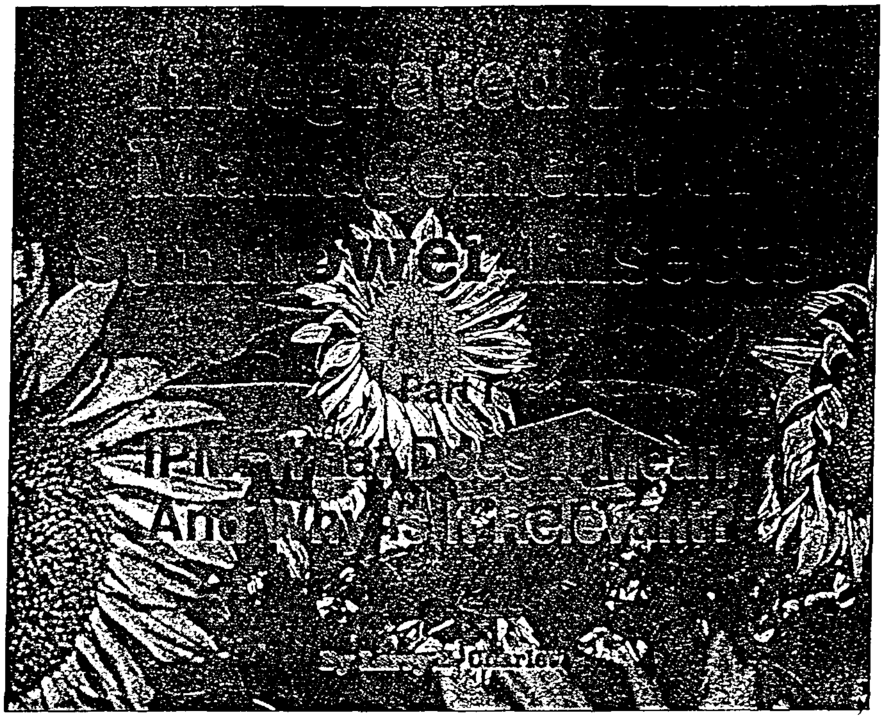
Integrated Pest Management of Sunflower Insects
Part 1 IPM: What Does It mean, And Why Is It Relevant?



This is the first in a series of articles addressing the concept of Integrated Pest Management (IPM) of insects in sunflower. This introductory article addresses some of the currently used terms for agricultural production systems or approaches (e.g., "sustainable agriculture"); the topic of IPM; what it means; and what relevance it holds for sunflower production.

Subsequent articles — beginning with the December 1995 issue of The Sunflower *and continuing through the April/May 1996 issue — will discuss separate aspects of IPM. Among them will be: (1) pest identification, economic thresholds and monitoring of fields; (2) biological control action (action of parasites, predators and diseases); (3) plant resistance; (4) cultural control (planting date, tillage, plant population, etc.); and (5) chemical control.*

Insects are part of our world and share the environment. They have been very successful, are more diverse than any other plant or animal group — and they exist everywhere.

That "everywhere" includes in our agricultural crops. In the natural environment, insects usually are held in check by a variety of forces, including their natural enemies. Agricultural crops, on the other hand, are artificial environments and thus need constant maintenance.

Fortunately, only a very small percentage of insects actually are economic pests. Many insects are beneficial, serving as either pollinators or natural enemies of other insects. The natural enemies, by and large, keep the others from becoming significant pests.

Insects become pests when their populations grow — usually as a result of something we humans have done. Planting large monocultures or acreages of one crop, for example, provides an excellent food source that allows certain insects to increase their numbers. Since those insects have become our competitors, we must do something to reduce their densities so that producing a crop is profitable. Most of the time, this means killing the insects.

So why do we need to concern ourselves with managing pests? Why can't we just destroy them and forget about complicated and time-consuming strategies as we work to keep them from damaging crops?

There was a time, shortly after the development of synthetic pesticides in the late 1940s, when some people thought all insect pests could be killed by the new insecticides and thereby become extinct. Scientists and agricultural producers soon realized, however, that some insects became resistant to the chemicals that were applied to destroy them. More-frequent applications and higher doses were required to achieve the same amount of control.

Also, a new problem often arose. Insects that had not been a problem before suddenly were causing economic damage. This unpleasant development was due to the destruction of natural enemies (parasites and predators) which previously had been feeding on those insects and preventing them from achieving the status of "economic pest."

Today, there also are health and environmental concerns stemming from the overuse or long-term use of pesticides. The desire to have agricultural production that is "sustainable" also has increased the need for pest management strategies which minimize economic, health and environmental risks. The need for a variety of approaches to pest management — though certainly complicating the work of the grower — has become necessary due to both practical and environmental concerns.

One of the things the scientific community does well is to come up with terms. Many have been coined for a variety of agricultural production systems. Among them are: organic agriculture, alternative agriculture, low-input agriculture, low-input sustainable agriculture (LISA), ecological agriculture and sustainable agriculture.

While "organic agriculture" seeks to eliminate synthetic chemical-based management practices, "LISA" has the goal of reducing the application of purchased inputs — and thus is more economically focused. (Continued on Page 16)

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Evidence shows that, when adopted, IPM results in economic benefit to both the agricultural producer and society at large.

"Sustainable agriculture" is defined as an integrated system of production practices that are site-specific and, over the long term, will satisfy food and fiber needs, enhance environmental quality, make the most of nonrenewable resources, integrate natural biological cycles and control, sustain the economic viability of farm operations — and enhance the quality of life. The idea is to meet the needs of the present without compromising the ability of future generations to meet their own needs.

Stewardship of both natural and human resources is cited as being of prime importance.

The goals of sustainable agriculture — environmentally sound, socially acceptable, economically viable — are certainly valid; but the term cannot be permanently defined: What's "sustainable" today might not be tomorrow. Research enabling us to move in this direction needs to be long-term, large-scale and integrative from all disciplines.

A key element in moving toward the goal of sustainability is the use of Integrated Pest Management. An increased national focus on IPM is evolving, since the Clinton Administration committed itself to helping agricultural producers implement this approach on 75 percent of total crop acreage by the year 2000. Last December, USDA announced an "IPM Initiative" to provide farmers with the new tools they need, through research and education, to move toward this goal and to deal with the environmental and economic challenges into the 21st century.

Integrated Pest Management is an ecologically based pest control strategy that is part of the overall crop production system. *Different ways of controlling pests have been used for centuries;* but the idea of combining various methods into an integrated system dates from the 1950s.

IPM is integrated because it incorporates all appropriate methods from many scientific disciplines into a systematic approach to optimize pest control. All available management decisions or options are considered — including that of taking no action at all. Knowledge about the pest is required, as are established economic or treatment thresholds and the results of field monitoring to determine whether the pest has reached the threshold.

Control tactics with IPM include such techniques as cultural control (crop rotation, tillage, planting dates, field sanitation); use of resistant plant varieties; biological control (introduction of new natural enemies, conservation of natural enemies, mass release of natural enemies); and insecticidal control (synthetic-organic pesticides, pathogens, nematodes).

IPM involves maximum reliance upon natural pest population control, along with the other tactics which may contribute to suppression of the pest. Chemical pesticides are used only when necessary.

From this list of tactics, it is obvious that prior planning is critical to effective pest management — *i.e.*, a number of the techniques must be put into effect prior to the crop going in the soil.

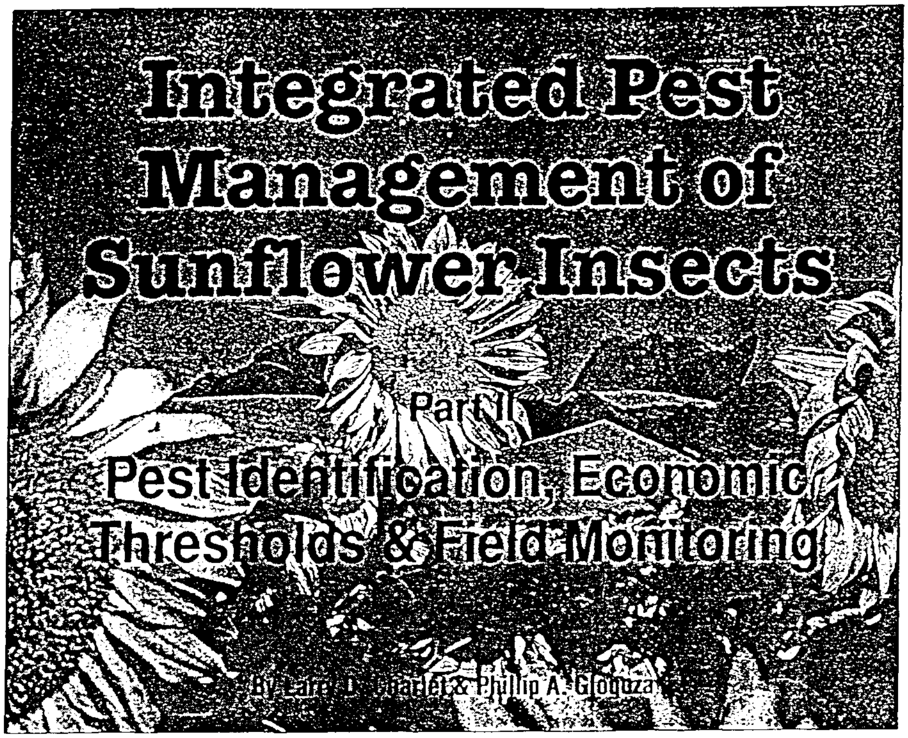
Evidence from numerous efforts to incorporate IPM into major crops around the United States shows that, when adopted, IPM results in economic benefit to both the agricultural producer and society at large — typically accompanied by a reduction in pesticide use.

IPM of insects in sunflower is now being utilized, and research is continuing in the development of additional tactics. Whenever crops are rotated or planting dates altered to avoid synchronizing crop development to times when plants ar most susceptible to pests, IPM is being utilized. Producers who monitor the pest density in their fields and treat with pesticides only when the economic threshold has been reached also are practicing IPM.

Implementing IPM does take more effort and knowledge, but it will be beneficial in the long term. Research and extension personnel are well aware of the importance of IPM and are willing to assist in developing the best management strategies possible. Doing so is in the best interest of all of us.

As one writer recently remarked, "Everyone wants a quick fix, but there are no silver bullets." There are only good farming practices using all available resources. The goals are clean water, environmental safety and reduced pesticides in foods. IPM is the way to move toward these goals; and while it may not be the only avenue, it certainly is an essential one.

As mentioned earlier in this article, future articles in *The Sunflower* will discuss many of the key elements and methods forming the basis of Integrated Pest Management and how they relate to sunflower production specifically. □



This is the second in a series of articles addressing Integrated Pest Management (IPM) of insects in sunflower. In the introductory article (August/September issue of *The Sunflower*), IPM and other currently used terms for agricultural production systems or approaches were defined and their relevance to sunflower production discussed.

We now move into a description of the different aspects of knowledge that are important to a successful pest management plan for the crop. As noted in the initial article, IPM incorporates all appropriate methods from many scientific disciplines into a systematic approach to optimize pest control. All available tactics are considered. Knowledge about the pest, its numbers and the established economic thresholds are required. These aspects comprise the topic of this month's article.

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Pest Identification. Identifying the pest damaging the crop — or those with potential to have an economic impact — is an important first step. The appropriate pest management strategy cannot be decided upon without knowledge of which insect is present in the field.

Correct identification can be difficult because of possible differences in the life stages of insects. Some species, such as grasshoppers and crickets, do not change much physically as they develop; whereas others, such as moths and beetles, have a very different appearance when they are immature (*e.g.*, caterpillars) as compared to when they are adults (*e.g.*, moths).

The different stages can also produce different degrees of injury to the plant. Some adults, such as moths, feed only on nectar or moisture on the plants. Others, such as grasshoppers, feed on plant tissue as soon as they hatch from the eggs through the adult stage. Certain beetles may be pests at all stages or only as larvae.

Identification of a particular pest may be determined by noting the type of damage to the crop, since insects are often specific to one portion of the plant (leaves, seeds, stem). It is also important to know the adult stage of many of the insect pests because control measures may have to be initiated before many eggs have been laid or the immature stages have begun feeding. This is especially important with the red sunflower weevil and the sunflower stem weevil, as those larvae cannot be controlled after they have entered the plant and become protected within the stem.

Identification of the pest insect allows the producer to check the published information that is available on the biology of the pest, its importance, the type of damage it produces — and the different strategies available to reduce losses caused by its feeding.

Economic Threshold. In addition to knowledge about the identification of the insect, the relationship between pest numbers, amount of damage and the cost of management must be considered. Some of the recognized terms used in this regard are economic injury level, economic threshold and treatment threshold.

The bottom line is this: Will the number of insects in the field result in feeding injury that causes an economic loss to the crop greater than the cost of managing the pest?

It may be that if the pest population present is below a specific level, it would cost more to manage than the dollar return from implementing the tactic. The break-even point is called the "economic injury level." Numbers of pests above that level are worth managing, because the return will be above the cost of initiating a management tactic.

Because there usually is a time lag between the determination of the density of pests that result in injury and the implementation of management strategies, the "economic threshold" is lower than the economic injury level. The use of an economic threshold discourages the producer from treating when not warranted, yet allows him to treat when it is warranted. This saves money, since

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control measures — often meaning the use of pesticides — are initiated only when numbers of pests exceed the threshold. It has been estimated that monitoring of pests and the use of economic thresholds can reduce pesticide usage by 30 to 50 percent, thereby increasing the producer's return.

The establishment of an economic threshold is often a dynamic process. There are, with a number of insects, several factors to consider. For instance, with the sunflower beetle, the threshold varies depending upon the stage of plant growth, *i.e.*, larger plants with more leaf surface area can tolerate greater feeding injury before there is any economic loss to the plant.

This brings up another point: the difference in the location where the pest is feeding. Direct pests — those that feed on the portion of the plant which is utilized (seeds) — often have lower economic thresholds than do indirect pests that attack stems or leaves. Plants often have more leaf or stem tissue than is required for seed development, so they can thus tolerate a reduction in plant material before economic losses in yield occur.

The genetic makeup of plants also varies and can be utilized in breeding for resistance to damage. Thus, plants with resistance or tolerance to damage by a certain insect will have a higher economic threshold than those without this resistance or tolerance.

There also are a number of additional factors which must be considered in determining the economic threshold for the pest. Among them are the crop's projected market price, cost of the management and the plant population. Another key ingredient in the decision is the standard set by the marketplace for crop damage. That ingredient is clearly evident in the different amounts of infested seed tolerated in oil-type versus confection or nonoil sunflower seed.

Often, economic thresholds are set for the adult stage of the pest — a stage that may not cause the damage. Directing management strategies at the adult has the purpose of reducing successful egg laying. A prime example is the sunflower stem weevil. Once its eggs have been inserted into the plant stem, control is not very effective. Those eggs — and their resulting larvae — are protected within the stem tissue.

The same situation occurs with the red sunflower seed weevil, so its thresholds also are set on the basis of adult numbers. In the case of the banded sunflower moth, however, the economic threshold is established for the adult, but control is directed at the larvae before they move into the seeds to feed.

The sunflower beetle has thresholds for both the adult and larval stages of the insect, since each can cause economic damage if densities are high enough.

Monitoring or Sampling. Good management practices require that the crop be monitored for a variety of reasons. Checking for insects is just one part of this process. Of course, a past history of pest problems would make this practice even more necessary.

The identity of the particular insect will determine when and where sampling should take place in the field. This may mean the crop needs to be surveyed only at a specific time of year or when the plant is at a certain growth stage.

The objective of field surveys is to determine if the numbers present can be tolerated or if they exceed the economic threshold, thereby justifying corrective measures. Because most crops are attacked by a variety of pests, monitoring really should occur at regular intervals during the season.

The area of the plant to check is determined by the pest of concern and guidelines established by research into the insect's biology. An understanding of the biology and movements of the pest also establishes the locations to be monitored within the field. Because they often migrate from last year's fields, many sunflower insects tend to congregate initially on field margins; so surveys of only these locations would produce an incomplete picture of the true situation. This could lead to a decision that management should be initiated when, in fact, if other areas of the field also were checked, the average density might be very low. Thus, field scouting strategies usually emphasize moving well into the field and surveying plants or groups of plants at a number of widely spaced locations.

The pheromone trap is a tool used to monitor for pests in a number of crops. The trap is baited with a material based on the chemical used by the female to attract the male for the purpose of mating. Once research has determined the relationship between (1) trap counts, (2) the projected number of pests that will be in the field and (3) damage to the crop from that density of insects, that information may be used for pest management decisions. Guidelines have been established for using traps for sunflower moth management decisions in the High Plains, and research currently is being conducted to provide this information for the banded sunflower moth.

In summary, then, the foundation of pest management consists of (1) correctly identifying the pest, (2) monitoring the crop for the pest of concern and (3) utilizing established economic thresholds to determine whether any action is needed.

In the January issue of *The Sunflower*, we will discuss the pest management approach known as "biological control." This method employs the action of parasites, predators and diseases against insect pests. □

This is the third in a series of articles addressing the Integrated Pest Management (IPM) of insects in sunflower. The introductory article defined and discussed the relevance of IPM and other current terms in agricultural production systems or approaches. The second article examined the importance of knowing pest identities, populations and established economic thresholds. This month, we move on to some of the specific measures used to manage or hold pests in check. We begin with biological control — the use of predators, parasites and diseases to reduce insect pest densities.

Biological control as a management tool dates back more than 1,000 years to when the Chinese used ants to control insect pests of citrus. In the late 19th century, predatory beetles were brought from Australia to control scale insects which were destroying the citrus industry in California. That program, still in effect, showed that insects could be successfully utilized to manage other insects, and it helped biological control become an important scientific discipline.

Biological control is defined as *"the intentional manipulation of populations of beneficial organisms (natural enemies) in order to limit populations of pests."* In addition to insect pests, the approach also can be used to manage weeds and diseases.

Agents of biological control include predators, parasites, nematodes and diseases (pathogens). Predator insects, such as lady beetles, consume more than one individual insect (prey) during their development. In contrast, parasites generally lay their eggs on or in the pest species, and their young kill and consume the host as they grow. Usually, only one host is needed by the developing parasite.

Parasites are often small and thus easily overlooked. Parasites are not harmful to humans and tend to be specific to one type of host. Predators often feed on a number of different species of pests. Insect-parasitic nematodes are small worms that attack and kill insects that live in moist habitats. They do not harm animals or plants, and a few species are currently being sold for insect control.

Diseases — caused by fungi, viruses, bacteria and other micro-organisms — also occur among insects. Disease outbreaks usually do not occur unless insect populations are very high or environmental conditions are especially suitable for the disease organism. These pathogens are important in the suppression of pest species; some viruses and bacteria can be manipulated to control specific pests and are commercially available. They do not harm nontarget organisms such as humans, animals, plants or beneficial insects.

Natural enemies do not destroy or eradicate all insect pests; but they may prevent the pest population from becoming too high. In some cases, where the natural enemy becomes an established part of the environment, they do this year after year.

There are three broad approaches to biological control: (1) importation, (2) augmentation and (3) conservation.

When an alien species is accidently introduced and becomes a pest, natural enemies are searched for in the pest's native home. When located, these beneficial organisms are "imported" to the area where the pest is a problem.

"Augmentation" is the release of large numbers of natural enemies to temporarily increase their numbers in a given area. The natural enemies then seek out and attack the pest insect.

The third approach — "conservation" — is concerned with protecting the natural enemies that are already present in an area. Usually, this means the use of farming practices which are less disruptive to natural enemy populations. Reduced or carefully timed insecticide treatments can provide a major contribution by minimizing the destruction of beneficial organisms.

Sunflower is one of just a few cultivated crops that are native to North America. So insects associated with sunflower have evolved with the plant for many centuries, and many have moved to the cultivated crop to feed and develop.

Insects on sunflower include a mixture of plant-eating species, pollinators and natural enemies. Although hundreds of

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insects have been recorded on sunflower, only a small number have achieved "pest status." Indigenous or native natural enemies have been a significant factor in preventing many plant-eating insects from becoming economic pests of sunflower. However, even the insect species that *have* become pests are subject to attack by numerous natural enemies, including predators, parasites and diseases.

Given our limited knowledge about the species of predators, parasites and diseases that attack the important insect pests of sunflower, the best biological control approach is to utilize farming practices that conserve and protect these beneficial organisms.

The example reveals how information about the natural enemies can be used in understanding their role in the population dynamics of the sunflower pests:

One important pest of sunflower is the sunflower stem weevil. Larvae of this weevil cause crop damage by feeding, developing and overwintering in the stem. Parasitic wasps attack both the egg and larval stages of the weevil, with the most common parasite of the weevil larva being a wasp called *Nealiolus curculionis*. It also attacks the stem weevil in wild sunflower, indicating it also moved when its host transferred to cultivated sunflower. The immature parasites pass the winter within overwintering or diapausing weevil larvae in the sunflower stalk.

Overall, parasitization by this wasp has increased from the levels reported in the late 1970s and early 1980s. Field densities of adult weevils have been quite variable since those years, but the consistent rates of parasitism suggest that *N. curculionis* effectively locates its stem weevil host regardless of pest population densities.

Photo: V. Beregovoy / Courtesy L. Charlet

LEFT: This adult parasite is no friend of banded sunflower moth larvae. This female is probing the sunflower disk flowers in search of larvae to attack. It is one of many natural enemies of sunflower insect pests who serve as allies in producers' efforts to control these pests. Each of the various insect pests has its own complex of predators, parasites and diseases which attack and feed upon them.

The ability of the female parasitoid to find and attack hosts is of paramount importance to the success of a given parasite population. Delaying planting has been an effective cultural control tactic for reducing larval stem weevil numbers in sunflower stalks and thus decreasing damage. Studies also have revealed that the parasite was active and capable of attacking larvae of the sunflower stem weevil in sunflower plantings from three different planting dates.

The successful combination of biological and cultural controls helps the producer further reduce potential damage from this pest. Since the parasite appears to have a consistent impact on the mortality rate of the stem weevil in cultivated sunflower, it is important to utilize cropping practices that also conserve and protect these natural enemies of the weevil.

The other important pests of sunflower — such as sunflower seed weevils, banded sunflower moth and the sunflower beetle — also have their own complex of predators, parasites and diseases feeding and attacking the various pest life stages. Conservation of these beneficial organism will help prevent the pest insects from reaching densities that cause economic losses for the producer.

Biological control is one of the safest methods of pest management available. Natural enemies are not toxic, pathogenic or injurious to humans or wildlife. They're usually self-perpetuating and, because of their specificity, do not harm nontarget organisms. Natural enemies are not polluting or as disruptive to the environment as synthetic insecticide, nor do they leave residues on food.

There are many factors (*e.g.*, crop, pest complex, environment) that can influence the success of beneficial organisms in reducing pest densities to manageable levels. Thus, in many instances, the biological control method must be utilized in conjunction with other tactics. This is consistent with the IPM approach to pest control, *i.e.*, ensuring that the least-disruptive practices are used since they fit best into sustainable agriculture.

Next Month: We'll discuss plant resistance and how that approach fits into Integrated Pest Management. □

This is the fourth in a series of articles addressing the Integrated Pest Management (IPM) of insects in sunflower.

Last month, we discussed a specific insect management approach called "biological control" — a tactic which uses predators, parasites and disease to reduce insect pest densities. This current article addresses plant resistance to insects, which is another biologically based method for managing insect numbers and the damage they cause.

The cultivation of plant varieties that resist damage by insects actually dates back thousands of years. When farmers saved seed for the next season's planting, they inadvertently made plant selections based on a variety of criteria. One criterion was insect-resistant plants wherein (1) the insects did not attack; (2) the insects did poorly on; or (3) the plant itself showed less damage.

Two early examples of purposely developed plant resistance to insects are (1) wheat varieties resistant to the Hessian fly and (2) apple cultivars with resistance to the woolly apple aphid. In a very important development in the late 1800s, resistant U.S. rootstocks were grafted onto French grapes susceptible to a certain underground aphid. That "foreign aid" saved the French wine industry from ruin.

Plants may have physical or chemical traits that repel, kill or enable them to tolerate pests. These traits can be utilized by plant breeders in developing cultivars that possess superior agronomic features and also are resistant to insect pests. The use of resistant plants is both a cost-effective and environmentally sound tool for pest management. It also can be used in conjunction with other strategies to manage pests more effectively in the field. Traditional breeding methods have been used for years to develop insect-resistant plant varieties. Today, genetic engineering technique are used in some crops to supplement traditional breeding and shorten the time frame to develop insect-resistant varieties.

Plant resistance is defined as "plant qualities that are genetically inherited and result in one cultivar being less damaged than a susceptible plant in which those particular qualities are absent." It is rare for a plant to be totally immune or completely resistant to a particular insect.

Resistance to insects is thus measured in degrees, with the amount of "acceptable" damage depending upon many factors. For high-value crops where the insect attacks the harvestable product (*e.g.*, fruit to be sold fresh), there's a very low damage tolerance. However, if leaves (rather than fruit) of the plant are being consumed, some feeding damage can often be tolerated before a measurable loss of yield or fruit quality occurs. In that case, the amount of needed resistance can be lower. The relative resistance needed to protect a crop is an important factor in the development and success of a breeding program.

Scientists categorize resistance to insects as being one of three types:

• In "antibiosis," the biology of the insect is affected, meaning the insect may be destroyed or there might be an impact on its development or reproduction.

• Nonpreference, or "antixenosis," conveys to the pest that the plant is a bad host (*e.g.*, tastes bad or is unsuitable to lay eggs on). So the insect moves on or selects another plant.

• "Tolerance" means the plant is able to outgrow or overcome the damage caused by the pest when compared to the damage suffered by susceptible varieties. So even though insects are present and feeding, yield remains high.

Of course, there is overlap among the resistance categories. The degree to which a plant exhibits resistance to a particular pest can be affected by environmental conditions and by the size of the insect population.

The major advantage of pest-resistant crops is insect control with lower input costs. With pest-resistant varieties, some or all of the insect management costs are incorporated into the cost of the seed itself.

Among the additional advantages, (1) the effects of plant resistance are limited to the specific pest, (2) the effects accumulate over time (*i.e.*, overall pest populations are reduced, and (3) pest resistance is persistent. There's also the option of combining other nonchemical management strategies (*e.g.*, biological and cultural

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controls) with pest resistance to further lower the pest-caused damage. (This is particularly important when crops are attacked by multiple pests.) Finally, plant resistance to insects does not pollute the environment and is nontoxic to humans, natural enemies of the pets, bees and other pollinators, livestock and wildlife.

Research on a number of sunflower pests has shown there is potential for the development of insect-resistant cultivars by using genes from the wild sunflowers (*Helianthus* spp.). Since sunflower is native to North America, wild sunflower has been subject to attack by many species of insect pests over thousands of years. In response, many wild sunflowers evolved mechanisms to protect themselves from insects and their feeding.

For example, perennial *Helianthus tuberosus* L. (Jerusalem artichoke) and two other *Helianthus* species have increased the mortality of banded sunflower moth larvae and also have reduced egg laying by the adults. Certain wild sunflower species also have lower densities of red sunflower seed weevil larvae, while others have been shown to reduce the survival rates of sunflower beetle and stem weevil larvae.

Incorporating pest resistance from these wild sunflower species into commercial lines could be helpful in developing pest-resistant sunflower hybrids. A major obstacle is the fact that many of the wild sunflower species with insect resistance are perennials, which makes the transfer of pest resistance to commercial hybrids difficult.

Insect resistance may be the only practical control method for some insect pests of sunflower. The sunflower midge has been a severe problem in parts of the Red River Valley of North Dakota, Minnesota and Manitoba. Midge are difficult to detect, and insecticide applications are not effective. Even delayed planting may not be effective since the midge has several generations per year. Research has shown that a number of commercially available hybrids do have resistance to the midge. The discovery of a method by which sunflower cultivars can be screened with synthetic chemicals will assist scientists in their search for resistance to this insect.

Research from other parts of the world may help develop resistance to some of our sunflower pests. In Europe, resistant sunflower varieties are used to reduce damage from larvae of the European sunflower moth. A material called "phytomelanin" is present in seeds of the resistant varieties and greatly reduces larval feeding of this insect. Some U.S. research has been conducted to identify lines of sunflower with greater amounts of phytomelanin in their seeds. Transferring this trait to commercial hybrids could have important implications for areas of North America where the sunflower moth is an economic pest.

The screening of sunflower lines for resistance to both the red seed weevil and banded sunflower moth has been conducted in USDA-ARS and North Dakota State University field trials for a number of years — and some gains have been made in identifying germplasm resistant to these two insects.

For example, researchers have discovered four lines that reduce numbers of red seed weevil larvae in sunflower heads by 25 percent. This resistance was based on antixenosis (nonpreference) since adults laid fewer eggs on the heads of these lines compared to susceptible lines.

The ability to detect resistance to insect pests in plants is largely dependent upon field research in which different lines are compared when subjected to attack by natural pest populations. The difficulty with this screening process lies in the inconsistent nature of pest populations from year to year. High pest densities enable the scientist to clearly detect lines offering some type of resistance; low populations, however, make these evaluations difficult. In many cases, there are ways to artificially rear the insects and apply them to the plants; or, there are artificial techniques which can simulate damage to the crop and thus aid in evaluations.

Development of insect resistance can be a very time-consuming process. But its advantages as a pest management strategy make it a tactic worth pursuing.

Next Month: The use of cultural controls to manage insect pests.

This is the fifth in a series of articles addressing the Integrated Pest Management (IPM) of insects in sunflower.

As noted in earlier articles, the ideal management strategy utilizes techniques that require low input costs, are cost-effective and avoid negative impacts to the environment. Cultural controls can meet these criteria. The ideas inherent in this method of pest control attempt to make the environment unfavorable to the pest by reducing its growth, reproduction or survival.

Cultural controls often use farming practices already associated with crop production. Thus, they usually require no additional outlay for equipment, lack deleterious side-effects and are generally quite simple, effective and inexpensive to implement.

However, cultural control measures do have to be applied early; they require detailed knowledge of the particular crop and pest's biology; and control of the pest is not always complete. Also, attention must be given to recognizing the weak links in pests' life cycles.

These tactics are generally designed to prevent buildup of the pest rather than relieve an already-present insect problem; so timing becomes very important. Since cultural control methods frequently need to be employed long before the pest or its damage becomes apparent, it often can be hard to quantify the technique's effectiveness. Sometimes, for example, management is directed at a stage of the insect which is not actually causing the damage, rather than at the pest stage of that insect.

Finally, some cultural control practices are more effective if used across a wide geographic area and combined with other IPM tactics.

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There are numerous cultural control methods. Among the most common would be: sanitation, altering planting dates, crop rotation, tillage, trap crops, plant spacing or population, and interplanting.

Sanitation refers to the removal of pest breeding or overwintering sites in order to reduce the number of insects and prevent future damage to crops. The total destruction of crop residue is not always necessary or even desirable, since the impact on soil erosion also must be considered.

Altering or adjusting a crop's planting date can translate into growing the crop during a period when the pest is not present — or at least avoiding the overlap of the vulnerable stage of plant development with the time of year when the insect is most abundant.

Crop rotation helps reduce overall pest densities over time through the planting of crops which are not subject to attack. Thus, there are one or more seasons when vulnerable plants are not available for insect feeding or breeding. This tactic is most effective for insects that have few alternate hosts or those which cannot move over long distances.

Tillage destroys crop residue harboring overwintering pests by (1) burying the insects to prevent their subsequent emergence or (2) bringing them to the surface and reducing their survival rate.

Trap cropping has been used to lure insect pests away from the main crop and into a small area where they are more easily controlled. This prevents the pests from moving into the crop which is being protected.

Crop spacing can impact pest damage by affecting the growth of the plant, the behavior of the pest as it searching for its food or site to lay eggs, or the effectiveness of natural enemies attacking the pest.

The use of *strip cropping or interplanting* has, in some crops, been shown to reduce pest densities and create a habitat that builds up populations of beneficial predators and parasites.

A number of sunflower date-of-planting studies have indicated the potential of planting date variation for reducing damage from the crop's insect pests. For example, later planting dates have reduced sunflower stem weevil populations in plant stalks and thus subsequent lodging. Seed damage due to banded sunflower moth larval feeding also has been lessened when planting was delayed. Delayed planting will usually avoid the first (and major) emergence of the sunflower midge (although if conditions are favorable, later infestations can be severe as well). In the High Plains of Texas, sunflower planted early or late will avoid a bloom period in early July when the highest densities of sunflower moths occur. Finally, seed damage from the red sunflower seed weevil has been lower when sunflower has been planted early.

The manipulation of planting dates is a technique requiring knowledge of the biology of the pest, since its effectiveness depends upon not having the preferred plant growth stage available when insect pest numbers are highest. Unfortunately, the life cycles of various sunflower insects are different; so a single planting date strategy will not work for all the pests that attack sunflower.

How can tillage impact some sunflower insects? In South Dakota studies, fall or spring plowing was shown to reduce adult emergence of the red sunflower seed weevil. In Texas, tillage increased the mortality of overwintering larvae of the long-horned sunflower stem girdler.

In both the Northern and Southern Great Plains, however, plowing sunflower stalks proved ineffective in reducing survival of the sunflower stem weevil. The stem weevil larvae are protected in the woody portions of the stalk not broken up by the plow. Adult emergence the following spring can be reduced, though, if the stalks are buried beneath the soil surface.

Recent studies in North Dakota and Minnesota have shown that trap cropping has promise in the management of the red sunflower seed weevil. The planting of an early flowering border of sunflower around a larger sunflower field serves as a trap for the adult red seed weevils, which are attracted to the trap rows and concentrate in the flowering heads.

These trap rows are then treated with a chemical which may effectively reduce weevil populations to the point where there's no need to spray the entire field. The result would be a much lower cost of insecticidal control.

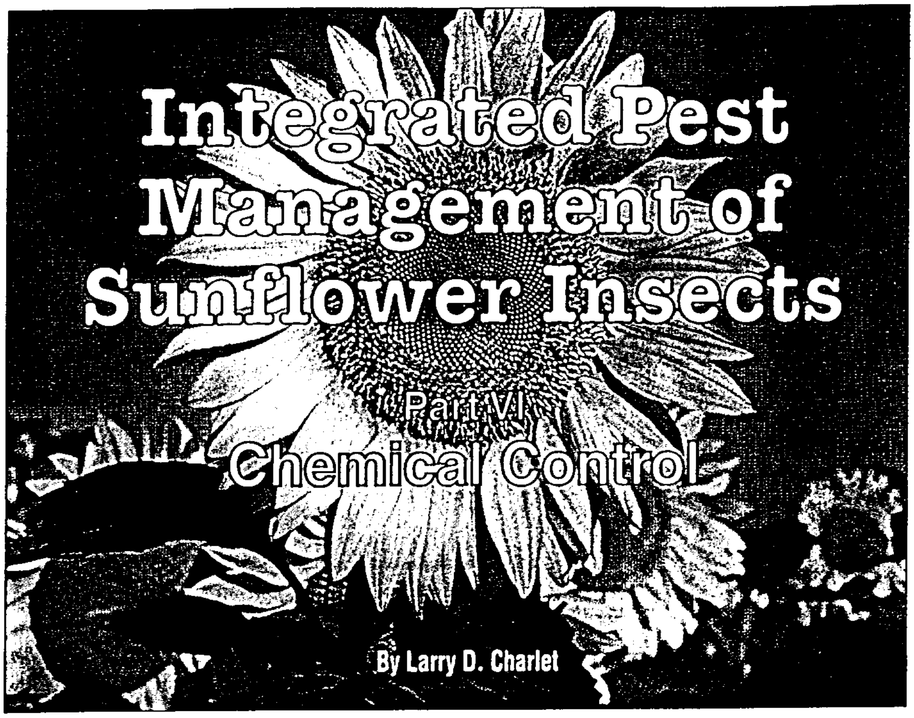
Plant populations will affect both the sunflower stalk diameter and the percentage of plants lodged by the sunflower stem weevil. The larvae of this insect overwinter in the stalks by constructing chambers in the stem. These chambers weaken the plant; and, if weevil numbers are high, the plant can lodge prior to harvest.

Studies have shown that the density of plant stand has no effect on the numbers of weevil larvae within the stalks. However, as plant population is increased, individual stalk diameter is reduced and lodging increases. It's important to maintain the structural integrity of the sunflower stalk by keeping its diameter large enough to withstand lodging. This can be achieved by reducing the plant stand. The result will be larger-diameter stalks, no change in insect levels within stalks — but decreased losses due to lodging.

The techniques used in cultural control basically consist of modifications in timing or in the manner of performing necessary functions in the production of the crop. Thorough biological research is required for such controls to work correctly. Also needed is an understanding of the basic life cycle of the pest and its interaction with crop growth and the environment.

Sometimes the slight insect population reduction due to cultural practices will delay the rise of the pest to economic levels, thereby reducing or eliminating the need for more-costly management tactics (such as chemical applications). Using cultural controls may not always provide dramatic results — and it may require a combination of additional IPM practices if benefits are to be maximized. Nonetheless, cultural controls can be an important tool for protecting the crop and minimizing damage from insect pests. □

In the April/May Issue: The final article in this series will be devoted to chemical control and how it fits into an Integrated Pest Management program.



This is the last in a series of articles addressing the Integrated Pest Management (IPM) of insects in sunflower.

Writings of the Chinese, Greeks and Romans indicate that the use of chemicals, usually referred to as insecticides or pesticides (from the Latin word meaning "to kill") for the management of insects dates back about 3,000 years. However, the modern use of insecticides in the United States began in 1867 when Paris Green (an arsenic compound) was first applied for outbreaks of the Colorado potato beetle.

The earliest chemical pesticides were inorganic compounds (such as sulfur, arsenic or copper) or products derived from plants (*e.g.*, nicotine, pyrethrum, rotenone). Since the 1939 discovery of the insecticidal value of DDT, thousands of other synthetic organic chemicals have been produced. These products are mostly modifications of petroleum-based molecules and kill the insects through contact, inhalation or ingestion. Some newer products — called "insect growth regulators" — are synthetic insect hormones which act by interfering or disrupting the normal growth, development or reproduction of the pest. "Microbial pesticides" are products containing insect pathogenic organisms; and although they constitute a form of biological control, they can be applied like a chemical pesticide.

Insecticides usually are considered the first line of defense against insect pests. They have been widely used because they often provide rapid and effective control of a variety of pest organisms. Pesticides also are relatively easy to use, predictable, can be adapted to a variety of situations, quickly reduce large insect populations, and usually have an immediate effect.

The use of insecticides has increased the yield, quality and efficiency of plant production — and, consequently, has increased the stability of the agricultural sector. Pesticides also have had a positive impact on human health through the destruction of insect vectors of disease organisms. The need for and use of insecticides will undoubtedly continue for the foreseeable future.

The decision to employ insecticides to manage an insect problem in sunflower or any other crop should depend upon an overall assessment of the situation. The principle to follow is that all possible techniques or combinations of methods should be considered. The use of a pesticide is justified only when the expected loss without treatment exceeds the cost of treatments.

Sole reliance on chemicals for pest control does have a number of downsides — among them: pest resistance, resurgence, outbreaks of secondary pests, environmental contamination, destruction of beneficial pests and the expense of the pesticides.

• Reliance on chemical control can foster the development of *pesticide resistance* in important pest species. This encourages an increase in dosage and the number of pesticide applications, which can then magnify the resistance and also have adverse effects on beneficial organisms (pollinators, predators and parasites).

• Pests may also *resurge*, because when numbers are lowered, there is less competition for food, thereby allowing maximum reproduction of the insects. In addition, the destruction of predators and parasitoids results in surviving pests being able to breed without restraint from natural enemies.

• A *secondary pest outbreak* may occur when a pest's natural enemies — which were not the target of the application — are destroyed. The second species, released from the pressure imposed by its enemies, may then increase to damaging numbers and require further insecticidal treatments.

• Because they are basically poisons, pesticides can result in *hazards to humans, wildlife and/or the environment.* Though some insecticides break down quickly in the environment, others may persist for days or even weeks. This may prolong the destruction of the pests, but it also may destroy nontarget organisms and become a source of contamination.

• If pesticides *eliminate natural enemies*, pest populations may increase and emigrate to surrounding habitats, possibly damaging crops at considerable distances from the site of the application.

• The *expense of pesticides and their application* is an important problem associated with excessive reliance upon chemical pest management. This problem often can be addressed by recognizing that many crops can tolerate substantial damage without economic loss; and that scheduled applications can be replaced with applications based on population assessment.

The amount and frequency of pesticide use on our crops has been, to a large extent, determined by the general public. The public has been conditioned to demand food products which are totally devoid of blemishes or damage caused by pests. In many cases, the marks are only superficial and do not actually reduce the quality of the product; but producers have been led to expect that there should be an absence of all pests — a situation frequently not required in order to prevent economic loss.

Recent years have witnessed a greater interest in organic foods and crops grown without the the use of pesticides. This change in the public's expectations has been coupled with the realization that reliance on a single-component management system (*e.g.*, insecticides) is often inefficient.

The proper use of insecticides in a sunflower — or any other — crop pest management program relies on knowledge of the pest and the properties of insecticides themselves. With fundamental information about the biology of the pest, chemical applications can be aimed at a weak point in the insect's life cycle. For example, treatment is geared toward management of the adult stage of the red sunflower seed weevil and sunflower stem weevil; toward

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the larval stage of the banded sunflower moth; and toward both the adult and larval stages of the sunflower beetle.

Timing of application is based on the plant stage as well. Also, pesticides should be used only when the population has reached or exceeded economic thresholds. Economic thresholds have been established for most major pests of sunflower.

The selective use of insecticides can be a tool to curb the number of pest organisms while having a minimal impact on all other components of the environment. There are pesticides which are physiologically selective, meaning they have a narrow spectrum of activity and affect only certain specific groups of insect (*e.g.*, moth larvae) or mite pests. However, most currently used insecticides for sunflower pests are toxic to natural enemies and pollinators.

Pesticides also can be ecologically selective when the actual application of the chemical is manipulated to minimize the exposure of nontarget organisms while killing the pest. This method includes the use of different pesticide formulations and the altering of the timing of application, method of application and the treatment's spatial distribution. It exploits the differences in the biology between pollinators and natural enemies and the pest, and it requires knowledge about the pest's life history, movement and spatial distribution.

Treatment of sunflower fields should occur when activity of the natural enemies and pollinators is at a minimum, such as early morning or late in the day. Also, applications may be made to only a portion of the crop. Since pests and natural enemies differ in their patterns of movement, spot treatments or stratified applications may be made within a field or crop. Examples would include treatment of field perimeters, strips or selected plots, or the use of trap crops that are treated separately. Trap cropping has shown potential for management of the red sunflower seed weevil.

Timing pesticide applications to take advantage of differences in pest-natural enemy biology has probably been the single most common and effective means used to achieve ecological selectivity. Using baits and seed treatments can drastically decrease pesticide residues in the environment while concentrating chemicals where they are effective and selective. The use of granular materials also may control pests selectively while conserving natural enemies through spatial separation of the pesticide and natural enemy of the pest.

The successful use of pesticides with other management tactics (noted in earlier articles) in a successful sunflower IPM program is dependent upon knowledge of the cropping system and the biology, ecology, and behavior of pests and their natural enemies. The best approach to managing sunflower insect pests is a combination of tactics, including: (1) detailed monitoring of life history and population dynamics of pests and natural enemies; (2) use of resistant plant varieties, if available; (3) crop rotation; (4) altering of planting dates; (5) employment of selective pesticides; (6) use of the least-disruptive formulation of the pesticide; (7) application only when absolutely necessary and based on established economic thresholds; and (8) correct timing for maximum effectiveness against the pest and at the least-injurious time for pollinators and natural enemies.

Integrated pest management is a dynamic and evolving process. Specific management strategies vary from year to year and region to region, depending on the species present and population numbers.

As new IPM approaches develop, they should be analyzed and incorporated into the local cropping system if appropriate. Consideration also should be given to how these techniques or approaches fit into the goals of sustainable agriculture: environmentally sound, socially acceptable and economically viable. □