VERTEBRATE CONTROL CHEMICALS: CURRENT STATUS OF REGISTRATIONS, REBUTTABLE PRESUMPTIONS AGAINST REGISTRATIONS, AND EFFECTS ON USERS

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INTRODUCTION

Man's use of chemical pesticides has received much attention in recent years, reflecting or generating public consciousness of our environmental welfare. The establishment of Water Quality Acts, the Toxic Substances Control Act, air pollution standards, and the Environmental Protection Agency (EPA) also exemplify this consciousness which has become a major political force. Although there is some unyielding antagonism against all chemicals used to control pests, there is general agreement that pesticides are necessary for the protection of our health, food, fiber, and habitats. Nevertheless, some pesticides have serious shortcomings, especially toxicity to nontarget organisms and long persistence in the environment. These and other problems involving commerce and safety led to the promulgation of federal regulations to mitigate the adverse effects of pesticides on human life and the environment.

Pesticides have been under increasing government regulation since 1910 when the Federal Insecticide Act was passed and administered by the U.S. Department of Agriculture (USDA). The Food and Drug Administration (FDA) became involved in 1938 under the Federal Food, Drug and Cosmetics Act. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947 was originally enforced by the USDA. In 1972, Congress passed the Federal Environmental Pesticide Control Act (Public Law 92-516) significantly amending FIFRA which is administered by the EPA established in 1970. Commonly known by "FIFRA, as amended," this Act, with the theme of protecting public health and the environment, regulates the use of all pesticides including the following major provisions which affect vertebrate pesticides:

1. Requires all U.S. pesticides to be registered or approved by the EPA through intertwining procedures involving registration, reregistration, renewals, classification, and labeling.

2. Through cancellation and suspension procedures, known as Rebuttable Presumption Against Registration (RPAR), the Act authorizes the removal from the market of registered products purported to cause unreasonable adverse effects.

3. Establishes state applicator certification programs and cooperative enforcement programs.

4. Requires experimental use permits (EUP) for field evaluations of experimental pesticides.

5. Prohibits misuse of pesticides (uses inconsistent with label directions) adding civil (39 FR 27711) to increased criminal penalties, strengthens enforcement functions.

My discussion of this broad topic precludes details on individual vertebrate control pesticides. In addition, the registration status of these materials is constantly changing and much of the information may be outdated before the Conference Proceedings are published.

REGISTRATIONS

The EPA Compendium of Registered Vertebrate Pest Control Chemicals issued in 1973 lists the following number of pesticides categorized by use groupings:

Rodenticides	18	Rabbit Toxicants	1
Rodent Repellents	8	Rabbit and Deer Repellents	6
Fumigants (rodents, moles, skunks)	11	Dog and/or Cat Repellents	31
Bat Repellents	1	Bird Toxicants	5
Mole Repellents and Toxicants	4	Bird Repellents	21
		Bird Chemosterilants	1
		Fish and Lamprey Toxicants	4

This list does not include other types of pesticides occasionally used in vertebrate pest management such as herbicides to control food and cover of pests.

Although the number of registered pesticides appears substantial, most are chemicals of questionable utility (e.g., naphthalene, mineral oil, bone oil, and sulfur dioxide), and are not considered as viable alternatives to more typical pesticides. Other pesticides are registered only for specialized uses such as Ornitrol[1], R-55, and fenthion. Some, especially anticoagulant rodenticides, are similar in efficacy and use patterns. Several of the more widely used chemicals are under RPAR review including rotenone, 1080, 1081, strychnine, arsenicals, and endrin. The production of others, such as ZIP, have

[1]Use of trade names does not imply endorsement by the federal government.

recently been cancelled by registrants. Further, the uses of some registered products are prohibited or restricted by Executive Order 11643, federal and state land management agencies, and regulatory agencies. The U.S. Department of the Interior, for example, prohibits the use of 16 and restricts the use of 47 pesticides of various types on Interior lands.

The numbers of registered formulations, use patterns, and labels of vertebrate pesticides are unknown to me. However, RPAR's listed 37 registrants of state and federal 1080 labels and 56 registrants of strychnine with 116 approved labels. Many uses of vertebrate pesticides are state registrations as provided by Section 24 of FIFRA (40 FR 40538) whereby certified states may register products for uses within the state.

Very few new vertebrate pesticides, DLP-787 and Mesurol are perhaps the only two, have been federally registered since 1973, although several different formulations and use patterns have been approved. The registration process is very difficult and costly requiring as many as 150 chemistry, environmental chemistry, phytotoxicity, toxicological, and fish and wildlife studies ranging from simple laboratory tests to replicated field trials. Guidelines for registering pesticides were published in the Federal Register (40 FR 26802) on June 25, 1975.

REREGISTRATIONS

Reregistration of all currently registered pesticide products is a major element of amended FIFRA. About 35,000 products containing approximately 1,400 active ingredients, including vertebrate pesticides, were to have been reregistered by October 1976, later extended to October 1977. The reregistration process (40 FR 28242) is so complex and burdensome that the extended deadline was not met, and I am not aware of a new target date. My opinion is that reregistration will take a minimum of 5 years unless the regulations are modified to simplify procedures and reduce data requirements.

The reregistration of currently approved chemicals involves an 8-step process:

Step 1. Based upon review of existing data, each chemical is placed in one of five categories:

Category I. No RPAR anticipated; sufficient data in the EPA files; reregistration and classification proceeds; upgraded label required. The first reregistration call-in issued February 17, 1976, included warfarin, aluminum phosphide, diphacinone, Pival, and zinc phosphide in this category.

Category II. No RPAR anticipated; long-term data gap identified, such as chronic toxicology; temporary reregistration and classification proceeds; upgraded label required. This category includes Avitrol, calcium cyanide, and thiram.

Category III. No RPAR; short-term data gap required to be filled before reregistration. The first call-in did not include vertebrate pest control compounds in this category.

Category IV. RPAR anticipated; discussed in the following section.

Category V. Pesticide not adequately reviewed for placement in another category. The call-in order is the last part of this first step. The first call-in included 34 chemicals of interest such as several anticoagulants, 1080, 1081, endrin, norbormide, ANTU, red squill, sodium cyanide, and strychnine.

Step 2. The EPA reviews Category V for RPAR's and categorizing, prioritization and scheduling RPAR's.

Step 3. The EPA working group formed, Suspect Chemical Review Committee gets draft position paper and RPAR notice.

Step 4. RPAR notice describing reasons for action sent to registrants and published in the Federal Register.

Step 5. Registrants and interested parties file rebuttal data within 45, or extension to 105 days.

Step 6. The EPA reviews data, drafts position document with a benefit/risk evaluation.

Step 7. Administrator of the EPA makes tentative decision as to (1) RPAR sucessfully rebutted, (2) benefits exceed risk, or (3) benefits do not exceed risk; review by the USDA and Scientific Advisory Panel.

Step 8. Final position document; notice in Federal Register defining the EPA actions as to reregistration, cancellation with opportunities for hearings, or reregistration on the basis of offsetting benefits with opportunity for hearing.

RPAR

Section 3 regulations of FIFRA also established criteria by which pesticides, or more properly their uses, could be judged to have caused, or suspected to have the potential for causing, adverse

effects on the environment, including man. The first application of these criteria is a review of data by which the EPA identifies those groups of chemical ingredients and/or use patterns which may have unacceptable risks. Such a pesticide is presumed not to be reregisterable. Provisions have been made for presenting rebuttals documenting why or how the product can be used without unreasonable adverse effects, and/or that benefits exceed the risks. Thus, those products necessitating special scrutiny in the reregistration process are said to have a Rebuttable Presumption Against Registration (RPAR).

A RPAR is triggered when significant adverse impacts have been exhibited or a potential is suspected during the data review process. The unreasonable risk criteria (40 FR 28281) are summarized as follows:

1. Hazard to humans and domestic animals; triggered by acute dermal and inhalation toxicity.

2. Hazard to wildlife; triggered by residues in or on feed at levels considered significant relative to the acute oral toxicity to mammals, the subacute dietary avian toxicity, and the acute toxicity to aquatic organisms.

3. Chronic toxicity; triggered if oncogenic or mutagenic effects are induced; if there are any other chronic or delayed toxic effects at dosages relative to exposure and safety levels for humans; and if anticipated to result in significant population reductions in nontarget organisms, or fatality of endangered species.

4. Lack of emergency treatments; triggered if no known antidotal or first aid treatments are available for treatment of humans.

Of special concern are chemicals which bioaccumulate or present special toxicities. When an RPAR is triggered, the process proceeds through steps 2 to 8 described in the foregoing section on Reregistrations. The EPA has tentatively identified over 100 compounds as candidates for RPAR. A surprisingly large number of manufacturers/registrants have requested voluntary cancellation due to concerns over the unreasonable adverse effects, effect on their reputation, lack of data to rebut the presumption, as well as the cost of filling data gaps and defending the registration when the sales market does not warrant the additional costs. Prior to 1972, for example, the U.S. Fish and Wildlife Service had 52 labels and products to control predators, rodents, birds, jackrabbits and porcupines. Following Executive Order 11643 and resultant Service policy changes, the number of registrations declined to about 17 which have to be reregistered or cancelled. Some are on the RPAR list.

As of January 1978, RPAR notices on 24 chemicals had been issued including endrin, strychnine, strychnine sulfate, 1080, and 1081, all used in vertebrate pest control. The endrin notice cited oncogenic, fetotoxic, and teratogenic effects, fish and wildlife kills, and hazards to humans and domestic animals. The strychnine notice specified acute toxicity hazards to wildlife and other exposed nontarget organisms. Compounds 1080 and 1081 were presumed on acute toxicity to mammalian and avian species, secondary poisoning, significant adverse effects on nontarget organisms, and lack of emergency treatment. No final actions have been taken by the EPA regarding these compounds. It seems apparent the EPA wants to cancel all uses of 1080 and 1081, and all outdoor, above-ground uses of strychnine although the presumption for endrin was based more on use patterns.

Other chemicals used in vertebrate pest control being considered for RPAR include ethylene dibromide, arsenicals, 2, 4, 5-T and related compounds, rotenone, and thiram.

The EPA is far short of meeting their original goals in processing RPAR's. Their revised time table is to have 24 of the original 42 RPAR chemicals at the point of final regulatory decision by October 1, 1978, and the other 18 at that point early in 1979.

RENEWALS

Amended FIFRA requires renewals of all registrations and reregistrations at 5-year intervals. Approvals of renewals will be based on criteria and data standards in effect at that time, which are likely to be more stringent. The matter of renewals is not one of immediate importance to those involved in vertebrate pest management because of other major problems with implementation of FIFRA.

CLASSIFICATION

The registration and reregistration process requires the EPA to examine each use of the 35,000 products as it is the use of the product which is registered and classified as either for "general use" or for "restricted use." "Restricted use" pesticides may be applied only by, or under, the direct supervision of a certified applicator. Some uses of a particular pesticide product may be classified for "general use" and other uses of the same product may be for "restricted use." Both "general use" and "restricted use" may be listed on a single label but the two must be clearly separated and distinguishable. Since it is uses which are classified, no simple list of restricted pesticides can be made. A few pesticides, such as most rodenticides and some vertebrate repellents, are likely to have only restricted uses because of their toxicity, use pattern, and potential for "unreasonable adverse effects" on the environment, including injury to the applicator.

The criteria for classification were published in the Federal Register (40 FR 28242) on July 3, 1975. These criteria relate to categories of acute mammalian oral, inhalation, and dermal toxicity; eye and skin effects; and subacute, chronic, or delayed effects on man or other nontarget organisms

including mammalian and avian species, aquatic organisms, and nontarget plants. On September 1, 1977, the EPA published optional procedures for classification (42 FR 44170). The EPA may now describe a group of products having common characteristics, such as the same active ingredient, and classify for restricted use some or all uses of all products included in that group.

On February 9, 1978, the EPA ruled "restricted use" classifications for all uses of aluminum phosphide, calcium cyanide, endrin, 1081, hydrocyanic acid, sodium cyanide, 1080; most uses of methyl bromide, and all uses of strychnine except when applied subsoil using less than 0.5 percent bait (42 FR 44176). The next round for classification includes carbon disulfide, chloropicrin, ethylene dibromide, ethylene dichloride, fenthion, nicotine, Gophacide, phosphorus, and zinc phosphide. Many of the vertebrate pesticides will be classified "restricted use" because their efficacy is inherently associated with toxicity and adverse effects toward vertebrates.

LABELING

The pesticide label is the final result of the registration and/or reregistration process and identifies the product, provides directions for use, and reflects the risks and benefits of a given pesticide to the user. The label is the primary source of information to the user and it is also the primary tool of pesticide regulation. The label, in a sense, is a legal document.

Amended FIFRA requires upgrading labels to specified standards and formats of the information to be included. Labeling requirements are presented in the Federal Register (40 FR 28277) and described by Moore (1975). It is unlawful to use a registered pesticide in a manner inconsistent with its labeling. One major problem is that there are vertebrate pests which are not specifically included on any registered label. Adding such pests to labels requires submission of efficacy and other data to support the addition. Questions arise as to the level of identifying pests, such as listing rodents as a target group, field rodents, ground squirrels, or each target species; identifying habitats to be treated, such as food or feed crops, cereal grains, or each kind of grain; and application methods such as broadcasting bait whether by aircraft, ground equipment, or by hand. In part, some of these issues are resolved in Pesticide Enforcement Policy Statements (PEPS) issued by the EPA. Due to the number of vertebrate pest species, habitats, and use patterns involved, and considering relatively minor significance of vertebrate pests compared to weeds and insects, and the economics of registration; use groupings of pests and crops appears to be the only viable alternative.

APPLICATION CERTIFICATION

Federal law requires that applicators of "restricted use" pesticides shall demonstrate practical knowledge of regulated pests, applicable laws relating to quarantine, control of pests, and the potential impact on the environment of pesticides used in pest control in addition to appropriate safety precautions and efficacy associated with use of pesticides. The objective is to insure safe, effective, competent and lawful use of pesticides, especially those of greater hazard potential classified as "restricted use." Standards for certification were printed in the Federal Register (39 FR 36446 and 40 FR 11698).

Most states have developed approved training and certification programs, and the EPA conducts the programs in states without approved programs. Certification applies to commercial and private applications and supervisors of noncertified applicators. Commercial and research applicators are tested and certified in one or more of the following pest control categories: (1) agricultural plants, (2) agricultural animals, (3) forest pests, (4) ornamental and turf pests, (5) seed treatments, (6) aquatic pests, (7) right-of-way pests, (8) industrial, institutional, structural and health-related pests, (9) public health pests, (10) regulatory pests, (11) demonstration and research which is combination of all the categories, and (12) other categories and subcategories as deemed necessary.

Nearly all users of vertebrate pest control chemicals must be certified as applicators of "restricted use" pesticides. In my opinion, the negative aspects of certification are minimal and potential benefits include alleviating misuses of pesticides which would jeopardize maintenance of current registrations. However, the categories designated by EPA and many states are not very appropriate to users of vertebrate pesticides.

EXPERIMENTAL USE PERMITS (EUP)

The EPA published regulations (40 FR 18780) revising procedures of using pesticides for experimental purposes so as to conform with amended FIFRA. The objective was to control and monitor the kinds and amounts of experimental, limited-data-based chemicals used in manners creating potential health and environmental hazards. Operational-scale use of some unregistered chemicals and nonlabeled uses of registered chemicals under the guise of experiments was probably a factor that led to promulgating these regulations.

Although the regulations are not as clear as they should be, chemicals being tested in the laboratory or in very limited field trials only to determine their value for pesticide pruposes are exempt from an EUP. Realistically, EUP's are required for nearly all field trials of candidate vertebrate pest control agents because pesticidal potential has usually been determined; food and feed crops, aquatic use, and animal treatments are involved; and tests are usually conducted on more than an accumulative total of 10 acres of land or 1 acre of water. Policies of the agency conducting the experiment or administering the land are frequently involved.

Several problems arise with EUP procedures, including: (1) extensive data required to support the application, (2) long delays in obtaining approval, (3) restrictions by EPA on testing procedures and parameters precluding necessary flexibility to accommodate test situations, (4) required quarterly reports, and (5) permits are valid for only 1 year, unless extended. I believe bona fide research should be exempt and these regulations cancelled. The incongruity of requiring an EUP to test a chemical on 11 acres compared to issuance of a Section 18 emergency use permit to treat 18,000 acres of the same crop with the same chemical is apparent.

EMERGENCY USE AND STATE REGISTRATIONS

Section 18 of amended FIFRA provides that the Administrator of the EPA may, at his discretion, exempt any Federal or State agency from any provision of the Act if he determines that emergency conditions exist which requires such exemption. Section 24 provides that a state may register pesticides formulated for distribution and use within that state to meet special local needs if that state is certified by the Administrator as capable of exercising controls in accord with the Act and if registration has not previously been denied, disapproved, or cancelled.

The final regulations for these sections have not been promulgated. I have elected to only mention them in this paper and recommend that users become familiar with appropriate proposed rules.

EFFECTS ON USERS

"The possibility of hazards now visible around most common chemicals took the public and more than a few scientists and lawyers by surprise, creating problems for government and industry. To have taken a few risks is grave business. To have been involuntarily subjected to unknown risks is outrageous." These statements by Dr. Thomas Shotwell (1975) exemplify the source of the problems we face resulting from Congress mandating more regulations and giving EPA the unenviable task of enforcing them. As users, we created some of our own problems through lack of knowledge, misuse, accidents, and not adequately measuring the benefits and risks. On the other hand, one reason we live longer, and perhaps have more cancer, is increased food production, better health, and better nutrition through the use of pesticides. Is anyone qualified to assess the benefits and costs in national and worldwide terms?

Focusing on vertebrate pest control chemicals, I view some of the inter-related positive and negative impacts of amended FIFRA and as enforced by the EPA as follows:

1. Land managers will be forced to absorb more losses caused by vertebrate pests due to the lack of chemical tools and higher costs of fewer pesticides. The number of minor-use chemicals and use patterns have decreased, and will continue to decrease, because small manufacturers cannot afford to gather the data necessary for registration. Their only recourse is to distribute a large manufacturer's product under a "me-too" label or go out of business. Thus, large manufacturers and/or the government will be forced to incur the data cost burden for everyone else. Marginally profitable compounds, especially those with only minor uses, will disappear from the market.

2. Higher costs are inevitable. The cost of bringing a new chemical on line has risen from $1 million in 1956 to $8 - $10 million. At the same time, the probability of success for an experimental compound decreased from 1 in 1800 in 1956 to 1 in 5040 in 1969 (von Rumker et al, 1970). Neumeyer et al. (1969) estimated the overall chance as only 1 in 36,000 and chances for a product to attain a sales volume of over $5 million per year as only 1 in 366,000. An analysis of reregistration and labeling costs reported that the impacts on the consumer, both direct and indirect, resulting from incremental requirements of FIFRA as amended could total $165 million annually for the next 10 years (Pesticide Chemical News, January 14, 1976). It is no wonder there is a lack of interest in minor-use vertebrate pest chemicals and a shift toward high volume products like herbicides and insecticides.

3. The matter of research and development time-frames of new chemicals also influences costs. It used to take 2 to 5 years to register and market a chemical leaving 12 to 15 years to recover costs and make a profit under 17-year patent protection. Now 5 to 10 years are needed to attain the point of applying for registration, then 2 years or so for registration processes, leaving only 7 to 10 years for recovering costs and garnering profit (St. Aubin, 1977).

4. The probability of finding new vertebrate pest chemicals is extremely low. Rumker et al. (1970) surveyed 40 pesticide manufacturers. Of 16 respondents synthesizing and/or screening chemicals for biological activity, only one used rodents in the screen, one used fish, and none used birds. Broad spectrum activity was preferred over narrow spectrum by a ratio of 7:2 and short persistence was preferred 8:1 over long persistence. The minimum annual sales volume considered necessary to justify development was $0.9 million for rodenticides and $0.9 million for avicides. This was in 1970 before FIFRA was amended.

5. A trend toward usage of less toxic or persistent products is in progress, even if effectiveness and low cost are sacrificed. I would be less concerned with cancellation of hazardous materials if economical, effective, and safer alternatives were available. Biological, cultural, and other technological nonchemical pest-control techniques are not, unfortunately, widely available. Vertebrate pest technologies are behind those of other pests where integrated pest management is more fully developed.

6. The recognized need for highly selective and safer products presents a cost and registration quandary. Chemicals having only a narrow use spectrum carry a proportionately higher research and development cost which is not compatible with limited market potential and economies from piggybacking multiple use patterns of broad spectrum pesticides. The basic research and development costs for the first registration is rather constant and it is relatively much less expensive to obtain additional use patterns. Emphasis is now on synthesis and screening analogs and homologs of existing or registered chemicals rather than new types of pesticides.

7. Amended FIFRA both positively and negatively impacts research and development. One result is more and better research with a greater understanding of pesticide effects and, hopefully, safer pesticides and nonchemical approaches to solving problems.

However, increased costs and time-frames decrease the growth rate of innovative research which must be more selective, with greater risks, because of the uncertainty of the timing and return on the investment of long-term development. Research effort is also siphoned off in order to defend existing products and expand use patterns wherever practical to replace chemicals being lost. Research must be more flexible because regulatory requirements are changing during development and product approval must be viewed as a moving target. To be cognizant of the changes, ready access to the Federal Register and trade bulletins such as the Pesticide and Toxic Chemical News[2] is essential.

Ironically, the EPA's inability to meet its time goals on RPAR's and reregistrations have caused research managers to take a "go slow and see what's going to happen" attitude toward expanded research efforts. I have heard nothing further of EPA's planned research program to identify safer, alternate chemicals to replace those cancelled or restricted (Anon., 1974). EPA's thrust is away from total reliance on chemicals toward integrated pest management and biological controls.

8. While the important pesticide problems have been identified, there are substantial gaps in both the qualitative and quantitative descriptions of these problems. Therefore, the judgement factor weighs heavily in this whole matter, especially as to acceptable and potential risk levels, assessing the need for control, and cost/benefit evaluations. There is also concern about who and where the decisions are made. A critical evaluation of a chemical hazard involves more than toxic potency, for toxic potency and degree of hazard cannot be considered synonymous. There is no such thing as "no-risk" health or economic situation when dealing with the use and nonuse of pesticides or alternate control methods where pest problems exist. Attitude toward pesticides is different than toward drugs and naturally occurring carcinogens, etc., in food and the environment. The legalization of guidelines and blanket-type criteria can preempt rationale and expert judgment. Such criteria developed for insecticides and herbicides are often not appropriate for vertebrate pesticides. Overregulation is not readily enforceable and encourages illegal actions. A purported benefit of FIFRA is safer pesticides but the benefit is generally unquantifiable as to the kind and amount of good achieved.

NEW FIFRA AMENDMENT

The Congress is presently considering new amendments (HR-8681) to FIFRA. To those of us concerned with faster registrations and minor uses, the most important element is that covering "conditional" registrations. This amendment would permit the EPA to provide conditional registration for a pesticide which is identical or similar to a currently registered product or for a new use of an already registered pesticide if it would not "significantly" increase the risk of unreasonable adverse effects on the environment. This would be very helpful for some vertebrate pest compounds and uses on minor crops, but RPAR'd chemicals would be barred from conditional registrations. However, some gains in this area may be offset by the new Toxic Substance Control Act which will have an impact on pesticides.

CONCLUSION

The pendulum of public emotion regarding pesticides has swung from blind commitment to all forms of progress to another extreme. The pendulum has not yet swung back to a position many of us consider reasonable. I doubt that it will. Perhaps changes in agricultural and cultural technology and economics will give rise to new growing methods, improved crop varieties, and shifts among production inputs. These changes could reduce the need for pesticides. However, the need will not be eliminated and could increase above current levels.

LITERATURE CITED

ANONYMOUS. May 1974. Strategy of the Environmental Protection Agency for controlling the adverse effects of pesticides. Office of Pesticide Programs, Environmental Protection Agency. 36 pp.

MOORE, J.A. 1975. The label. National Pest Control Operators News 35(7 and 8):5-7.

NEUMEYER, J.D., D. GIBBONS, and H. TRASK. 1969. Pesticides, Chem. Week, April 12, p. 38-68; and April 26, p. 38-68.

[2]Published by Food Chemical News, Inc., 420 Colorado Bldg., 1341 G St., N.W., Washington, D.C. 20005

ST. AUBIN, F. 1977. How much do regulations inhibit pesticide development? Pest Control 14(5):16, 17, 20, 62, 64, 66-68.

SHOTWELL, T.K. 1975. Patterns in federal regulation of pesticides. Pest Control 43(1)16, 18, 19, 22.

VON RUMKER, R., H.R. GUEST, and W.M. UPHOLT. 1970. The search for safer, more selective, and less persistent pesticides. Bio-Science 20(18):1004-1007.