinger Ctr
Feb. 13, 14, 15	Moses Lake	Convention Center	Mar. 27, 28, 29	Bellingham	Whatcom Comm. Coll.
RECERTIFICATION					
Feb. 7, 8	Spokane	Valley Doubletree	Feb. 1, 2	Des Moines	Highline Comm. College
Feb. 14, 15	Moses Lake	Convention Center	Feb. 7, 8	Kirkland	Lake WA. Tech. College
Special Commercial Applicator Workshop Feb 9, Spokane, Valley Doubletree			Feb. 13, 14	Port Orchard	Givens Comm. Center
			Mar. 8, 9	Seattle	UW Urban Hort. Ctr.
			Mar. 27, 28	Bellingham	Whatcom Comm. Coll.

For more detailed information, visit the Pesticide Education Program website's training page at

http://pep.wsu.edu/education/educ.html

Federal Register Excerpts

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

In the December 6 Federal Register, EPA announced the issuance of a cancellation order for chlorpyrifos that was signed November 27, 2000. This order confirms the use deletions and product cancellations announced in the September 20 Federal Register. (Page 76233)

In the December 12 Federal Register, EPA announced that the revised risk assessment for malathion was available for comment. The malathion risk assessment, as well as other related documents, is available electronically at the following URL: **http://www.epa.gov/pesticides/op/malathion.htm**. (Page 77624)

In the December 15 Federal Register EPA announced the availability of the interim risk management decision documents for seven organophosphate and carbamate pesticides: Coumaphos, fenitrothion, mevinphos, oxamyl, phostebupirim, propetamphos, and tribufos. These decision documents are available for review at the following URL: **http://www.epa.gov/pesticides/**. (Page 78488)

In the December 20 Federal Register EPA announced that the Reregistration Eligibility Decision (RED) documents for the pesticide active ingredients diclofop-methyl, etridiazole (Terrazole), and vinclozolin were available for review and comment. Comments must be received on or before February 20, 2001. These REDs and the associated Fact Sheets are available electronically at the following URL: **http://www.epa.gov/oppsrrd1/REDs/**. (Page 79832)

PNN Update

The Pesticide Notification Network (PNN) is operated by WSU's Pesticide Information Center (PIC) 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 can be viewed on our web page. Access the PNN page via the Pesticide Information Center On-Line (PICOL) Main Page, **http://picol.cahe.wsu.edu/,** or directly, at **http://www.pnn.wsu.edu/**.

Should you have questions about the PNN or information on our PICOL page, e-mail PNN Coordinator Jane M. Thomas at **jmthomas@tricity.wsu.edu** or contact Pesticide Information Center Manager Catherine Daniels at **cdaniels@tricity.wsu.edu** or (509) 372-7495.