Integrated Pest Management
Michigan State University Extension Service

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Integrated PEST MANAGEMENT

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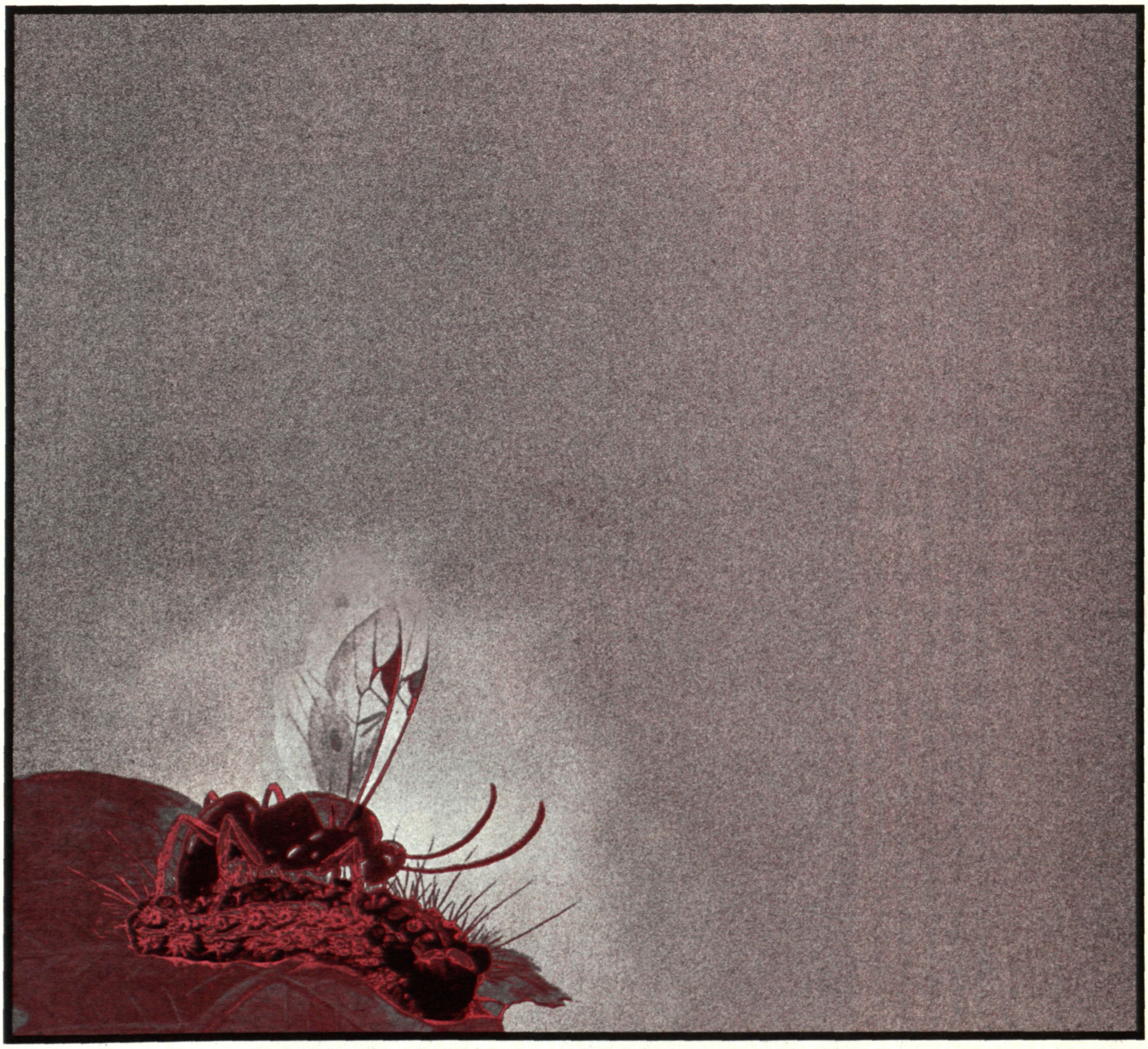

Small gypsy moth larvae are parasitized by the *Braconid* wasp *Colesia melanoscelus*.

Integrated PEST MANAGEMENT

MICHIGAN STATE UNIVERSITY EXTENSION

Task forces draw from a range of expertise to address critical needs

About two years ago, Fred Poston, dean of MSU's College of Agriculture and Natural Resources, called for the formation of a college-wide Integrated Pest Management (IPM) Task Force and a subsequent companion Minor Crop Pesticide Use Task Force.

Task force membership represents most disciplines within the college that have an interest in finding new methods for pest management and integrating these with existing tools (including pesticides) into agricultural systems that are sustainable and environmentally safer.

An overriding goal for the two groups is to help focus scarce research funds where they will do the most good for people (including consumers) involved in Michigan's agricultural system — from fruit and field crop production to turfgrass and home lawn management.

"The demand for alternatives to chemical pesticides and advanced IPM technology is escalating rapidly, but our ability to respond is limited," says Robert Hollingworth, director of MSU's Pesticide Research Center and IPM Task Force chair. "Consequently, we have a major crunch coming."

The crunch is evident in the decline of available pesticides for minor crops, such as apples, asparagus, celery, cherries, plums, pears, ornamentals, tomatoes, lawn and turf—roughly $1 billion of Michigan's production agriculture.

A purpose of the approximately year-old Minor Crop Pesticide Use Task Force is to analyze the cost and potential crop production decline stemming from the loss of minor use pesticides in Michigan and to identify those areas of greatest risk for further attention.

"Agrichemical companies consider most of the state's agriculture a minor market for their pesticides," Hollingworth says. "As environmental restrictions increase, reregistration costs escalate, and time, money and personnel scarcities occur for the agri-chemical industry. What goes overboard first are the least profitable products. The things they don't make a big profit on are these so-called minor crops that are so important to Michigan.

"[Under these circumstances] we will invest in some projects, choosing the very top priorities, to get some added insurance against the loss of key pest management materials," Hollingworth says. "We will define a number of projects that are critical to Michigan agriculture and areas where we should be investing in alternative solutions as well as maintaining the availability of chemical controls crucial to the continuation of the crop production system."

> **...finding new methods for pest control and integrating these with existing tools (including pesticides) into agricultural systems that are sustainable and environmentally safer.**

Both task forces (IPM and Minor Crop Pesticide Use) also collaborate with campus scientists who are developing biotechnology and biological controls for pest management and with MSU Extension specialists and field agents who are working with growers to broaden IPM use.

The challenge is to find a more environmentally acceptable way to use stan-

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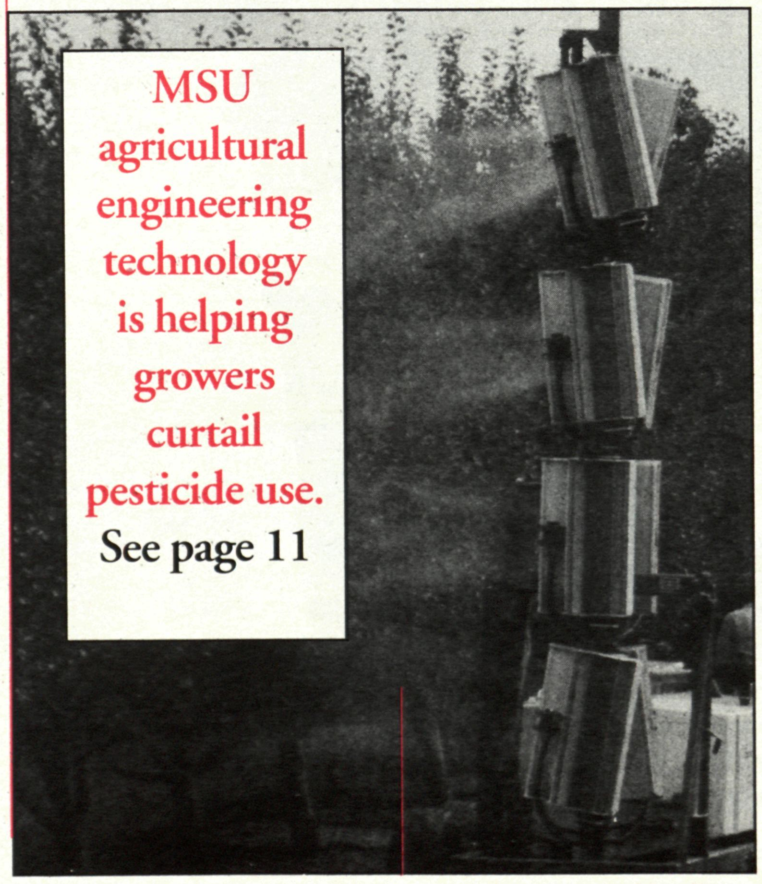

MSU agricultural engineering technology is helping growers curtail pesticide use. See page 11

Environmental concerns accelerate while IPM research atrophies

IPM research needs an infusion of support to be effective and help growers to comply with toughening environmental regulations

In the mid-1960s, researchers at Michigan State University began to make substantial headway in reducing the volume of synthetic pesticides used in agriculture through a new concept called integrated pest management.

IPM focuses on using as little pesticide as possible to protect the environment, yet effectively control or suppress pests — insects, weeds, pathogens [disease-causing organisms], nematodes, rodents — which can damage plants and animals. Farm production losses to pests are estimated to exceed 35 percent annually.

By the early 1970s, MSU researchers were leading the country in developing IPM practices, the results of which looked promising for practical use on the farm.

However, MSU's IPM research atrophied in proportion to eroding federal research dollars, and by the 1980s, new IPM research at MSU had significantly declined.

In addition, while concerns about the fate of pesticides in the environment were accelerating, Extension dollars for IPM education continued at static levels which allowed no new demonstration or implementation projects.

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dard chemical pest controls, an effective alternative to them, or a combination of the two that will allow a diverse crop production system — Michigan produces more than 50 major commercial crops — to exist under increasing environmental restrictions.

"The trend is toward specificity in pest management because this carries built-in safety. But the problem with specificity is that if you have a different solution for every crop/pest combination, you need literally thousands of solutions," Hollingworth says. "One great advantage of chemical pesticides is that one, two or three compounds can be used to solve a range of problems fairly easily.

"Another thing about specificity is economics — the cost of getting the pesticide developed and registered to control a single or a limited range of pests," he says. "The agrichemical industry is not going to develop highly specific pest management tools in most cases because it is simply too costly, and that ultimately cuts down on the pest control options for the grower.

"It becomes a real balancing act between effective, affordable pest management, increasing restrictions and consumer demand for affordable, high-quality produce," Hollingworth says.

"For us, it is a problem that demands a lot of resources if solutions are to be found; yet we are increasingly resource-limited," he says. "Certainly there are good things going on here in IPM research that will be useful to growers, but the big question is where to set our priorities, and that is exactly what we are trying to get to with the task forces."

His worry is that if the current pattern of ever more stringent and expensive regulation continues, it soon will outstrip the grower's ability to remain in compliance with the law and still produce a profitable crop.

"We made substantial progress in IPM in the 1970s, and while we are still doing a decent job, we need an infusion of applied research, and the ability to carry this to growers, to get us to the next level of IPM," Hollingworth says. "Otherwise we are going to be outstepped by restriction and the development of pesticide resistance in pests.

"If we fail in that regard, it is entirely possible that the face of agriculture in Michigan will change significantly in the next decade or so," he says.

"Considering production costs, the availability of pest controls — or lack thereof — and international trade agreements, it is entirely possible that we will not be producing many of our familiar crops here but importing them from countries where pesticide use is not as restrictive," Hollingworth says. "For instance, loss of a single fungicide — chlorothalonil — would jeopardize much of the state's vegetable production."

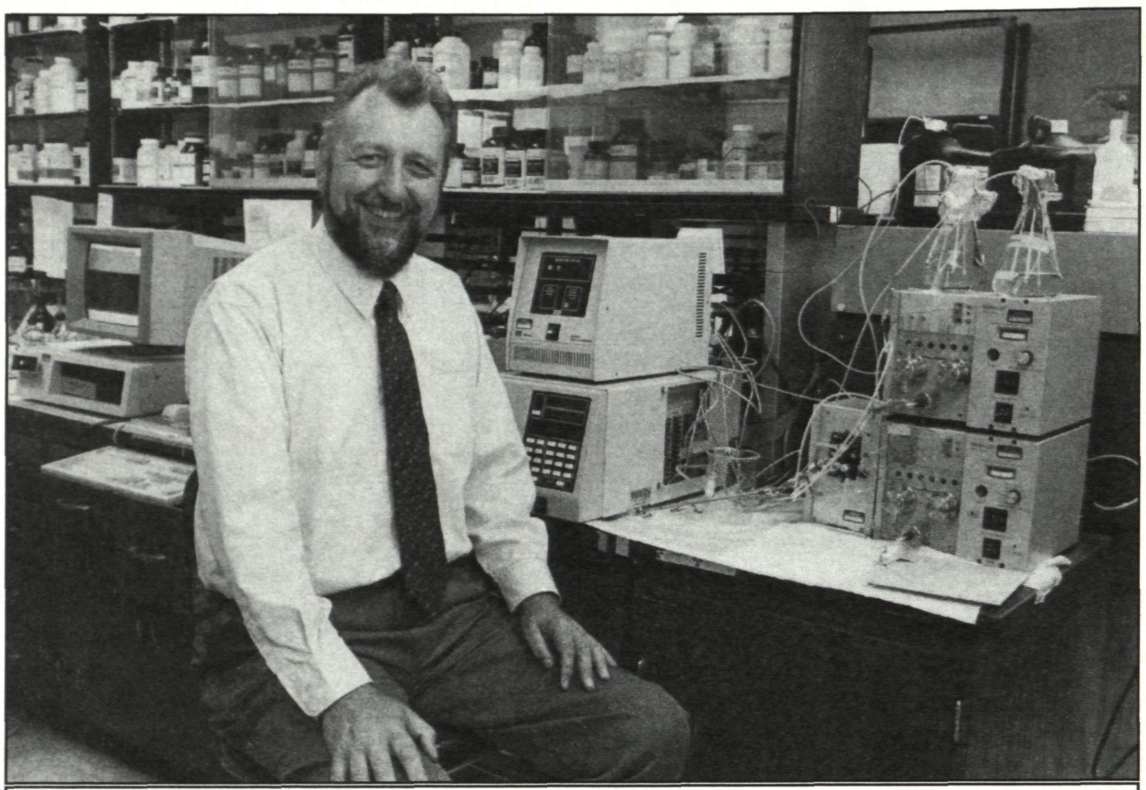
MSU plant pathologists point out that chlorothalonil is the only fungicide that Michigan growers of processing tomatoes can use against septoria leafspot, early blight and late blight. About 170,000 tons of processing tomatoes valued at about $13.5 million are produced in the state each year. Without a suitable fungicide, it is predicted that crop losses would reach 40 percent, making it economically impossible to grow this crop.

Hollingworth has no doubt about the capability of research to find solutions that will reduce reliance on synthetic pesticides for pest management.

"However, it will take years to devise effective alternative pest management systems to cover the state's most important crops and put them into place," Hollingworth says. "The continuing loss of effective pest management options is not something that can be ignored until there is a crisis; because once production leaves the state and then society says, 'solve the problem for us,' by then it will be far too late.

"There are not, in the very near future, a host of [pest control] alternatives to what we are now using in agriculture. While we see interesting prospects ahead, the time frame to reach them is long and the need is likely to be on us very soon," Hollingworth says.

"We are really caught up in a trend that involves great uncertainty and with it a corresponding risk of losing some important crops in Michigan," Hollingworth says. "If we can't strike the right balance between the legitimate needs of the grower and the zeal for new and more stringent regulation, we may not like the outcome." ■



"...it is entirely possible that we will not be producing many of our familiar crops here but importing them from countries where pesticide use is not as restrictive. For instance, loss of a single fungicide — chlorothalonil — would jeopardize much of the state's vegetable production."

—Robert Hollingworth, director of MSU's Pesticide Research Center and IPM Task Force chair.

Analysis at MSU's Pesticide Research Center documents the efficacy of pesticides and helps underscore the economic importance of retaining effective pesticides to maintain the value and quality of Michigan's diverse agricultural production. Michigan is second only to California in crop diversity.

THE ABCs OF IPM

INTEGRATED PEST MANAGEMENT is a pest management program that limits pest damage or losses using control methods that are economically feasible and cause the least disruption to the environment.

The goal of IPM is to keep pest populations to a level where damage that occurs is tolerable.

"Pest" typically refers to harmful insects, weeds or diseases. Traditional pest control methods usually relied heavily on chemical pesticides (insecticides, fungicides, herbicides).

Unfortunately, heavy reliance on pesticides has created some problems:

- sole reliance on pesticides has sometimes been detrimental to the environment;
- some pests build up a resistance to once effective pesticides;
- attempting to eliminate a pest species can upset the natural balance that keeps pests in check;
- some workers who have been exposed to pesticides have become ill.

To avoid these problems, IPM seeks to link several control methods into a management program that limits pest damage and crop losses. The goal is to keep pest populations at a level where the damage that occurs is tolerable by detecting the pest, identifying the species, measuring the economic significance, selecting management methods and evaluating the management program.

Detecting the pest

Pest populations are easier to manage when infestations are discovered early. An IPM program requires frequent and careful monitoring of pest populations. In farming, this means that the farmer or a scout walks the fields (or orchard) for close-up inspection. Golf course superintendents and their staff members regularly check fairways and greens for signs of pests. Indoor pests may be detected by traps that are frequently monitored.

Identifying the species

Accurate identification of the organism is critical for two reasons: required management tactics vary from species to species; and an organism should not be treated as a pest until it is proven to be one.

There are species of insects that are predators or parasites of pest insects. Certain fungi and bacteria also help check pest populations. Some plants even have certain chemicals that inhibit the growth of other plants. These beneficial species must be protected.

Knowing the current stage of the organism's life cycle is just as important as correctly identifying it. Most pests have specific life stages when they are most vulnerable. Use of management tactics should correspond with susceptible life stages.

Measuring the economic significance

Control measures should be used only if the organism will cause an economic loss. Small numbers of pests may cause little loss of quality or yield. Sometimes the cost of controlling the pest is higher than the loss caused by the pest.

Many IPM programs set thresholds for pest population size. Control tactics are applied if the pest population exceeds the economic threshold.

Selecting management methods

A producer may choose from several pest management options.

- Biological controls enhance plant and animal populations that are parasites or predators of a pest, such as a wasp that parasitizes the alfalfa weevil and predatory mites that eat spider mites in greenhouses.
- Cultural controls are routine management practices that prevent pests from developing. Examples include changing watering and ventilation patterns to prevent moss and algae from growing in greenhouses and rotating crops to help break pest life cycles.
- Mechanical controls — fencing, netting, mowing to suppress weed seed development on unused crop ground — help prevent the spread or reduce pest populations.
- Sanitation controls are cleanup measures that remove and prevent pest breeding sites and food supply sources.
- Resistant varieties are plants and animals bred for resistance to pests. Examples include crabapples that are resistant to apple scab and soybean varieties that are resistant to Phytophthora root rot.
- Pesticides are part of IPM. They are used when other methods are unable to keep pest populations at acceptable levels. Some pesticides are biological, such as the bacterium Bt that is used to manage the gypsy moth.

Control methods are integrated with environmental factors (rain, temperature, etc.) and natural enemies of the pest.

Evaluating the management program

After various controls are used, the effectiveness of the entire management program should be evaluated. Pest populations are measured before and after treatment or tactic. Control methods can then be rejected or fine-tuned for greatest impact.

IPM programs will vary greatly, depending upon the site where pests are being managed. However, whether the program is for indoor or outdoor pest management, urban or rural, these five steps are the heart of the program. ■

Annual on-farm crop ground sprayer calibration workshops conducted through MSU Extension's Pesticide Education Program show farmers how to substantially reduce the amount of pesticide used while curtailing costs. Proper calibration is one of several tactics MSU Extension pursues with growers to assure good pest control and environmental safety.

Vegetable growers are looking for improved MSU IPM practices

Although integrated pest management has been researched at Michigan State University since the early '70s, its importance has only just recently been felt by vegetable growers, researchers, consumers and government agencies.

"There was a tremendous push for IPM in the early '70s through early '80s," says Ed Grafius, MSU entomologist. "This department was big in IPM research at that time. Sometime between then and now we haven't been able to apply the knowledge. There wasn't a need by growers to change what they were doing."

That all changed with the recent drive for reduced pesticide residues, the severe insecticide resistance problems seen in pests, and the beginnings of resistance problems with fungicides and herbicides.

"There is a much increased demand for IPM from clientele," Grafius notes. "Growers, and processors also, are concerned about pesticide residues and produce quality. I think the consuming public wants better pest management. None of these people want reduced vegetable quality, but they all want fewer pesticides."

At times it is difficult to have it both ways, but Grafius acknowledges that there are pest management programs helping vegetable growers become more efficient at using pesticides and adopting alternative pest management practices.

Two such alternatives in pest management are cultural and biological controls.

Cultural controls include crop rotation, which is common in many crops but uncommon in celery and potatoes, and the use of disease- and insect-resistant vegetable varieties.

Biological controls use natural pest enemies. Ladybeetles, tiny wasps that parasitize insects and diseases that attack insects are examples of these.

Celery has been targeted as one vegetable where more IPM practices are needed.

"Because of the nature of the crop, celery is intensively sprayed," Grafius notes. "Any chewing injury, insect or disease damage is very evident, and it worries producers."

There have been some records of up to 55 insecticide and fungicide materials applied to celery crops, according to Grafius.

"This is extreme, and although these applications were applied according to labels and residues were within FDA requirements, it indicates reason for concern," he says.

The original research and development of the celery IPM program at MSU began in 1989 and was funded by Campbell Soup, Celery Research Incorporated (a group of celery growers supporting research) and the Michigan Agricultural Experiment Station. MSU Extension provided grants specifically for the program.

The objective was to develop IPM systems for processing and fresh market celery. A video on general IPM practices was also created. Initial goals were to reduce pesticide use and maintain crop quality.

Maria Davis, MSU entomologist, coordinated the program along with Grafius and Mel Lacy, professor of botany and plant pathology, and Extension horticultural agent Tom Dudek. This team worked with individual growers, scouting for pests and making recommendations for pesticide applications on half of each scouted field.

"On a 40-acre field a grower can save $800 by knowing what and when to spray by using a test kit."

"The scouting involved monitoring insects and diseases and some weed mapping," Grafius explains.

Growers would follow their usual pesticide control on the other half of the field.

By the end of the project, growers had cut their pesticide usage by more than one-half while still maintaining quality.

Propane-fueled flamers are being used by some Michigan potato growers to control overwintering Colorado potato beetle adults that feed on young potato plants. Michigan is among the top 10 potato-producing states, having a crop valued at about $65 million each year.

During the latter part of the program, Lacy began developing disease forecasting systems, which monitor the weather and predict periods of high disease risk.

"As an example, on days of high humidity, fungus grows well," Grafius says. "Farmers can time their fungicide sprays with the forecasting system."

On potatoes, where the foliage is not as large a concern as it is in celery, researchers see more potential for IPM biological controls.

"At the moment, growers are experiencing severe problems controlling Colorado potato beetles," says Grafius. "We have high insecticide resistance problems. In the majority of Michigan potato fields, the beetle is immune to all synthetic pesticides registered for use."

With a 1991 industry survey estimating the cost of Colorado potato beetle control plus yield loss at more than $15 million in Michigan (20 percent of a $70 million industry), emergency registration of pesticides has been applied for.

Growers are also utilizing biological controls. Crop rotation (rarely done in potatoes), use of cover crops to reduce beetle movement and insect crop vacuums are a few methods. Propane burners have proven effective as well.

"The use of propane burners is a concept developed on Long Island, N.Y., and has been adopted by Michigan growers," Grafius explains. "The burners are used to kill adult beetles on small plants early in the season. The growers adjust the burners and the speed of the tractors so they kill beetles and not the plants. It's pretty amazing."

An insect resistance test kit developed at MSU has been used widely by growers in Michigan, testing beetles for all classes of beetle insecticides.

"On a 40-acre field a grower can save $800 by knowing what and when to spray by using a test kit," says Grafius. "They can pick something that works rather than something that doesn't."

These kits are now being used in Ontario, Quebec, Pennsylvania, Ohio, Indiana, North Dakota, Idaho and Illinois.

Growers are also using trap crops (potatoes planted along the edge of last year's field) to attract beetles, then utilizing the propane burners or other technology to kill the beetles in the trap crops, thus avoiding having to treat an entire field.

New this year is technology using trenches lined with black plastic, which intercept beetles migrating into this year's fields.

Researchers are also looking at ways to keep the beetles from flying, using cover crops combined with trap crops. This keeps the beetles from infesting this year's field and reduces the spread of the beetles' insecticide-resistant genes.

Another technology is the development of plants genetically resistant to beetles.

"Currently we are using plants provided by Monsanto, but we expect to have plants developed in Michigan in the near future," says Grafius.

IPM strategies are also focused on onions, including insect monitoring and disease forecasting. Results of a project using these strategies will be used in educational materials and videos for growers and crop consultants to use.

"It is really exciting to see the interest in IPM and the tremendous creativity of vegetable growers in addressing pest problems," Grafius says. "The only downside is there isn't much IPM data currently in use. Because insects and environments are so different, we are unable to use information from California, Texas and Florida, all big vegetable growing states." ■

Tomato growers using TOMCAST to reduce pesticide use, cost

In years past, growers of processing tomatoes, like commercial producers of many other crops, routinely applied fungicides to protect their crop against disease organisms. Spray calendars for tomatoes required fungicide applications every 7 to 10 days to protect against early blight and other leaf-spot diseases and fruit rots.

The growth and development of the fungi that cause these diseases, and their ability to infect the plants, depend primarily on the weather. With the right combination of temperature and moisture on the foliage, disease problems occur and sprays are necessary to prevent yield and quality losses.

A spray calendar approach to crop protection does not consider whether conditions are favorable for disease to develop. Essentially, its basic assumption is that conditions will always be optimal for disease development, and it calls for sprays to be applied accordingly.

Concern about residues on their crop, worker safety, environmental effects and rising input costs have motivated Michigan growers to look for a way to reduce fungicide sprays without hurting yields or crop quality. Their answer: TOMCAST, an easy-to-use modeling program that keeps track of temperatures during the hours that tomato foliage is wet to determine when disease controls are needed. The longer that leaves are wet when temperatures are above 55 degrees F, the greater the disease threat to the crop. Higher temperatures (within certain limits) also increase the disease threat.

Various combinations of these two variables are assigned disease severity values (DSVs), and these values are added up each day. When the cumulative total reaches a certain threshold level, protective fungicides are recommended. After a fungicide treatment, DSVs are set back to zero and begin to accumulate again.

The first version of the system was developed at Penn State, says Mary Hausbeck, assistant professor of botany and plant pathology at MSU. Modifications done in Ontario made it simpler for growers to use, and this version has been widely adopted throughout the tomato-growing states in the Midwest.

Even in a wet year like 1992, growers have been able to save significant amounts of money by using this system, she says. Research indicates that they can easily cut back on fungicide applications by 20 to 30 percent or more.

A critical part of the system is establishing threshold levels. That's where MSU research comes in.

For the past three years, research plots at the Southwest Michigan Research and Extension Center in Benton Harbor have been dedicated to pinpointing the threshold for fungicide treatments on processing tomatoes.

Monroe County tomato grower Kevin Iott pulls information on temperature and leaf wetness from a data pod for use in forecasting the disease threat to processing tomatoes.

"We've also looked at reduced rates of fungicide," Hausbeck adds, "but we found that it's better to maintain the full strength rates but reduce the number of applications."

To develop recommendations for growers, researchers spray at various thresholds and look at subsequent disease development in the plants, effects on yield and quality.

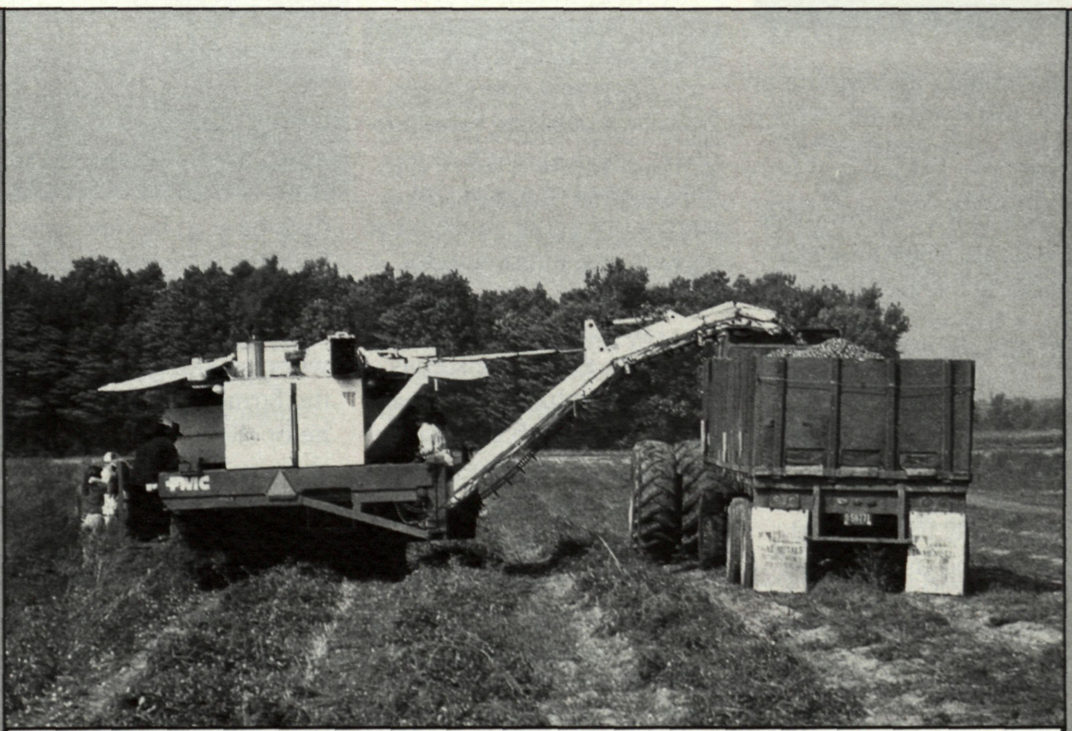
"We have growers who are very excited about this," Hausbeck reports. "Michigan growers tend to be very progressive — they want to do a better, more efficient job and reduce pesticide residues, as well as costs and potential environmental impacts."

This year, the research emphasis was on fresh market tomatoes. They still tend to be produced with a routine spray program, she notes, partly because of the need to produce a better looking tomato for fresh market sales, but also because fungal diseases rapidly render tomato fruit inedible and, therefore, unsalable.

"Some fresh market growers are so eager to apply forecasting to their crop that they're not going to wait for the results of our research — they're moving ahead on their own with the assistance of a consultant," Hausbeck notes. "I am really impressed that growers want to move forward with these programs."

Processors, too, have been very supportive. Some have even helped fund MSU research projects. And last year, they provided a toll-free telephone number that growers could call to get the disease severity values for their area and so determine the need to spray. The first to provide such information to growers was Extension agricultural agent Paul Marks, in Monroe County. For several years, growers there have been able to call a Code-a-Phone system to get information on the threat of crop disease.

"The tomato disease forecasting program has been so successful that asparagus growers have been asking why there is no such program for their crop," Hausbeck says. "They realize, of course, that it takes time to build up the biological data base. But they wouldn't mind if we were ready to go with it tomorrow." ■



Yield and quality at harvest indicate how successful disease control has been using TOMCAST.

IPM POLICY ISSUES

IPM involves more than just pests and the methods that control them. It's also about policy and how it encourages or discourages IPM practices.

"One way policy makers could encourage IPM would be to subsidize pest scouting activities," says Scott Swinton, MSU agricultural economist. "An example of a policy that promotes IPM is the SP53 pilot program. Currently in its third year, more than 100 farmers in the Saginaw Bay area are receiving up to $7 an acre in Agricultural Stabilization and Conservation Service cost-sharing funds to help defray the additional costs of practices that are expected to improve water quality. These include soil testing, scouting insects and weeds, and other techniques that will reduce either chemical leaching or erosion."

Swinton says taxation is another policy method that can promote IPM.

"There's the carrot approach — subsidies — and there's the stick approach, which is banning or taxing things," Swinton explains. "One way policy makers can change incentives for farmers is to think about whether to tax agricultural inputs, such as pesticides."

The Delaney Clause is an example of the stick approach. Under the Delaney Clause, the EPA is required to ban any chemical that has been shown to cause cancer. Bans are based on laboratory animal exposure to chemicals that far exceed ordinary field levels that humans face. Scientists disagree about the degrees of risk associated with certain chemicals — research has shown that atrazine exposure has caused mammary cancer in rats, but there is no scientific agreement on the risk to humans and other species by long-term atrazine exposure in small amounts.

...if the alternative is banning the substance altogether, then taxation might be a better approach...

"If certain chemicals are considered to be hazardous, either to wildlife, nontarget insects or to people, one approach the EPA has traditionally followed is to ban them," says Swinton.

But there are alternatives to banning. Rather than an outright ban on certain chemicals, Swinton and other researchers have suggested limiting the amount of the chemical available. This could be accomplished by identifying a level of the chemical in the environment that is a safe minimum and prohibiting use beyond this point. A ban-equivalent tax could be levied at a rate that would make most people prefer not to use it. But farmers who grow crops that require the chemical and are willing to pay for it would still be able to use it.

Regional bans or limited use controls could be put on chemicals based on their levels in groundwater. This approach allows farmers in areas where the groundwater is farther from the surface — or the soils are less permeable — to continue using the chemical.

"Taxing can be a tool," says Swinton. "Most people immediately say no to more taxes: 'We don't want taxes,' and 'The government has no business taxing farmers.' But if the alternative is banning the substance altogether, then taxation might be a better approach — particularly if the tax money is put back into agriculture."

Regional bans based on physical and climatic characteristics of certain areas are another policy approach. For example, groundwater contamination is a problem in areas with sandy soils or porous limestone layers under the soil surface. Regional bans or limited use controls could be put on chemicals based on their levels in groundwater. This approach allows farmers in areas where the groundwater is farther from the surface — or the soils are less permeable — to continue using the chemical.

"An across-the-board ban penalizes everyone because something could be a problem in one area," explained Swinton.

BIOECONOMIC MODELING

Crop pest control can become expensive for a producer, and too much or too little control of a pest can strap a budget or cause more serious pest infestation for the next year.

To help control producers' costs, Swinton also has been researching weed management through bioeconomic modeling. With MSU weed scientists Karen Renner and Jim Kells, he is gathering information to predict how much crop yield damage will result from a certain weed population and when weed control is necessary.

Swinton's research with weed management models involves actually counting the density of weeds in sample areas and entering the information into a microcomputer. Conventional weed management would treat with recommended Extension practices, with an aim to killing weeds effectively rather than profitably.

Rather than an outright ban on certain chemicals, Swinton and other researchers have suggested limiting the amount of the chemical available.

"It doesn't necessarily take less labor to use a computer model — because it takes labor to count weeds," explains Swinton. "It's like insects. It takes labor to go out and scout for insect egg cases and adults."

One cost of using the model approach is time. The farmer or someone else may need to scout for pests. The need to treat the crop would then have to be determined. Swinton acknowledged that under some situations costs will be higher, particularly when scouting reveals that the farmer should do what he or she would have done anyway. However, there are other situations where the information will show that treatment isn't necessary.

Bioeconomic models can predict whether the value of the yield loss from the given population of weeds is more or less than the cost of applying different kinds of weed controls.

"If the value of the expected yield loss is greater than the cost of the control, then it's sensible to go ahead and control," says Swinton. "But if it turns out that all you're likely to lose is one bushel of corn per acre and the cost of herbicide is going to be $10 per acre, then it's not worth it. That's what this kind of integrated weed management is all about."

Swinton's research takes into account yield that might be lost both this year and next because of inadequate pest control this year.

But what about the cost of economic modeling to the producer?

"Most of the modeling software is being developed at public universities so eventually it will be available to farmers at a fairly low cost," says Swinton. "Also, a weed management model helps in two ways: it tells you whether weeds need to be treated and what is the most economical treatment. Farmers are interested in making a good living from farming — making profits. Sometimes the herbicide that will kill the most weeds is also the most expensive. A model like this will identify the treatments that are the most profitable."

Swinton, Renner and Kells are cooperating with researchers across the Midwest to improve their weed management model. The model has just entered field testing with financial support from the Michigan Agricultural Experiment Station and the Michigan Soybean Promotion Committee. ■

IPM POLICY ISSUES

Tough regulatory restrictions, public concern about chemical use in food growing and processing, and pest resistance to these chemicals have growers worldwide in a quandary.

Growing food profitably and safely, now and in the future, is going to take some major changes in the agricultural practices and technology picture.

Integrated pest management is a part of that picture. Back in the 1940s, `50s and early `60s, manmade chemicals used in growing food were in their heyday. Killing pests and fertilizing the soil with these chemicals meant more yield per acre, which in turn meant more money in the pocket. And it worked.

"Researchers then did not see the problems these chemicals would produce, for the environment, for ecology, for human health and for the long-term sustainability of agriculture," says Mark Whalon, entomologist and pesticide researcher at Michigan State University. "The educational features and the history of environmental impact weren't there."

Whalon says IPM is a philosophy and practice whose time has come.

> **"We've gone so far down the road in agricultural production that to turn around and go back to simpler production practices that didn't use chemicals would be foolhardy."**

"IPM is the philosophy whereby we put in place the best set of management strategies, tactics and tools to manage pest populations below an economic injury level while minimizing the adverse effects of these methods on environments, and on society in general," he says.

The philosophy is unlike the past, when the ecological and environmental costs of the practices used in food production were not factored into what was being done.

"As an example, what was the ecological cost of running a plow through climax sod in the Midwest?" Whalon says. "How many species became extinct as a result of plowing up the Midwestern plain? It's difficult to know now; we only have a few hundred acres of it left."

Although use of agricultural chemicals is frowned upon, Whalon notes that it is impossible to go back to a totally chemical-free environment.

"We've gone so far down the road in agricultural production that to turn around and go back to simpler production practices that didn't use chemicals would be foolhardy," he says. "The price of food would go through the roof, and whole sectors of our economy and our society would be out of work. There would be tremendous impact.

"What we need to do is create better tools and develop a better understanding of the environment, ecology, and population dynamics and genetics of our target pests."

Sustainable agriculture in fruits and vegetables, a philosophy that parallels IPM, could work if IPM is integrated.

"Rather than pests being considered way down the line and thinking we can handle them with chemicals, we are seeing that they are an important aspect in the plants we plant, and how, when and where we plant them," says Whalon. "Regulations and the cost of control have reached the point where some growers are going out of business because they can't do the things they need to do to control the pests."

Michigan State University was once a leader in IPM technology.

"It was really born in this institution," Whalon explains. "In the late `70s, and early `80s we were in a leadership position in IPM nationally and worldwide."

But MSU lost that lead when budgets for IPM were cut to the point where it was difficult to function.

"The program was downsized, and it impacted what could have continued to be a world-leading IPM program," Whalon notes. "The Department of Entomology is one of the top three in the nation, if not the world, and IPM has been the forte of many of the people here. I'm doing IPM internationally because there are few resources in Michigan and limited support from Extension. We have an IPM task force with a small amount of money."

He feels IPM should not be considered something to be added onto whatever else is being done in agriculture.

The dilemma of producing quality produce with fewer chemicals has led researchers to trying different methods of biological and cultural controls, and testing them against conventional methods of control. This has been done by MSU in low chemical inputs in peach production at the Southwest Michigan Research and Extension Center (see related story). Whalon sees this as the type of research that will determine the future of pest management.

"There will be no more quick fixes, silver bullets or wonder drugs, which the broad spectrum insecticides were," he says. "They are biocides, which kill us as well as the insects."

Environmental and ecological concerns, and regulatory constraints will not lessen, but increase, Whalon notes.

In the future, Whalon sees global free trade as a force driving the entire world agricultural system to implement low chemical input systems.

"The global market situation is going to build in private sector residue and quality detection systems on fruits and vegetables," he says. "One of the big secrets is that diseases on vegetables and fruits produce their own little toxins which may be far more significant than pesticide residues.

"When that hits the market, we won't be able to have scab and powdery mildew russeting on apples or brown rot on peaches."

He forecasts that some growers will go out of business because they won't be able to meet the standards.

To keep that from happening, Whalon says that MSU's role should be to develop sustainable, environmentally friendly production practices that growers can use to compete on a global basis.

"The university has the strength," Whalon says. "What we need is the public sector support and recognition of its importance. If we don't want our agriculture going to other countries, the public is going to have to pay something for the development of these alternative systems."

> **If we don't want our agriculture going to other countries, the public is going to have to pay something for the development of these alternative systems."**

Whalon sees the possibility of IPM becoming more privatized in the future to get the job done. He also warns that if the United States is to compete in world agricultural markets, it has to invest.

"Agriculture is still 38 percent of our national GNP; that's just agricultural exports," he says. "That's a huge sector."

He feels the university has been busy training more people internationally than in this country.

"When society wakes up, they will wish we hadn't had a downturn in training entomologists, plant pathologists, horticulturalists and crop scientists like we have in the last 10 years," he notes. "We've been giving more and more technology away to the world. This is fine, but it makes for a level playing field in competing worldwide." ■

Research has human health applications

The same sort of chemical detective work that yields new pesticides also provides drugs to treat human ailments.

One of these is Spartanamicin, an antifungal antibiotic useful for treating common yeast infections caused by *Candida albican.* Isolated from a soil microbe from a potted plant, it has been patented by MSU and licensed by a corporation.

Another is taxol, the only drug known to be effective against ovarian cancer. It was discovered in 1971 during National Cancer Institute screening of materials as possible cancer treatments.

Researchers at Virginia Polytechnic Institute figured out a way to solubilize taxol so it could be delivered. Other scientists have been working for 10 years to synthesize it, without success.

Muraleedharan Nair, MSU assistant professor of horticulture, has taken another tack. Rather than try to create the molecule in the laboratory, he has gone looking for another natural source.

Until now, taxol has come exclusively from the bark of the Pacific yew, which grows only in the Pacific Northwest. It takes three 30- to 40-year-old trees to provide enough bark to get enough taxol to treat one patient, so the cost of the drug is astronomical.

Clippings from Michigan nursery growers will be the primary source of a cancer drug, now in short supply, that will soon treat tens of thousands of cancer victims.

Nair went looking for taxol or similar compounds in common ornamental yews — and found it. He also found a simple, economical way to extract this complex molecule, and he and several others — John Kelly and Robert Schutzki, from the MSU Department of Horticulture, and Chicago businessmen Lou Morgan and William Rigby — have formed a company, Natural Product Technologies, Inc., to produce taxol and related compounds in Michigan from ornamental yews.

The current supply of taxol is very limited. The aim is to produce enough taxol to treat tens of thousands of people per year. Clippings from Michigan nursery growers will be the primary source. Nair figures it would take only five to six years to grow taxol-dedicated ornamental yews to harvest size.

In addition to ovarian cancer, where it's 40 percent effective, taxol has been shown to be 60 percent effective against breast and lung cancers. Clinical trials are now underway with lung cancer patients.

Taxol works by interfering with the rampant multiplication of cells that occurs in cancer. Nair hopes the new company will produce enough taxol to reduce the price so it is available to more people. He and his partners are trying to raise the money necessary to build the plant.

"Once we can show we have a buyer for the product, the money will come," he says.

Environmental concerns accelerate while IPM research atrophies

Continued from page 1

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Larry Olsen, MSU Extension pesticide education coordinator, says there appears to be a resurgence in federal interest for IPM research but he does not know to what extent support will be continued.

"In the 1930s and early 1940s, there was some excellent research done on biological controls for agricultural pests," Olsen says. "Scientists at universities and at the U.S. Department of Agriculture did most of that work, but the information was shelved when synthetic chemicals, which were very effective, were ushered in.

"Now we are paying the price through some very serious environmental problems," he says. "The IPM concept, it is hoped, will enable agriculture to wean itself away from a dependence on chemicals that, when used to excess, pose a threat to the human and natural environment."

The IPM concept is valid, and the biological pest management research that preceded that concept can be blended with IPM delivery if sufficient research and Extension funds are provided, according to Olsen.

"Both [modern IPM and biological controls] can be extremely effective in reducing harmful pesticide loading in the environment, but we must not lose sight of the fact that regardless of how good our intentions are at protecting the environment, we must assure that the resulting recommended practices can be afforded by the farmer," he says.

"Moreover, we are not going to achieve satisfactory widespread use of IPM and/or biological pest control through unduly restrictive state and federal legislation," he says. "There needs to be a balance between research and education, and it appears that environmental interests and regulations are beginning to outstrip the former at a rate that I fear may be the demise of the family farm as we know it.

"In the 1930s and early 1940s, excellent research on biological controls for agricultural pests was done. The information was shelved when synthetic chemicals were ushered in. "Now we are paying the price."

"I do not know of a grower who would intentionally use a pesticide to his or her detriment or at the peril of the environment to control a pest," Olsen says. "Yet there seems to be a perception outside of agriculture that pesticides are used carelessly. Barring accidents, that simply is not the case."

He points out that there are literally hundreds of insects, weeds and diseases that, unchecked, can ravage a crop in a matter of days, and that pesticides will be required if growers are to provide quality food at readily affordable prices.

"Agricultural regulations and laws should be formulated on credible, refereed scientific data and based on a risk/benefit analysis," Olsen says. "Were I a policy maker, I certainly would not allow a pesticide to be used that would pose a significant environmental or human health risk. But if the benefits are significant and the potential adverse effects are not, then the use of that particular pesticide should be permitted."

He believes that many of the current pesticide use regulations that have been and are being put into effect are too heavily weighted toward a hypothetical fear that often is not scientifically proven.

"I think that the farmers' point of view should also be carefully considered in policymaking," Olsen says. "Many of the farmers I know are years ahead of MSU in finding innovative approaches to IPM because of their interest in producing a safe, quality product and from their concern about the environment. Pesticides are extremely expensive but they are a necessary tool for food production as we know it today.

"However, an overriding fear among farmers is the potential liability they have when they use a pesticide, and if this concern continues, it is apt to negate what could be a very productive relationship between the farmer and the scientist," he says. "I do not know of anyone who can manage well in an atmosphere of fear, and right now that is what is beginning to predominate."

Nonetheless, Olsen believes that, given financial resources and time, the scientific community and the farmer can move in lockstep to a more complete environmentally compatible agriculture.

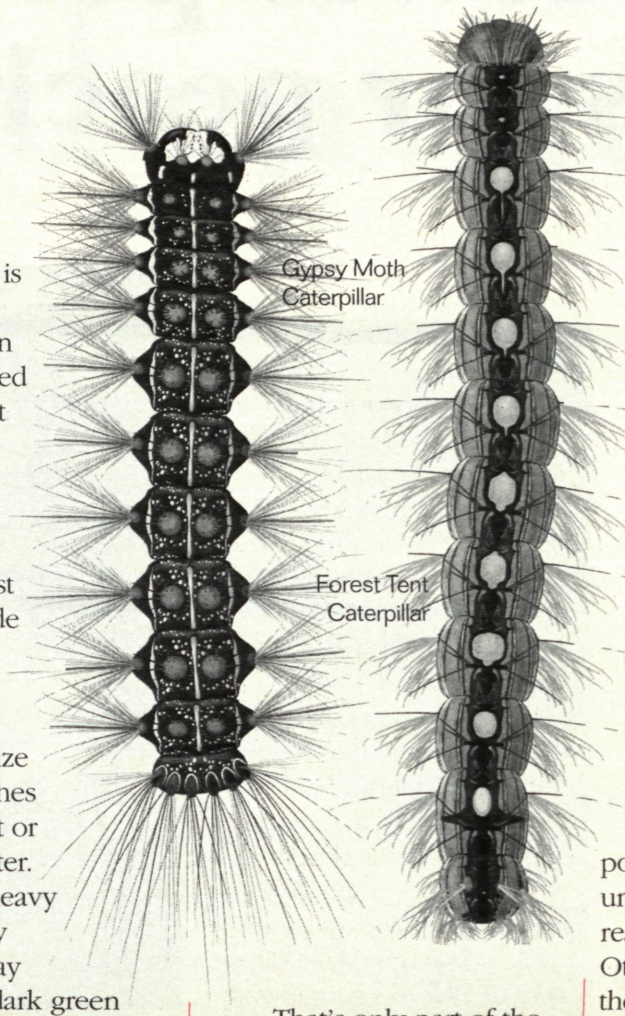
"Biotechnology can develop the crops that can more ably fend off pests and retain their wholesomeness, and where we must use pesticides based upon need, computer technology can be fitted to the applicator to target a particular pest that is threatening the crop," he says. "But this is going to take time, and the practicality of the new practices must be proven."

Agriculture is a complex, technology-driven business that is guided by research and education as much as any other business, Olsen says.

"Farmers do not operate in a vacuum, and the research that ushered in the so-called chemical age in agriculture did originate in the scientific community," Olsen says. "Farmers followed that direction with amazing results, and as we continue to evolve toward a new frame of reference for agriculture, we should not penalize the farmer for whatever ills we found as a result of scientific discovery and government policy 40 and more years ago.

"My point is, this time around, let's make sure we are on the right track so that agriculture can remain viable in this country, and let's reach our environmental aspirations through education rather than trying to legislate our way," he says. "I sense that we are at somewhat of a crossroads and, depending upon which direction we take, we can fortify the resilience of farm family agriculture as we know it or we can force agriculture into a tightly regulated monoculture production that none of us may like." ■

MSU SCIENTIST SEARCHES THE SOIL FOR NATURAL PESTICIDES



When Muraleedharan Nair explains his research, he makes it sound deceptively simple: he looks for soil microorganisms that produce compounds that act as natural pesticides, ferments the organisms in the lab to produce those compounds, extracts and purifies them, then tries to achieve the same pesticidal effect in the laboratory with the pure chemical. The result may be a new fungicide for an old problem in turf or ornamentals, or a new source for a proven but expensive pharmaceutical.

It all boils down to chemistry — and a hefty dose of detective work.

Nair, an associate professor in the Department of Horticulture and the Pesticide Research Center at MSU, is an organic chemist. His study of soil microorganisms and their products is aimed at finding naturally occurring alternatives to existing chemical pesticides. Sometimes, as in the case of a fungicide that has shown promise against fusarium and botrytis diseases, his research turns up a possible control for a problem that previously had no treatment.

It is very difficult, he says, to take one of these organisms producing active compounds out of the soil and put a compound back to achieve the desired effects as a biological control. Several patents for new pesticides, however, attest that he has surmounted the difficulties.

He is currently looking at a compound that may be useful as a nematicide. Already patented is a control for soybean cyst nematodes and sting nematodes in turf. This compound, like a number of others he is working on, came out of an unlikely place: fairy rings.

Fairy ring is an ecological phenomenon in turf characterized by a ring of fast growing, dark green grass. Often a ring of thin or dead grass occurs just inside or outside the ring of healthy-looking grass. Rings vary in size from a few inches to up to 50 feet or more in diameter. After rains or heavy watering, many mushrooms may appear in the dark green area. The fungi associated with fairy rings usually start at a central point and expand outward more or less evenly in all directions to produce the characteristic ring.

A simple question started Nair on his quest: why is the grass in the ring greener and healthier looking than nearby grass? As he delved into the fungi and other microorganisms associated with fairy ring, he discovered an antibiotic, faeriefungin, that kills certain plant pathogens (disease-causing organisms) and the nematicidal compounds mentioned earlier. In seeking a chemical answer to an ecological question — why is the grass in the ring greener? — he discovered some compounds with practical applications.

That's only part of the story — after discovering them, figuring out a way to isolate them and showing in the lab that they may be effective in the field, he has to figure out their exact chemical structure. Only then can he begin to interest chemical or pharmaceutical companies in further testing and perhaps producing and marketing his find.

"As a chemist, I do the preliminary discovery," he explains. "We leave it to the chemical companies to take the product to market."

A turf fungicide is currently in its second year of field trials in Michigan. It's targeted at dollar spot, leaf spot and summer patch and some other minor turf diseases.

"We got good data on dollar spot last year, but nothing on summer patch," Nair says. "The weather didn't cooperate: no summer."

The fungicide for fusarium and botrytis diseases is undergoing greenhouse testing in Michigan and field trials in Germany, conducted by a German chemical company under a licensing agreement with MSU.

Royalties from the sale of patented compounds come back to the university to support further research, Nair points out. Other support comes from the MSU Foundation, chemical companies, and state and federal agencies.

Why put so much effort into discovering and developing these natural pesticides when perfectly adequate synthetic compounds are available and effective?

Gypsy moth and forest tent caterpillars: neither like to feed on the red maple or the paper birch. Why?

One big reason is that synthetic herbicides and fungicides tend to persist in the soil for months or even years. Naturally produced compounds are safer not because they are naturally occurring, but because they don't hang around forever.

This is especially desirable when the target pest is very seasonal. The gypsy moth, for instance, which defoliates hundreds of thousands of acres of forest each year in Michigan, other states and Canada, is in the destructive larval stage for only about six weeks. Then the caterpillars pupate, emerging in a few weeks as adults, which mate and lay the eggs that will hatch into next year's leaf-devouring pests.

Any insecticide applied to control the caterpillars needs to be quickly effective, not long-lasting. And the more it is specifically targeted to control gypsy moth caterpillar feeding, the better. This means less damage to other insects, wildlife and the environment.

Nair's research on gypsy moth and the forest tent caterpillar (another forest defoliator) is aimed at finding out why neither of these pests likes to feed on red maple and paper birch. Nair, Dan Herms of Midland's Dow Gardens and the MSU Department of Entomology; William Mattson, Department of Forestry; and James Nitao, Department of Entomology, are looking for the chemical or chemicals in these plants that the pests don't like.

"Once we know what they are, we have two courses open: to genetically engineer plants with more of these compounds, or to use them in aerial spraying as repellents," Nair says.

Genetic manipulation to produce more resistant trees would take many years, of course, so sprays are going to be part of a control program for a long time, he points out.

This is true of pest control in general, he notes.

"We have to control pests and diseases if the world isn't going to starve," he says. "There are a lot of compounds out there in nature, natural pesticides and fungicides. We are simply trying to find them and use them." ■

MSU research may point the way toward fewer pesticide applications for peaches

Growing a good crop of peaches is possible with less than a half dozen chemical applications per season, say Michigan State University researchers.

As part of a four-year project at the Southwest Michigan Research and Extension Center (SWMREC) in Benton Harbor, a team of specialists in entomology, horticulture, and botany and plant pathology compared conventional methods of pest control with moderate and low levels of chemical inputs.

Their aim was to reduce pesticide and fertilizer use and still produce a marketable peach crop.

Peach production was a concern, as southwestern Michigan has a high concentration of peach growers using a high level of chemicals.

"After the Alar scare in apples, where apple growers lost millions [of dollars], peach growers became concerned that a similar situation could confront them," says Jim Flore, MSU horticulture professor and one of those involved in the project. "This project came together in 1990 as a team approach to look at the different methods of control."

The project team decided to monitor three levels of chemical control, defined as:

1) Conventional method
Pesticides and fertilizers were applied according to a spray schedule most growers use. The plots are clean cultivated, have drip irrigation, nematicides are applied and are dormant pruned.

2) Moderate level
These integrated pest management (IPM) techniques available today and proven were used. Paraquat and simazine herbicides were used, insecticides were applied as indicated by insect trapping, nitrogen was applied through drip, standard fescue was used as ground cover and nematicides were applied.

3) Low level
This includes utilizing techniques not necessarily proven but that have shown a lot of promise, though they had never been put together in a total system.

At SWMREC, this meant no herbicides, straw mulch to control weeds, manure applied as a nitrogen source, summer pruning to reduce canker, endophytic rye used as a ground cover and as a control of tarnished plant bug, leaf hoppers and catfacing insects, pheromone disruption for Oriental fruit moth, nematode control and other insect monitoring. Low chemical input also meant higher management input.

> **"After the Alar scare in apples...peach growers became concerned that a similar situation could confront them."**

The project team was fortunate to have enough land at SWMREC to establish two one-acre blocks of land with a half-acre of the Newhaven peach variety in each block. This also was adequate spacing to keep each method from influencing another.

It also helped accomplish the project's objectives, namely:

1) to see how much the chemical input on peaches can be reduced;

2) to monitor the quality and yield of the fruit and tree growth to see if all were within standards of marketability; and,

3) to monitor the residue in the fruit, usually an expensive task.

Before anything was begun, an environmental study team at SWMREC surveyed the soils at the site, previously a farm, for possible pollutants.

"There are possibilities that there could have been things like arsenic, lead or other chemicals in the soil, and we wanted to know what our background was," Flore notes. "The question could come up, `What happened? Did you people contaminate it, or who contaminated it?' Or is there any problem there to begin with?"

Flore also points out that seven wells were dug to sample the groundwater at SWMREC.

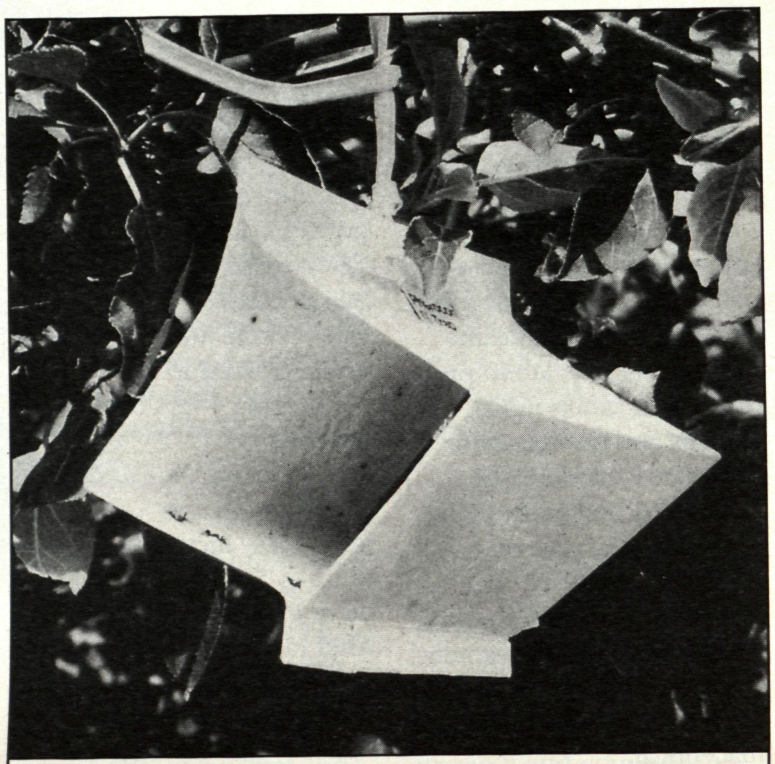
So far, the results from the low level of chemical control has been promising.

"We have been very encouraged by the results," Flore says. "The conventional method (plots) had 16 different pesticide applications, and that's not uncommon. The moderate level had 20 to 25 percent less pesticides, which is pretty good.

"But in the low level, we had only four applications, and three of those were sulfur, which some organic growers would not consider a pesticide.

"The bottom line is this — in the low input, 79 percent of the fruits were insect or disease free. In the conventional, where we had all those sprays, it was about 95 percent. That's only a 16 percent difference."

The team also determined that if they had applied one more spray on the low level, that fruit would have also reached the 95 percent level.



Pheromone traps, which exude the scent of female insects, are used to trap males, certain numbers of which trigger insecticide applications to prevent economic damage to the crop. The traps help growers fine-tune crop protection chemical use for maximum efficiency and environmental safety.

"What happens is, you have a whole new set of insects coming in," Flore explains. "Sometimes your secondary pests become your primary pests. In this case, rose chafers became a problem."

The total yield of the low level input was less than that of both the conventional and the moderate input plots, and though the specialists are not exactly certain why this occurred, they feel there may have been a set of contributing factors, including a spring frost in the low areas of SWMREC where the low level plots were located or the thinning method used by those taking off the damaged fruit.

"There is a whole series of things we are doing with low level inputs growers can use," Flore notes. "One of these aspects is pheromone disruption, where female Oriental fruit moths can't find the males and can't mate. We found this technology can work in as little as one acre; previously it was thought it worked best in five acres or more."

The ryegrass grown on the orchard floor of the low level plots was also an important factor in keeping peach pests in check.

"The ryegrass is infected with a bacterium," says Flore. "It's called an endophytic ryegrass, and it [the bacteria] makes the grass a little sick. It gives off a natural pesticide, which inhibits two major pests: leaf hoppers and tarnished plant bugs."

Leaf hoppers can also carry the peach x disease, caused by a mycoplasma, and if populations of this pest are controlled, the disease can't affect the trees.

Flore notes that any one of these nonchemical control methods can be used by growers.

"Growers can pick and choose methods of control to use," he says.

The low level input method does require a high level of human input.

"Someone has to be in the orchard every week, monitoring the level of the insects

A concern for the orchard environment

People's concern about food safety goes hand-in-hand with their demand for high-quality food. These demands are especially high when it comes to fruit. The tolerance for insect damage and bruises on fruit is very low, and the fruit must be produced with minimal effect on the environment. Research at one of the Michigan State University Agricultural Experiment Field Research Stations, the Trevor Nichols Research Complex in Fennville, is aimed at meeting both of these needs while offering orchard growers low-cost, effective solutions to insect problems.

"We are a fruit insect research station," says Jim Johnson, an MSU assistant professor of entomology and faculty coordinator at the station. "When you start looking at the control of an insect, you have to back up and look at when they're in the orchard. You have to monitor the insects, select and apply the control. We work at the field level and try to provide the best solutions."

Johnson says a field station like Trevor Nichols is essential to finding these best solutions.

"We're in the same area as the growers, we have the same pests that they have and the same environmental conditions. It's important that our site is the same as the growers'. I can't go out and talk to every grower, but they can come here and see our demonstration plots."

Johnson divided research at the station into three broad areas: insect biology, insecticide efficiency and insect resistance monitoring.

Insect biology projects, including searching for natural predators and studying pheromone mating disruption, encompass a large number of projects at the station.

"These insect biology experiments are critical to achieving a better understanding of pest monitoring and fit very well into IPM practices," Johnson says. "The more we know about the insects, the better IPM we have."

Researchers at the station are trying to rid orchards of codling moths using what Johnson calls "the Chanel No. 5 approach to pest management." Plastic tags containing synthetic female moth sex pheromone are placed on trees in the orchard. The tags release a constant amount of the pheromone, which attracts male moths.

This scent saturation does one of two things: it makes the males immune to the odor so they are not affected and do not try to find a female with which to mate, or because the odor is everywhere, they fly so long and hard around the orchard that they fly their wings off, damage themselves and are unable to mate. Either way, the males do not find the females, which means no mating, which means no larvae to attack and eat the fruit.

"This is a different approach to insect management," Johnson says. "Conventional insecticides kill immediately. Growth interrupters disrupt molting and subsequently kill the insects. Nothing dies in the pheromone approach."

According to Johnson, the approach also presents several questions and areas for experimentation. Scientists do not yet know what happens to secondary insect pests, which used to be killed by conventional sprays, when pheromone controls are used. They are also investigating the possibility of using more than one tag in each orchard to combat several insects or creating one scent that would disrupt the mating of a number of pests. Cost, however, is a concern.

"These pheromone tags costs approximately 40 cents a piece," Johnson says. "You need to use about 400 per orchard, so that would be about $160 per. Using two sets of these per orchard, the costs compare favorably with conventional insecticides. When you start considering three or more, it's more economical to use sprays.

"The tag cost is for the scent chemicals," he continues. "They're special, complex, blended compounds created precisely for this purpose. You can't just pull them off the shelf."

The amount of chemicals in the tags is so small that they are regarded as safe to humans, and Johnson says he has observed no problems at the Trevor Nichols complex.

One drawback to the mating disruption control method is the migration of previously mated females into the tagged orchard to lay eggs.

"This is a problem," the entomologist says. "To be effective, you have to have all the growers in the area, or even the state, using the same methods and have all the trees treated. But this is the most environmentally friendly method of control, and for one pest, it compares very favorably to conventional methods."

A part of the insecticide efficiency work involves side-by-side testing of new experimental compounds against untreated control sites. If the new compound is effective and meets rigorous residue requirements, it can then be registered for use in commercial orchards.

"We could never do this kind of work in a commercial orchard," Johnson says. "There's too much loss. A commercial grower couldn't allow insects full run of an untreated section of trees. To get a truer check of damage differences, we have to allow the bugs to eat the fruit."

Johnson and his colleagues at the station also monitor insects for resistance to conventional sprays so the instances of resistance can be documented and studied and alternative methods of control can be offered to growers. ■

Peaches... Continued from previous page

and diseases, and has to know whether to put into action a chemical spray or not," says Flore. "John Wise, the project coordinator, wants to take this another step further after we are completed with the project and look at the economics of the system and how the whole system can be integrated."

All in all, Flore says he is very encouraged by what's been seen in the low level input plots.

"We had pretty darn good peaches with four applications," he says." Granted, 1992 was a cool year, but it is still outstanding."

He also comments that consumers aren't the only ones worried about what's going onto their food.

"Growers are quite concerned about the compounds they use, the amounts they use and where they use it," Flore says. "They have to live there, and their children have to live there." ■

MSU AGRICULTURAL ENGINEERING TECHNOLOGY WILL HELP GROWERS CURTAIL PESTICIDE USE, YET MAINTAIN CONTROL OVER DAMAGING PESTS

TREE FRUIT CHEMICAL APPLICATION TECHNOLOGY DEVELOPED AT MICHIGAN STATE UNIVERSITY ENABLES GROWERS TO SUBSTANTIALLY REDUCE PESTICIDE USE, YET MAINTAIN CONTROL OF DISEASES AND INSECTS THAT CAN RUIN FRUIT QUALITY.

MSU's air curtain sprayer technology substantially reduces the amount of orchard chemical protectant that can escape into the atmosphere or fall to the ground by controlling the spray pattern into the tree. By contrast, the radial application pattern of conventional sprayers is prone to chemical drift.

Moreover, the technology — the air curtain sprayer — reduces the amount of pesticide that can escape into the air or fall to the ground.

Most of the air blast sprayers used in orchards and vineyards are inefficient in applying pesticide and provide the potential for environmental risk. In fact, the conventional air blast sprayer is built with technology developed 40 years ago.

Gary Van Ee and Richard Ledebuhr, MSU agricultural engineers, are the developers of the air curtain sprayer, which has undergone performance trials in several states and continues to undergo refinement at MSU. The "MSU concept" sprayer is being manufactured by B.E.I Manufacturing of South Haven and is sold under the Curtec trademark.

The sprayers most commonly used in orchards disperse pesticides in a radial pattern from the rear of the unit with a fan and nozzle system that propels the pesticide upward into the tree (and well above it). Research shows that pesticide from this type of sprayer does not penetrate the tree canopy evenly and may leave some parts of the tree leaf unprotected.

Some growers who use conventional sprayers feel that if the pesticide doesn't drip from the leaves after application, the tree has not been properly sprayed. Not so with the air curtain sprayer. In fact, little pesticide leaves the tree canopy when it is applied.

The air curtain sprayer holds the application nozzles and fans on a vertical boom which enables pesticide to be propelled horizontally into the tree canopy. Van Ee says that the concept of a horizontally moving curtain of air allows the spray to be more uniformly deposited in the tree canopy.

At the top of the boom, a blast of clean air aimed slightly downward prevents the pesticide from drifting above the tree while directing the pesticide downward. The operation is so unique that a casual observer might think the tree had not been sprayed.

The air curtain helps growers improve the timeliness (which is everything when rains are frequent and diseases are rampant) of pesticide applications with less material used.

David Alpers, a Michigan apple grower, has cooperated with Van Ee and Ledebuhr since the air curtain's inception. He calculates savings of $400,000 in pesticide cost while reducing the amount of chemical applied per acre by 50 to 60 percent.

Van Ee and Ledebuhr got the idea for the air curtain application principle from their years spent in developing mechanical harvesters, which use fans to separate leaves and stems and foreign material from harvested vegetables.

The harvester fans were the focal point of their interest. The type of fan used — tangential or crossflow — produces a straight stream or curtain of air flow. Why not, reasoned the two, use that fan technology to move pesticides more effectively into trees?

That was in 1984, and they literally went into the backroom to scavenge parts from existing equipment to make their concept a reality.

Van Ee credits the Michigan Apple Research Committee for providing seed money to get them started on the air curtain project.

One Michigan apple grower calculates savings of $400,000 in pesticide cost while reducing the amount of chemical applied per acre by 50 to 60 percent.

"We told them we had some very creative ideas that were a radical departure from the then current sprayer technology, and would they be willing to invest in a high risk research project?" Van Ee says. "They agreed, and although the amount they have invested was a small percent of the total project cost to date, they were the first to contribute. I think that underscores the interest that growers have in doing the best job possible in their industry."

The first air curtain field tests were in 1985. Van Ee and Ledebuhr have been refining the air curtain mechanics ever since. Their current goal is to develop the air curtain technology and a companion management system to the point that pest control will not be an environmental threat.

To accomplish that goal, Van Ee and Ledebuhr have joined with scientists and Extension specialists in MSU's departments of Horticulture, Botany and Plant Pathology, Entomology and Agricultural Economics in a project that will run through 1995. The MSU Agricultural Experiment Station has pledged $200,000 toward the project.

"If we have the capability to put most of the chemical where we want it on a tree, then we should be able to control to some extent where we don't want it. So from a mechanical standpoint, we are working on the technology that will provide environmental boundaries for the chemical being applied," Van Ee says.

The management system envisioned by the research team is a complete integrated pest management program at the orchard level. It will blend application technology with pest detection, weather conditions, timing, knowledge of chemical effect and fate, and personal protection for maximum environmental safety.

The air curtain technology may help retain the use of some of the current pesticides that are proven effective in controlling damaging insects and diseases because the new technology permits a reduction in the amount of insecticides applied per acre and reduces the off-target deposition.

Choices still needed...

However, if the proven insecticides continue to be removed from the market, more, not fewer pesticide applications may be required in the future, according to Jerome Hull, MSU Department of Horticulture, and Don Ricks, MSU Department of Agricultural Economics.

Hull and Ricks are the co-authors of "Tree Fruit," Special Report #57 in the series, "Status and Potential of Michigan Agriculture — Phase II," which was commissioned by the MSU Agricultural Experiment Station from mid-1990 to late 1991.

In their report, Hull and Ricks wrote the following:

"Although growers will try to reduce the amount of insecticides they use, this may not be possible. In fact, growers may be forced under certain circumstances to use more insecticides. If certain key, effective pesticide materials are not reregistered and hence not available for use by the growers, and if the remaining labeled pesticides are less effective in controlling the disease or insect pest complex, even growers using state-of-the-art IPM strategies may need to increase the number of applications.

"This would tend to increase the total amount of pesticides used. If this very real possibility occurs, the recent regulations designed to reduce pesticide usage, may, in fact, result in increased insecticide usage during the coming years.

"Achieving maximum pesticide reduction through implementation of IPM techniques is best accomplished when growers have a large number of effective pesticides from which to choose." ■

FIGHTING PESTS ON YOUR OWN TURF

Concern for the environment. Those words conjure up images of majestic forests and mountains, unspoiled prairies and wetlands, and pure oceans and streams — national treasures that must be protected from the careless encroachment of civilization.

But how many people think of their own backyard when they're concerned about the amounts and types of chemicals being applied to the planet? Ten years ago it may not have been many, but in today's proenvironment society, people realize that the substances they apply to their lawns are as important as the inputs used by agricultural producers and industry.

"Environmental issues are of paramount importance to the turfgrass industry," says Gordon LaFontaine, executive secretary of the Michigan Turfgrass Foundation. "The industry wants to be educated in integrated pest management and biological controls and will pay for this education."

To help meet this need for education for the professional as well as the homeowner, turfgrass researchers in the Agricultural Experiment Station at Michigan State University are working on many projects to solve turf problems.

Living With Grass Grubs

During the 1991 drought, many lawns in Detroit, Jackson and Grand Rapids were severely attacked by European chafer or Japanese beetle larvae, large white grubs that feed on turf roots. The hardest hit areas were reduced to bare earth. Homeowners were left wondering what they could do to prevent similar outbreaks.

"The extensive damage was due to the drought," says Dave Smitley, associate professor of entomology at MSU who is experimenting with ways to control grub damage. "When lawns are healthy and growing, the grubs don't do too much damage. But that fall the lawns that were water stressed and were heavily infested with grubs just succumbed."

In his work to discover how many grubs per square foot of turf it takes to cause damage, Smitley has found that irrigating one-tenth of an inch of water per day reduces grub damage more effectively than applying insecticide and not irrigating.

"We put 20 grubs per square foot on turf that was irrigated and there was little noticeable damage," the scientist says. "However, as few as five grubs per square foot will cause damage in unirrigated turf."

Applying the recommended one-tenth inch of water per day to an average lawn costs about 86 cents per day. Where there are no water restrictions, Smitley recommends irrigation as a more effective alternative to conventional pesticides.

"The standard treatment for chafer and Japanese beetle grubs [the two most serious insect problems in turf] is insecticides," Smitley says, "and this worries me because some homeowners have a tendency to go overboard. If the water is available, irrigation is a good way to go."

Smitley's research results were reinforced last fall. The tremendous amounts of rain the state received made grub damage virtually nonexistent compared with the year before.

"Last year, we had a hard time finding damage to any of the test plots," he says, "even those with very high grub counts. This year, I've constructed some shelters to keep the rain off certain plots so we can better control the amount of water they're getting."

Finding natural enemies that consider the grubs a tasty snack is another logical method of control, but because the root chompers are not native to North America, there aren't enough diners to make a dent in grub numbers.

"Skunks love them, and so do raccoons and moles," Smitley says, "but those animals can cause problems, too. It's not unusual to see raccoons digging up lawns that are heavily infested with grubs. But these creatures don't eat nearly enough grubs to control them."

Not to mention the wear and tear on the lawn.

Deterring Diseases

Ten years ago, Joe Vargas began investigating biocontrols for necrotic ring spot disease, the most chronic of lawn diseases. Vargas, an MSU professor of botany and plant pathology, and his associates were attempting to manage the fungus with a biofertilizer composed of soybean meal and other protein sources. And they were successful. The fertilizers caused the numbers of bacteria in the soil to increase (to digest the protein in the fertilizer) and this effectively reduced the fungus' disease effects. He also found that light, daily irrigation had the same effects (much the same way Smitley found that irrigation controls grub damage).

Building on this success, Vargas is also working to find a biocontrol for annual bluegrass, a problem that plagues golf courses. Its name is something of a misnomer because annual bluegrass is actually a perennial. Annual bluegrass is a lighter green than Kentucky bluegrass and creeping bentgrass, the two most common types of turf on golf courses, and has a tendency to invade golf courses.

"Some people don't mind annual bluegrass; some consider it a problem," Vargas says. "It's a fairly acceptable playing surface for golf, but when it is mixed in with the other types of turf, it doesn't look very nice."

Annual bluegrass has an advantage over the other grasses because it produces seed when the plants are relatively short. The seeds stay in the soil until one of the other types of grass dies out and leaves a bare spot. Then annual bluegrass springs up.

"If we could just get the other two to produce seed without having to grow so long," Vargas says.

"One of the best reasons to get rid of annual bluegrass is from an environmental standpoint," says Bruce Branham, MSU associate professor of crop and soil sciences. He works as a turf scientist but was first trained as an agronomist. He is studying cultural practices to control the invader. "Annual bluegrass requires higher inputs of water and pesticides to maintain a good turf. Kentucky bluegrass and bentgrass don't require as many inputs."

For his project, Vargas is studying a bacterium, *Xanthomonas*, that controls one type of annual bluegrass.

"It used to be thought that heat killed annual bluegrass," he explains. "So if it invaded a golf course and was allowed to take over, it would die when the weather got hot."

Vargas discovered, however, that it wasn't the heat that was killing the grass, but two fungi. He then developed methods of controlling these fungi so golf courses would have healthy annual bluegrass all season.

Dollar spot disease, another fungus disease that Vargas is researching, is primarily a golf course problem. Dollar spot is becoming resistant to the fungicides now used to control it.

"The fungicides in use now travel through the plant and are very specific about which part of the fungus' development they inhibit," Vargas says. "As a result, many of the fungi develop resistance to the fungicides, making us scramble for new controls. In two years, there will be only two fungicides available to manage dollar spot."

As he did with necrotic ring spot and annual bluegrass, Vargas is trying to find a bacterium to control the fungus. He is optimistic, but this type of research takes time — usually 10 to 15 years.

Another tactic that both Vargas and Branham are using is the biotechnological method of inserting disease-resistant genes into turfgrass.

Vargas and a graduate student have found a type of Kentucky bluegrass that is resistant to necrotic ring spot. They are attempting to identify the genes responsible for this resistance so breeders can incorporate them into new turfgrass varieties.

Branham and a graduate student are working on incorporating disease-resistant genes into bentgrass.

All the scientists agreed that low- or no-input green areas, such as golf courses, lawns and cemeteries, are becoming more and more common.

"People tend to think that golf courses use lots of pesticides, but many have reduced pesticide use to a minimum," Smitley says. "Walnut Hills, in East Lansing, for example, uses no insecticides on the fairways and very few fungicide treatments. At the Grand Traverse Resort, they use no insecticides except spot-treatment of the greens for ants. There's a lot of potential for no-chemical golf courses." ■

IPM IS BEGINNING TO CATCH ON WITH MICHIGAN'S GROWERS

Larry Mawby, co-manager of a 180-acre grape and tree fruit operation in northern Michigan, works closely with MSU Extension agents and research entomologists to reduce reliance on pesticide use and increase biological control of pests.

A recent national Gallup poll among farmers shows that:

- 3 out of 5 farmers are more concerned about environmental issues than they were 5 years ago.
- 92 percent are likely to use safer pesticides in the future and 71 percent are likely to use fewer pesticides.
- Two-thirds favor tougher penalties for misapplying pesticides and 41 percent favor certifying those who apply pesticides.

Those statistics seem to blend with the increasing interest that farmers are showing in MSU Extension education programs that focus on integrated pest management.

One such grower is Larry Mawby, co-manager of a 180-acre grape and tree fruit operation in northern Michigan and an ardent advocate for increased IPM research.

"Our IPM practices are all part of the idea that you're trying to manipulate the ecosystem and trying to extract economic value from it," Mawby says. "We aim for the least economic inputs and minimum long-term degradation of the ecosystem so there are lots of things that a grower can do — cultural practices that may not be thought of as IPM but in fact are.

"Every time you manipulate a growing plant, everything that the orchardist does to the plant, has some effect on the plant's susceptibility to insects and diseases," he says.

"Some of the effects are gross and some are minor but none of them can be ignored if you are trying to think about the whole system," he continues. "The critical word is 'integrated.' Everything works together and you have to be very careful about what you do to understand the interrelatedness of all those different aspects."

> **"When you have an understanding of the whole picture, there are a lot more subtle strategies that are more effective and will work in the long run."**

Mawby works closely with MSU Extension agents and research entomologists to reduce reliance on pesticide use and increase biological control of pests. He says there is a need for increased IPM research.

"There needs to be a more coherent interdisciplinary program to express IPM principles to growers so that they really have a better sense that this is not just a way to cut down on spraying ... [but that] they'll know how all of these different things that are going on in their orchards or vineyards are related, and how they can actually begin to exercise some control over things in ways other than the sledgehammer approach of dumping on more nutrients, water or pesticides," Mawby says.

"When you have an understanding of the whole picture, there are a lot more subtle strategies that are more effective and will work in the long run," he adds.

Trying to understand the whole picture is the purpose of the Integrated Pest Management Interagency Project (IPMIP) in St. Joseph County.

The IPMIP is a formal group of about 30 farmers and government agency staff members who have been meeting once a month the past several years over breakfast at the E&K Restaurant in Centreville to talk about IPM.

The group is headed by Sally Stuby, who, with her husband, Dale, grows seed corn. Sally is now the IPMIP coordinator for St. Joseph County MSU Extension.

The IPMIP is guided by representatives from MSU Extension, the MSU Agricultural Experiment Station, the Michigan Department of Agriculture, the USDA Soil Conservation Service, the St. Joseph County Soil Conservation District, Michigan Farm Bureau, growers, agribusinesses and private citizens.

Stuby likes to point out that St. Joseph County is the most heavily irrigated county east of the Mississippi River. It is a very sandy region which is prone to wind erosion. Agriculture also interacts heavily with nonfarm residents, recreationists and businesses.

"Consequently, we have a lot of growers who are acutely aware of the risk that crop production could pose to the environment and community," Stuby says. "We are also interested in providing an acceptable balance between a sustainable agricultural community and the nonfarm community, and that really is the mission of our project."

Stuby says that the breakfast discussion, frequently attended by Extension specialists and agronomists from MSU, ranges from the results of insect scouting and chemical input reduction to interest in curtailing soil erosion and building community relations.

The common denominator among the group, however, is a keen interest in advanced IPM.

"We have an astute group and they want to become better environmental stewards and they want the rest of the community to know that," Stuby says. "That will be a focus of the community meetings we will be having this winter." ■

Waging war on weeds

If weed scientist Jim Kells realizes his goals, he will probably have far less work to do. Kells is attempting to perfect weed control in corn.

"Basically, I'm trying to solve Michigan weed problems and reduce weed control costs for farmers," the scientist says.

In a research project that ran from 1990 to 1992, Kells and another MSU weed scientist, Karen Renner, studied weed control systems in corn. They compared mechanical methods with chemical applications and compared both of those with a combination of the two.

"Our research has shown that banded herbicide application combined with cultivation offers weed control and corn yield comparable to broadcast herbicide application," Kells says. "Using cultivation and banded application is not really new, but it hadn't really been studied in detail before."

Farmers use two-thirds less herbicide with 10-inch band application in 30-inch rows than with broadcast application.

However, according to Kells, most farmers are not using banded herbicide application and cultivation as control methods. He believes this is for two reasons: risk — farmers don't want to delay controlling weeds because the weeds may become too large or the weather may make it impossible to cultivate the fields; and time management — farmers may need to use their tractors for other chores and may not be able to cultivate at the ideal time for weed control.

"I think the motivation for adopting this system of weed control will be economic," Kells says. "If herbicide costs rise, this approach will become more attractive to farmers."

"Our research has shown that banded herbicide application combined with cultivation offers weed control and corn yield that is comparable to broadcast herbicide application."

Kells' and Renner's research demonstrated that banded application worked equally well with pre- and postemergent herbicides. It also showed that cultivation alone was somewhat successful in controlling weeds, but as the only method of control it was not adequate.

"Banded herbicide application and cultivation is the simplest, most immediate means of reducing herbicide input and still controlling weeds," Kells says.

Kells and other scientists are also working on developing cropping systems for corn-soybean-wheat rotations in Michigan. The researchers, headed by crops and soils scientist Fran Pierce, are in their last year of the three-year experiment and are comparing three systems.

The first uses conventional production management methods. They call the second system "tactical management."

"We tried to incorporate all the practices that would minimize inputs and are readily available to farmers and easily adopted," Kells explains. "We're using banded herbicide application, cultivation and postemergent herbicides and basing nitrogen application on nitrate testing."

The third cropping system is a more futuristic system. In it, the scientists are using the readily adoptable methods from the tactical management system and also testing other methods that would minimize or eliminate pesticides.

"These less studied methods include using only mechanical methods to control weeds and using a legume cover crop, in this case mammoth clover, to fix nitrogen in the soil," Kells says. "The clover is killed with a non-residual herbicide and the corn uses the nitrogen the clover fixed in the soil."

Using corn as an example, in the second system the researchers used banded herbicide application, ridge tilling, rotary hoeing and cultivation to control weeds. In the futuristic system, they used all of these and also applied commercial nitrogen to the corn after soil testing the field and determining the amount to be added.

In soybeans, the scientists used narrow rows and only postemergent herbicides to control weeds in system two. In system three they used ridges, rotary hoeing and cultivation. They were not as successful in controlling weeds with only mechanical methods.

In wheat, system three included interseeding the crop with mammoth clover. The clover was killed with non-residual herbicide and corn was planted the next year.

"So far, the economics for the futuristic system haven't looked as good as the other systems," Kells says. "As the project continues, we hope to refine the methods and make them more economically feasible." ■

Showing growers how to more accurately identify weeds and apply the appropriate herbicide in bands over the crop row to reduce input volume cost is the focus of periodic field seminars taught by Sara Stuby (left, holding corn plant) and Dale Mutch (with microphone). Banding can reduce herbicide use by two-thirds. Stuby is the coordinator of the IPM Interagency Project in St. Joseph County and Mutch is the Michigan State University Extension district crops pest management agent for southwest Michigan.

About this publication...

THIS PUBLICATION OUTLINES THE STATUS OF research and grower education on integrated pest management (IPM) at Michigan State University. IPM is the use of all available tactics to manage weed, insect and disease pests. Successful IPM produces acceptable yield and food crop quality and acceptable aesthetics for turf and ornamentals. It does so in an economical manner with the least disruption to the environment and to non-target organisms while enhancing human safety.

Though the content reflects concern about the potential loss of effective pesticides, it also presents examples where increased use of alternative pest controls reduces reliance on chemicals for pest management. As I look to Michigan's agricultural future, I believe we need to renew our emphasis on researching alternatives and teaching producers to use them, while retaining our critical chemical pesticides. To maintain a productive agriculture we must find an appropriate balance.

Public and private decision makers are engaged in debate about issues of pest management and pesticide use at the federal, state and local levels. The outcomes of these debates will have long-lasting effects on our food supply, the environment, our economy and the agricultural community. We hope this MSU publication helps prepare you to engage in these critical debates.

For additional perspectives on integrated pest management and the role of pesticides in Michigan, I encourage you to review two additional MSU publications. One is the Michigan Minor Use Pesticide Report, to be available on or about December 1, 1993. The second is the Summer 1993 (Volume 10, Number 2) edition of Futures magazine, published by the MSU Agricultural Experiment Station. For information on ordering copies of either of these publications, contact your county MSU Extension office or the MSU Bulletin Office, 10-B Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039.

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IPM
MICHIGAN STATE UNIVERSITY EXTENSION

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