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Insecticide Information Sheet

Insecticide	Toxicological Effects	Ecological Effects	Fate in the Environment
Endosulfan			
Methamidophos			
Imidacloprid			
Esfenvalerate			
Dimethoate			

Insecticide Information Sheet with Answers

Insecticide	Toxicological Effects	Ecological Effects	Fate in the Environment
Endosulfan	Toxicity Class I—highly toxic through the oral and dermal routes; only slightly toxic through inhalation; may cause mutagenic effects in humans if exposure is great enough.	Highly to moderately toxic to bird species; very highly toxic to four fish species and to both of the aquatic invertebrates studied. (It is moderately toxic to bees and is relatively nontoxic to beneficial insects such as parasitic wasps, lady bird beetles, and some mites.)	Moderately persistent in the soil environment with a reported average field half-life of 50 days. (Large amounts of endosulfan can be found in surface water near areas of application. It has also been found in surface water throughout the country at very low concentrations.)
Methamidophos	Toxicity Class I—highly toxic through the oral, dermal, and inhalation routes of exposure; reduced sperm count and reduced sperm viability observed in humans; may be weakly mutagenic.	Very toxic to birds; toxic to aquatic organisms; toxic to bees.	In aerobic soils, half-life of 1.9 to 12 days; half-life in water of 309 days at pH 5.0, 27 days at pH 7.0, and 3 days at pH 9.0.
Imidacloprid	Toxicity Class II and Class III—moderately toxic; may be weakly mutagenic; considered to be of minimal carcinogenic risk.	Toxic to upland game birds; moderately low toxicity to fish; highly toxic to bees if used as a foliar application, especially during flowering, but not considered a hazard to bees when used as a seed treatment.	Half-life in soil of 48–190 days; half-life in water that is much greater than 31 days.

Insecticide Information Sheet with Answers (continued)

Insecticide	Toxicological Effects	Ecological Effects	Fate in the Environment
Esfenvalerate	Toxicity Class II—moderately toxic compound through the oral route; slightly toxic through the dermal route; practically nontoxic through inhalation.	Slightly toxic to birds; very highly toxic to fish and aquatic invertebrates; highly toxic to bees.	Moderately persistent with a half-life ranging from about 15 days to 3 months; half-life in water of about 21 days.
Dimethoate	Toxicity Class II—moderately toxic by ingestion, inhalation, and dermal absorption.	Moderately to very highly toxic to birds; moderately toxic to fish; highly toxic to honeybees.	Low persistence in the soil (half-life of 20 days); half-life in raw river water of 8 days.

Herbicide Information Sheet

Herbicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Linuron			
Glyphosate			
Metribuzin			
Paraquat			
Metolachlor			

Herbicide Information Sheet with Answers

Herbicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Linuron	Toxicity Class III—slight toxicity by ingestion; slight toxicity by inhalation; either nonmutagenic or slightly mutagenic.	Slightly toxic to birds; slightly toxic to fish and aquatic invertebrate species; nontoxic to bees.	Moderately persistent in soils, with a field half-life of 30 to 150 days in various soils and under various conditions; slightly to moderately soluble in water; not readily broken down in water.
Glyphosate	Toxicity Class II—practically nontoxic by ingestion; practically nontoxic by skin exposure. (Some formulations may show high acute inhalation toxicity.)	Slightly toxic to wild birds; practically nontoxic to fish; may be slightly toxic to aquatic invertebrates; nontoxic to honeybees.	Moderately persistent in soil, with an estimated average half-life of 47 days; half-life in pond water that ranges from 12 days to 10 weeks.
Metribuzin	Toxicity Class III—slightly toxic through the oral route; practically nontoxic dermally; moderate toxicity through the inhalation route.	Moderately to slightly toxic to birds; slightly toxic to fish; nontoxic to bees.	Moderate persistence in the soil environment (soil half-life of 30 to 120 days); half-life in pond water of approximately 7 days.

Herbicide Information Sheet with Answers (continued)

Herbicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Paraquat	Toxicity Class I—highly toxic through ingestion; moderate toxicity through the dermal route. (Persons with lung problems may be at increased risk from exposure. Many cases of illness or death have been reported in humans. Evidence regarding carcinogenic effects of paraquat is inconclusive.)	Moderately toxic to birds; slightly to moderately toxic to many species of aquatic life; nontoxic to honeybees.	Highly persistent in the soil environment, with reported field half-life of greater than 1,000 days.
Metolachlor	Toxicity Class III—slightly toxic through ingestion; slightly to practically nontoxic by skin exposure; slight toxicity through inhalation.	Slightly to practically nontoxic to birds; moderately toxic to both cold-water and warm-water fish, including rainbow trout, carp, and bluegill sunfish; nontoxic to bees.	Moderately persistent in the soil (half-life of 15 to 70 days); highly persistent in water over a wide range of water acidity.

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Fungicide Information Sheet

Fungicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Dimethomorph			
Chlorothalonil			
Maneb			
Mancozeb			
Metiram			

Fungicide Information Sheet with Answers

Fungicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Dimethomorph	Toxicity Class III—slightly toxic; slightly toxic to mammals.	Practically nontoxic to birds; moderately toxic to fish; slightly toxic to aquatic invertebrates, algae, and bacteria; nontoxic to bees.	Low soil mobility and low leaching potential.
Chlorothalonil	Toxicity Class II—moderately toxic; slightly toxic to mammals, but can cause severe eye and skin irritation.	Practically nontoxic to birds; highly toxic to fish, aquatic invertebrates, and marine organisms; nontoxic to bees.	Moderately persistent; in aerobic soils, half-life of from 1 to 3 months.
Maneb	Toxicity Class IV—practically nontoxic by ingestion; through the dermal route, is slightly toxic; very high level of exposure necessary to cause reproductive effects in humans; that level of exposure not likely under normal circumstances.	Practically nontoxic to birds; highly toxic to fish and aquatic species; may be toxic to livestock; not thought to be toxic to bees.	Low persistence (with a reported field half-life of 12 to 36 days), but readily transformed into ethylenethiourea, which is more persistent; would degrade completely within 1 hour under anaerobic aquatic conditions.

Fungicide Information Sheet with Answers (continued)

Fungicide	Toxicological Effects	Ecological Effects	Fate in the Environment
Mancozeb	Toxicity Class IV—practically nontoxic through the oral and dermal routes; metabolite that produced birth defects and cancer in experimental animals; either not mutagenic or weakly mutagenic; carcinogenic potential of mancozeb not currently known.	Slightly toxic to birds; moderately to highly toxic to fish and aquatic organisms; not toxic to honeybees.	Of low soil persistence, with a reported field half-life of 1 to 7 days; not poisonous to plants; degrades in water with a half-life of 1 to 2 days.
Metiram	Toxicity Class IV—practically nontoxic when ingested; slightly toxic through the dermal route; slightly toxic through inhalation route. (Ethylenethiourea, a contaminant and a breakdown product of metiram has been shown to cause birth defects and cancer in experimental animals.)	Slightly toxic to birds; slightly to moderately toxic to fish; practically nontoxic to bees.	Of low persistence and strongly bound to most soils; very rapid breakdown in water.

Pota-pourri

1/3 .... Fraction of U.S. potatoes grown in Wisconsin.

60 percent................ Percentage of Wisconsin potatoes turned into potato chips, french fries, or other processed potato foods.

100............................ Pounds of potatoes the average American eats each year.

80,000 .... Acres used in Wisconsin to grow potatoes.

789 million .... Pounds of pesticide used for agriculture in the United States in 1994.

5th .... Potatoes rank fifth in overall pesticide use after corn, soybeans, cotton, and grapes.

67 million .... Birds killed each year by pesticides.

74 percent................ The percentage of all U.S. households using some form of pesticide in 1994.

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Ranking Pesticides Question Sheet

Using the information you gathered about the five different pesticides that your team researched, discuss these questions as a group. Record your answers.

1. Which one would you consider the most toxic and least toxic according to **toxicological effects**?

2. Which one would you consider the most toxic and least toxic according to **ecological effects**?

3. Which one would you consider the most toxic and least toxic according to **fate in the environment**?

4. If you had to advise farmers about which of the five pesticides your group researched is the "worst" to use in terms of its effects on people and the environment, which would you choose? Why? What about the "best" one to use? Why?

5. Was it easy to establish the ranking for Question 4? Why or why not?

Fields of Change

by Jennifer Curtis

Adapted with permission from *Fields of Change, A New Crop of American Farmers Finds Alternatives to Pesticides*, Natural Resources Defense Council, July 1998.

John and Andrew Wallendal; their father, Peter; and their brother-in-law, Robert Stodola, grow vegetables on 3,225 acres in the Central Sands region of Wisconsin, north of Madison. The area has sandy soils that were turned into one of the most productive vegetable-producing regions of the country through the invention of irrigation equipment and manufactured fertilizers. The Wallendals' number one crop is potatoes—and they grow a lot of them. Every year, they harvest 39 million pounds of potatoes, most of which are sold and made into french fries.

Besides being characterized by sandy soils, the

Central Sands region also has a shallow *ground-water aquifer*. That term means that there is a lot of water not far below the surface of the soil—water that can be tapped by wells and used for people's homes, businesses, and farms. But because the groundwater is close to the surface and the soil is sandy, chemicals such as fertilizers and pesticides that people spread on the ground can easily percolate down into the groundwater.

Concerned about contaminating the underground aquifer with pesticides and fertilizers, the Wallendals wanted to change the way they farmed. They also wanted to help prevent soil erosion on their property. But they wanted—and needed—to address those concerns while still producing a high yielding, top-quality crop. They have been so successful that they have earned recognition throughout the industry. From 1991 through 1996, the Wallendals' farm was awarded six top grower awards for the central states region for outstanding potato quality. And in 1997, the Wallendals were recognized nationally by the National Potato Council for their efforts to practice "Environmental Stewardship." Here is how they did it.

Finding New Ways to Fight Old Foes

The Wallendals started out farming in the conventional way, relying extensively on the use of pesticides and synthetic fertilizers. But around 1990, the family members decided they wanted to take a more integrated, holistic approach to growing vegetables. One of the events that made them want to change what they were doing was the ban of an acutely toxic insecticide called Temik (also called *aldicarb*)

Rose aphid

Until 1987, John used Temik every year at planting. It controlled all three of the worst potato pests: Colorado potato beetles, potato leafhoppers, and aphids. It also left residues on plants—

Fields of Change (continued)

residues that could harm people who ate the food. When Temik was pulled off the market because of such health concerns, the Wallendals had to figure out a way to combat all three potato pests using other tactics.

For 18 years, the Wallendals had been using professional Integrated Pest Management (IPM) services to monitor pest levels in their fields. The IPM professionals checked the fields according to a schedule set out before the beginning of the season. After Temik was pulled from the market, the Wallendals hired a second in-house person to scout for insect population levels in fields on an as-needed rather than a prescheduled basis. In addition, John's brother-in-law, Robert, began devoting most of his time to pest management issues. This more intensive scouting regimen enabled the Wallendals to make more informed decisions about whether and when to spray different pesticides to combat the different pests. And their greater scrutiny ended by reducing the number of times the Wallendals needed to spray, as well as by reducing the total amount of pesticides they sprayed. Between 1990 and 1998, the Wallendals went from spreading insecticides four times during the season to spreading insecticides just once. They reduced their insecticide use by 75 percent.

In recent years, Temik has been allowed back on the market for use on potatoes. John is amazed that some states are welcoming it back. "We're glad to see we can manage without the use of a chemical that presented such a problem for our groundwater and health of our workers," John remarked.

Fighting Fungus with WISDOM

Insects are not the only pests that potato farmers such as the Wallendals face. One of the worst threats to potato production are disease-causing fungi that can rot potato leaves, stems, and tubers if conditions are right. The fungi—referred to as early and late season *blights*—live in the soil and can become airborne and travel great distances. (The infamous potato famines in Ireland were largely caused by blight.)

The Wallendals still use fungicides to control blight outbreaks when they occur; over the years, however, they have fine-tuned ways to prevent blight infections. The Wallendals buy potato seeds that are disease resistant, and they make sure that the seeds themselves are not already infected. They also rotate their crops on a four-year cycle to reduce the buildup of disease organisms in the soil. They grow potatoes in any given field only once every four years, growing another vegetable crop that is not susceptible to the same potato diseases, such as sweet corn or snap beans, in the alternate years.

The Wallendals have also converted their irrigation system so that it is now computer-controlled. This change enables them to time their irrigations and to limit the lengths of time that plant leaves are wet. It also helps reduce the infection rate and potency of fungal blights. They can preprogram irrigations to occur in the evening, when there's less evaporative water loss than in the heat of the day. This timing helps save electrical power and money.

In 1986, the University of Wisconsin approached the Wallendals and several other farm operators to join a six-year research project that is designed to test how multiple IPM strategies, including crop rotations and biological control, work together to control pests over time. The Wallendals donated 24 acres of irrigated crop land, equipment, and management; the university provided technical and data collection expertise. Money to help fund the study was also provided by the Wisconsin Potato and Vegetable Growers Association and the U.S. Department of Agriculture.

The most significant outcome of the project was the development of a computer disease fore-

Fields of Change (continued)

casting system called *WISDOM*. The Wallendals enter certain data into the computer, including weather conditions and the cultural practices that they use. Cultural practices include when and how they plant, the types of seed they use, their crop rotation cycle, and so forth. Then WISDOM predicts the appearance of early blight and late blight. This system has allowed the Wallendals to know exactly when to first apply fungicides to keep disease pressure to a minimum and how to stretch out the time between fungicide applications. Between 1987 and 1995, WISDOM helped the Wallendals cut their fungicide use for early and late blight by 50 percent. In 1996, however, a severe late blight pandemic hit the area, and the Wallendals had to act quickly to save the crop; they increased their fungicide use to conventional levels. The Wallendals believe that, averaged over the 10-year period between 1987 and 1996, they cut the amount of fungicides they spread by one-third.

Potato blight

The Wallendals are proud to have been involved in *WISDOM*'s development and are even more enthusiastic about the cooperative multidisciplinary nature of the project. John notes, "Partnerships between farmers and university researchers not only are instructional, but also have a huge capacity to generate positive changes in agricultural systems." *WISDOM* is now being promoted throughout the Wisconsin potato industry; it has been particularly helpful for disease management.

Changing the War on Weeds

Not too long ago, the Wallendals used a "moldboard" plow as the main way to cultivate the soil and to eliminate weeds. This type of plow churns, or tills, the top 10 inches of soil. Such deep tilling is highly disruptive to the integrity of the soil and makes the soil vulnerable to erosion. In recent years, the Wallendals have switched to a minimum tillage method. The Wallendals' minimum tillage method involves tilling in such a way that the crop residue remains on the soil surface and the soil stays in its original vertical position. They estimate that only 1 percent of the soil is displaced using this method.

Another important aspect of the Wallendals' weed management program is a fall planting of rye grass as a winter cover crop. The Wallendals have noticed that weed infestations are less severe when they plant potatoes after a winter of rye grass. They believe this change is because of allelopathy, the chemical influence of one plant on another. The rye plant, because of a biochemical interaction in the soil, is able to inhibit the growth of certain weed species. This allelopathic effect can also be harmful to potato plants, so the Wallendals kill the rye grass with the herbicide Roundup® (*glyphosate*) before they plant potatoes so they can stop biochemical interaction to the soil. They allow the rye grass to remain in the ground after it has been killed; thus, the rye helps prevent soil erosion and makes it easier for water to soak into the soil.

The Wallendals still rely on herbicides for weed control, and although they have only minimally reduced such use, they have switched to compounds they believe are less hazardous. In particular, they have replaced the use of Dual® (*metolachlor*) with Roundup®.

Fields of Change (continued)

Giving Plants What They Need

To grow, potatoes and other plants need nutrients. By using fertilizers, farmers such as the Wallendals provide nutrients that the plants need. But too much fertilizer at the wrong time can mean the fertilizer ends up in groundwater rather than in the plants. The Wallendals have taken significant steps to improve nutrient management and to reduce their use of fertilizers.

John, who worked as a medical technician for eight years before returning to farming, has set up a testing laboratory in the family's farm office. Family members test plant tissue using a chlorophyll meter, which enables them to determine what nutrients the plants need and in what amounts. Instead of having to send tissue samples out to be tested and waiting at least a week for the results, John is able to have results within one to two hours.

When the family first set up the lab and started testing plant samples, John realized that 50 percent of the fertilizers being applied to the soil were not being used by the potato plants. That meant the Wallendals were wasting fertilizers—fertilizer that most likely ended up leaching through the soils into groundwater. Now, instead of applying all the fertilizer early in the growing season when the fertilizer is most vulnerable to leaching, the Wallendals wait and apply only as much as the plant needs. In the past eight years, this practice has allowed them to make a 5 percent reduction in high-salt fertilizers, particularly potash. John points out, "Although the reduction in volume is not particularly significant, we have vastly improved our timing so that all the nutrients we put in the field are used by the plant. This timing, more than anything, has the greatest effect on reducing water contamination."

Tissue testing helps the Wallendals fight plant diseases. Plants have natural defenses against disease, but when the plants lack nutrients, those defenses weaken. By putting a nutrient program in place throughout the growing season, the Wallendals are able to minimize outbreaks of diseases such as early blight.

In the future, John hopes they will be able to work with a dairy farm so that he can have a constant and consistent supply of cow manure to use as a source of nitrogen and organic matter for his soils. He is even considering diversifying their farm's operation by adding dairy cows. John says, "There is the potential for a beneficial and symbiotic relationship between dairy cows and vegetable production. The crop residue we generate can be fed to cows, and the waste they generate is a valuable input for vegetables. This is the way it was always done in the old days, except on much smaller farms." The major stumbling block for making this change right now is that for their scale of vegetable production, the Wallendals would need 2,000 cows. "This [change] would be a capital intensive and risky endeavor, and right now it would mean less time with our families," says John.

Yields and Quality

The Wallendals have consistently attained yields that are comparable to the yields they achieved when they farmed using conventional methods. Their yields equal the countywide average. The

Fields of Change (continued)

Wallendals have also consistently met or exceeded the quality standards established by the potato processing industry.

Potatoes sold on the fresh market, however, must meet a higher standard than those made into french fries. According to John, "The consumer wants a regular blocky unblemished potato from the fresh market, thus we must choose varieties that are based on those characteristics. Unfortunately, those potato varieties have not been bred to be extremely resistant to diseases, which makes it difficult for us to reduce chemical and fertilizer use. If consumers were less picky and could accept slightly blemished, yet nutritionally sound, food on occasion, then we could use more of our sustainable disease management techniques to grow potatoes for the fresh market."

Production Costs

By reducing their use of pesticides and fertilizers, the Wallendals have lowered their total cost of production by 9 percent. The amount they spend on chemical inputs has gone down 39 percent. The Wallendals show a net gain of $20 per acre because of a reduction in purchased inputs. Although these are real gains, they are at least partially offset when the value of the increased management time is accounted for.

Concerns and Recommendations

The Wallendals would like to continue to reduce their pesticide use. John speaks adamantly that if this reduction is to occur, they need much more support in the marketplace. "We sell our products to internationally based processors and marketing groups who are inherently risk averse. If consumers don't have a means of choosing IPM-grown potatoes, then they can't demonstrate their support, which is what is needed to change the marketing habits of processors. We have tried to market our potatoes ourselves, but this is an area of expertise we do not have right now."

In addition to the need for national processors that are willing to market an IPM-based product, John identifies the need for research devoted to figuring out how farms of his scale can convert to more sustainable practices.

John says, "I think there are two reasons farmers don't adopt more sustainable practices. First, it is a big risk. Farming is not only a lifestyle but also a livelihood. And, second, it is human nature to resist change unless that change is your own idea. Farmers are fiercely independent. To see overall changes to the agricultural industry will require a great deal of patience."

The Wallendals attribute their success to their willingness to embrace change and to work cooperatively together. John notes that each of the family partners has different strengths, and balancing their different instincts has been critical to their success. They also give credit to the University of Wisconsin Extension system for focusing on multidisciplinary research that addresses on-farm concerns.

Fields of Change Question Sheet

Read the "Fields of Change" article, and use it to answer the following questions:

1. What factors motivated the Wallendals to change their farming practices?

2. What changes did the Wallendals make to their farming methods and for what purpose? List as many as you can.

3. Were the Wallendals able to reduce their use of insecticides? Fungicides? By how much?

4. How do the potatoes the Wallendals raise compare to potatoes grown by more conventional methods? How do their costs of production compare?

Fields of Change Question Sheet (continued)

5. What obstacles do the Wallendals see to reducing their pesticide use even further?

6. What obstacles do the Wallendals see to other farmers adopting methods that use fewer pesticides? What tactics or programs would you suggest to encourage farmers to adopt new methods?

7. What do you think about what the Wallendals have accomplished? What advantages and disadvantages do you see in their farming methods?

8. What do you think about the notion of fresh potatoes needing to be blocky and unblemished? Would you be willing to settle for less than perfect fresh potatoes? Why or why not?

Answers to Fields of Change Questions

1. What factors motivated the Wallendals to change their farming practices?

Answer: Concerns about groundwater contamination and soil erosion, prohibition of a pesticide they had relied on heavily, and the need to do things differently.

2. What changes did the Wallendals make to their farming methods and for what purpose? List as many as you can.

Answer: Hired second in-house Integrated Pest Management (IPM) specialist to monitor insect population levels in fields, as needed; purchased potato seeds that are resistant to diseases; made sure seeds weren't infected; rotated crops every four years to reduce buildup of disease organisms in soil; switched to computer-controlled irrigation system to time irrigation so it limits leaf wetness and, therefore, reduces infection rate and potency of fungal blights; joined University of Wisconsin's disease prediction project, which helped them know when to apply fungicide; switched to minimum tillage method to reduce soil erosion; planted rye grass as winter cover and then killed the grass with Roundup®; replaced herbicides with less-toxic alternatives; set up tissue-testing laboratory to determine what nutrients are needed when, which saves on fertilizer, and which helps combat disease.

3. Were the Wallendals able to reduce their use of insecticides? Fungicides? By how much?

Answer: Yes; insecticides—75%; fungicides—50%.

4. How do the potatoes the Wallendals raise compare to potatoes grown by more conventional methods? How do their costs of production compare?

Answer: Yields that are comparable to countywide average; quality that meets or exceeds industry standards for processed potatoes; potatoes that are not consistent enough for fresh marketing; fact that they saved $20/acre.

5. What obstacles do the Wallendals see to reducing their pesticide use even further?

Answer: Need national processors willing to market IPM-grown potatoes; need more research on how farms of this scale can adopt more sustainable practices.

6. What obstacles do the Wallendals see to other farmers adopting methods that use fewer pesticides? What tactics or programs would you suggest to encourage farmers to adopt new methods?

Answer: High risk, farmers who always resist change; get support from local universities and Agriculture Extension Offices.

7. What do you think about what the Wallendals have accomplished? What advantages and disadvantages do you see in their farming methods?

Answer: Student answers will vary.

8. What do you think about the notion of fresh potatoes needing to be blocky and unblemished? Would you be willing to settle for less than perfect fresh potatoes? Why or why not?

Answer: Student answers will vary.