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An Introduction to Integrated Pest Management

Definition

Integrated Pest Management (IPM) can mean different things to different people. As a result, definitions are diverse and have ranged from those which advocate mostly organic control to those which focus on chemical control. One commonly used definition that is easy to understand is the following:

IPM is a decision-making process that utilizes all available pest management strategies, including cultural, physical, biological and chemical control to prevent economically damaging pest outbreaks and to reduce risks to human health and the environment.

Important concepts of this definition include:

1) *is a decision making process...*

IPM is a continuum of management practices that range from simple field scouting to biointensive IPM which utilizes a systems approach to crop and pest management. Action thresholds have been incorporated into many IPM programs to assist with the decision making process. Two types of thresholds are commonly used:

Economic thresholds

have been developed for crops where yield in the primary concern. The economic threshold is that pest level at which control practices must be implemented to prevent economic damage (i.e. cost of control is less than expected damage).

Aesthetic thresholds

are used for crops such as fresh market vegetables, fruits and ornamentals where appearance plays a critical role in the crop's marketability. Aesthetic thresholds are subjective and not absolute. They are driven by consumer preference.

2) *that utilizes all available pest management tactics...*

IPM utilizes all available pest control tactics. IPM does not rely on a single tactic to control pests. Some of the problems that result when a single management tactic is used include pest resistance and secondary pest outbreaks. However, preventative non-chemical control tactics should be used, whenever feasible, as a first line of defense.

3) *to prevent economically damaging pest outbreaks*

and reduce risks to human health and the environment. IPM must continue to focus on economic, public health and environmental goals. Public health and environmental protection have been the foundation of IPM since its inception. However, the producer's profitability and livelihood has to considered in all management decisions. Finding the appropriate mixture can be difficult.

History of IPM

Although IPM has become a "buzz word" in recent years the concept has been evolving for a long time. In the early years of IPM, pest management was centered around the control of a single pest. This concept , called "Integrated Control", was introduced in the 1950's and used similar philosophies that are used today (i.e., conservation of natural enemies, proper selection of pesticide and host plant resistance). However, IPM differs from Integrated control in at least two areas:

IPM focuses on management not control.

The word control seems to imply that you have power over something and to many people means total eradication. Conversely, management implies a less threatening method of dealing with pests.

IPM is concerned about the whole cropping system.

Integrated Control dealt with the management of a single pest species. Consideration must be given to how one management practice impacts other components of the system. For example, crop managers are concerned about the frequent use of fungicides for disease control in potatoes because their use can increase aphid populations by inhibiting natural fungal pathogens of the aphids.

Components of an IPM Program

One of the major components of an IPM program, if not its foundation, is crop scouting. The goal of crop scouting is to provide accurate and unbiased pest and crop development data. Without this information an intelligent pest management decision cannot be made. A crop advisor must have a thorough understanding of crop growth/development, key pests and their life cycles. Additionally, the crop advisor must know how the environment affects each of these components. Only after this information is collected can an appropriate pest management decision be made.

Pest prevention is another key component of an IPM program. This implies that action be taken against the pest before economic damage is reached and in some cases before a pest problem is even detected. This can be accomplished in a number of ways including physical, cultural and biological controls. These practices should be implemented prior to the use of therapeutic controls (i.e. chemical control). Therapeutic controls are recognized as a necessary component of IPM programs. However, all appropriate non-chemical control options should be implemented before pesticides are recommended.

Multi-disciplinary research and education, are also necessary components of an IPM program and are required to move IPM along the continuum. Although IPM has achieved significant accomplishments, it has a long way to go. Without the above components, IPM will continue to be a management system that is chemically based. As new management methods become available they must be worked into existing programs through education. IPM programs should not be viewed as static; they are constantly changing. What is considered an IPM program today may be considered out dated technology in three years. Growers and crop advisors must be ready and willing to adapt new technologies into their farming enterprise.

Collecting and Submitting Plant Disease and Insect Specimens

Proper disease and insect identification requires two basic steps:

1. Gathering the pertinent background information. Detailed use of the submission form is necessary.
2. Studying the affected plants properly; and properly collecting and submitting plants to a diagnostic laboratory when this is necessary.

Suggestions for collecting and submitting plant specimens:

1. Whenever possible, you should collect the specimens yourself, so that you can examine the field or crop area concerned, and can examine healthy as well as diseased plants.
2. Examine all parts of the plant(s), including the roots if at all possible.
3. Dig plants—do not pull them.
4. Send immediately after digging—do not let plants lie around for a period of time before packaging and sending.
5. Send in the entire plants when feasible. **
6. When possible, submit plants or plant parts showing the range of symptoms—healthy, slightly and seriously affected.
   ** Remember leaf abnormalities are often symptomatic of a problem in some other part of the plant.
7. See directions for packaging on the following pages
8. Collect and send specimens during the early part of the week to reduce the chance of weekend delay and deterioration.
9. Submitting Insect Specimens for identification.

A) For <u>Beetles</u> and <u>True Bugs</u>. Place dead specimens in a clean, small vial. Within twelve hours after death insects become very dry, hard and brittle. Appendages such as antennae, which are important characters for identification, are easily broken. Cotton or tissue paper inside the mailing tube will cushion the specimen in transit, and increase the chances of the specimen arriving in one piece.

B) Adult <u>moths</u>, <u>mosquitoes</u> and other insects covered with fine scales or hairs should be kept dry. Proper identification is very difficult if scales or hairs are rubbed off. Again, handle with care, and use some form of "padding" for shipment, after placing specimen in a vial.

C) For <u>Caterpillars</u> and other <u>worms</u> and <u>maggots</u>. The simplest and best method of killing these larvae is to drop them into very hot or gently boiling water and then transfer them immediately to alcohol. This will preserve both their shape and color (color is often an important character for species determination). Alcohol alone may be used as a killing agent, but it may cause discoloration. Seventy percent ethanol is the best liquid preservative, but rubbing alcohol (which is available in local drugstores) is satisfactory. Both aftershave lotion and clear cocktail alcohol such as gin will work in a pinch.

D) Small soft bodied insects such as <u>aphids</u> or <u>leafhoppers</u> should be put directly into and shipped in alcohol.
<u>Glass</u> or plastic prescription bottles (often available in quantity from local pharmacists) make good storage containers only if they are sealed to prevent leakage and if they are packed within a sturdy box or mailing tube. The mails are very rough on unprotected glass.

The recommendations for submitting insect damaged plant material are the same as for diseased specimens.

Packing Specimens for Submission

Pack all specimens in outer carton with packing so they do not bounce around. Mail early in the week so packages do not sit in post office over a weekend.

Potted Plants

Place pot into plastic bag.
Secure around base of stem with straws or twist 'em.

Entire Plant

Wash roots.
Wrap roots in paper towel and then in plastic bag and secure around base of plant.
Aerial portion in flat position in alternate layers of moist (not wet) and dry newspaper with moist layer next to plant.

Aerial Portion of Herbaceous Plant

Lay as flat as possible between layers of newspaper.
Layer next to plant may be <u>slightly</u> moist.
Use cardboard for outer layers.

Single Leaves

Press flat between alternate layers of moist (not wet) and dry layer next to leaf.
Cardboard for outer layers.

Fleshy Fruits and Vegetables

Wrap in dry <u>newspaper</u>.
Place in perforated plastic bag.

Where to Go for Help in Diagnosing Plant Problems

Following is a list of plant diagnostic services currently available and, in most cases the cost of tests (1997 prices) is included. The services are listed by institution.

UW-Madison Extension Specialists Plant Identification and Culture

Agronomic and Horticultural Crops

Corn: Joe Lauer (263-7438)

Forage Crops: Dan Undersander (263-5070)

Soy Beans & Small Grains: Ed Oplinger (263-7436)

Flowers: Department of Horticulture (262-1490)

Forest trees: Ted Peterson (262-0249),
Jeff Martin (262-0134)

Fruit: Teryl Roper (262-1490)

Turf: John Stier (262-1624)

Vegetables: Helen Harrison (262-1749)

Weeds

Corn and small grains: Chris Boerboom (262-1392)

Alfalfa: Jerry Doll (263-7437)

Vegetables: Larry Binning (262-1689)

Turf: John Stier (262-1624)

Woody Ornamentals: Laura Jull (262-1450)

Vertebrate pests: Scott Craven (262-6325)

Soil Fertility and Management

Department of Soil Science (262-2633)

Corn and soybeans: Larry Bundy (263-2889)

Forages and small grains: Keith Kelling (263-2795)

Vegetable crops: Larry Bundy (263-2889)

Lawns and gardens: Wayne Kussow (263-3631)

Irrigation and drainage: Leonard Massie (262-0604)

Waste application to soils: Keith Kelling (262-2631)

Analytical services

Plant analysis: Sherry Combs (262-4364)

Forage analysis: John Peters (715/387-2523: Marshfield lab), Sherry Combs (262-4364)

Soil analysis: Sherry Combs (262-4364), John Peters (715/387-2523: Marshfield)

Extension Entomologists Insect Identification

Entomology Dept., UW-Madison
237 Russell Laboratories, Room 240,
Madison, WI 53706-1598;

(608/262-3227)

General diagnostic assistance, nuisance pests, structural pests: Phil Pellitteri (262-6510).

Agronomic crop pests, stored grain pests: John Wedberg (262-3226).

Vegetable pests: Jeff Wyman (262-3229).

Fruit Pests: Dan Mahr (262-3328).

Directions for collecting and mailing specimens are available form the laboratory mentioned above. Submit as much information with specimens as possible: such as where found, the environment and host. Insects should be preserved in alcohol (rubbing alcohol works) & properly packed for mailing.

Extension Plant Pathologists Plant Disease Identification

Plant Pathology Dept., UW-Madison
283 Russell Laboratories
Madison, WI 53706-1598

(608/262-1410; Fax 608/263-2626)

General diagnostic assistance: Brian Hudelson (262-2863).

Vegetable crop diseases: Walt Stevenson (262-6291).

Fruit diseases: Patricia McManus (265-2047).

Agronomic crop diseases: Craig Grau (262-6289).

Note: Directions for collecting and mailing specimens are available form the laboratory mentioned above, as well as a plant identification form. This form must accompany any suspect plant disease specimens submitted to extension plant pathologist. Diagnosing disorders caused by fungi, bacteria, viruses, and phytoplasmas generally requires fresh or recently diseased plant materials. Thus, submit representative materials promptly.

1998 Fees for Diagnosis

The Plant Pathogen Detection Laboratory accepts samples for diagnosis through the county extension office. If the county agent prefers the samples may be sent directly and we have a special form for use by the professional in these cases.

In order to recover some of the costs incurred in the diagnosis process we have been charging since July 1, 1985. Please call prior to sample submission to confirm pricing and available tests. (608) 262-2863.

Regular samples*	$10.00
Ginseng samples	.$18.00
Potato Ring Rot Test	$25.00
DAPI tests for MLO's	$30.00
Electron Microscope work	$180.00
Tissue sent to AGDIA for Virus analysis	$30.00
Soil Test for *Pythium* or *Phytophethora* or *Aphanomyces*	$25.00
P Root Rot Test	$50.00
PCR Test for Phytoplasmas	(Inquire at clinic for availability)

*Additional costs may apply if other tests are necessary.

Lab will confirm prior to additional testing.

Nematode Analysis

Ann MacGuidwin
Nematode Diagnostic Lab, UW-Madison
1630 Linden Drive, Room 491
Madison, WI 53706-1598

(608/263-6131; Fax 608/263-2626)

Root & Soil Analysis	$22.00
Soybean Cyst & Corn Needle Analysis	$14.00

Soil Analyses for Verticillum Propagules

Pest Pros
P.O. Box 188
Plainfield, WI 54966

(715/335-4046) Call for price

Dr. Douglas Rouse
1630 Linden Drive, Room 395, UW-Madison
Madison, WI 53706-1598

(608/262-1395; Fax 608/263-2626)

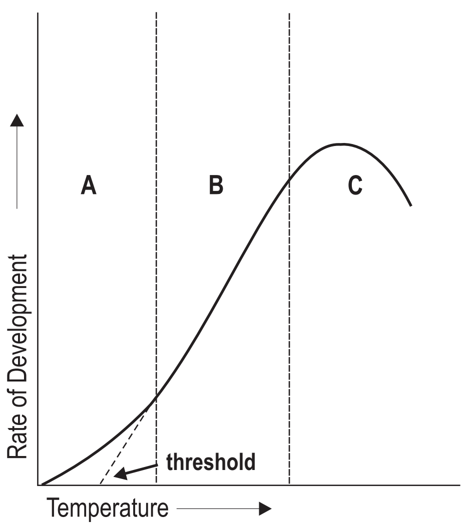
Degree Days — What Do They Mean?

David Hogg, Entomology

Degree days (also known as "day-degrees" or generically as "heat units") provide a means of predicting insect phenology (i.e., the timing of life history events) by combining time and temperature to measure insect development and activity. The utilization of degree days is becoming increasingly important in insect pest management programs, due to the potential for increased accuracy over calendar time in predicting phenological events. Applications to pest management include the scheduling of pest scouting and in some cases insecticide applications or other types of control tactics.

Theoretical Basis

The degree day concept is based on the fact that insects are cold-blooded, and thus an insect's body temperature is similar to the temperature of the surrounding environment. As a result, the physiological activity of insects is governed largely by environmental temperature. This is illustrated most vividly in the case of the development of the immature stages of insects. The relationship between the rate of immature development and temperature is shown in a general way in the figure below.



For convenience, the relationship has been divided into three regions. In B, the relationship between developmental rate and temperature is linear. In A, the relationship begins to deviate from linearity, and as cooler temperatures are encountered the rate slowly approaches zero (no development). In C, the relationship also begins to deviate from linearity, and as warmer temperatures are encountered, the rate reaches a maximum and then begins to decline.

Temperatures in the linear portion of the temperature-rate relationship generally are the most favorable for insect survival and development, and in most cases the life history of an insect species is geared so that the insect is active when temperatures in this region are encountered most commonly. Although higher temperatures (region C) may promote faster development, prolonged exposure to these conditions usually results in excessive mortality.

In developing a degree day scale, the linear region of the temperature-rate relationship is utilized. The assumption is made that the relationship remains linear in region A, and a base temperature or "developmental threshold" (i.e., the temperature below which no development is assumed to occur) is determined by extrapolation of the linear relationship (see figure). The importance of assuming linearity is that, by so doing, the number of degree days required to complete development will be the same regardless of temperature. Of course, the details of the temperature-rate relationship will vary depending on the insect species; for example, the pea aphid has developmental threshold of about 38°F, whereas the corn earworm has a threshold of about 56°F. The threshold an degree day requirements for each species and stage of interest can be determined experimentally.

Calculating Degree Days

A degree day can be defined as one degree of temperature above the threshold for one day. There are several methods available for calculating degree days. The easiest is to use the high and low temperatures for the day, calculate an average temperature, and subtract the threshold:

[(High + Low) / 2] – Threshold = Degree Days for one day

For example, if a threshold of 50° is used, and a high of 80° and a low of 60° have been recorded, the number of degree days for the day would be:

[(80 + 60) / 2] – 50 = 70 – 50 = 20

This procedure is accurate as long as the low temperature is greater than or equal to the threshold. However, if the low temperature is less than the threshold, this procedure underestimates the actual number of degree days. When this occurs, there are several other methods available for calculating degree days. One of these is known as the "modified" degree day method, in which the low temperature is set equal to the threshold whenever the low is less than the threshold, and degree days are calculated as before. A drawback to this method is that it tends to overestimate the actual number of degree days. A more accurate procedure is known as the "sine wave" method. A sine curve is fit through the daily high and low temperatures, and the area under the curve and above the threshold equals the number of degree days. The sine wave method is also the most difficult to calculate, requiring a computer or at least a programmable calculator. One approach to overcome computational difficulties is to prepare a table that gives the number of degree days above some threshold temperature for every possible combination of high and low temperatures. Daily degree day accumulation can then be determined simply by referring to the table.

On a seasonal basis, degree day accumulation (a process known as "thermal summation") normally starts the first day the temperature goes above the developmental threshold. After that, a running total of accumulated degree days is kept.

Applications

For degree days to be useful in a management program for a particular insect pest, two criteria must usually be met. First, the pest must overwinter locally; in Wisconsin this is accomplished by hibernation in a physiological condition known as diapause. Examples of insect pests that are unable to survive the winter in Wisconsin are the potato leafhopper and the corn earworm. These species overwinter only in areas well to the south of Wisconsin, and each year both migrate into the state. Usually the potato leafhopper arrives during May and the corn earworm arrives during August, but the arrival times of migrants are not predictable enough to calibrate with degree day seasonal totals. The second criterion is that the pests have discrete generations. For example, the pea aphid overwinters in Wisconsin; however, the aphids have very short generation times and reproduce continuously, so that in a short time the generations overlap. As a result, all aphid stages are present in the field during virtually the entire growing season, and aphid abundance is related to factors other then degree day totals.

Two pest species that meet both criteria and for which degree days have proven useful in management programs are the alfalfa weevil and the European corn borer.

The alfalfa weevil is a pest of first crop alfalfa in Wisconsin. It overwinters in the adult stage. In the spring the adults come out of hibernation, feed and lay eggs. It is feeding by the larvae that hatch form these eggs that can cause significant damage to the crop. Only one generation of larvae occurs each year, and it either is completed by the time the first cutting is taken or is interrupted when the field is cut. The developmental threshold of the alfalfa weevil is 48°F. In southern Wisconsin damaging populations of weevil larvae do not occur until a seasonal total of at least 300 degree days above 48°F has been accumulated; thus, in southern Wisconsin it is recommended that scouting for alfalfa weevil be initiated when a total of 300 degree days is reached.

The European corn borer is a pest of field and sweet corn in Wisconsin. The corn borer overwinters as a mature larva. In the spring the larvae pupate, emerge as adults, and lay eggs. Two discrete generations of this pest are normally completed during the growing season in southern Wisconsin. The developmental threshold of the European corn borer is 50°F. Seasonal degree day (DD) totals above 50°F for various events in the seasonal history of the corn borer in southern Wisconsin are given in the following table:

First (Spring) Generation	DD
First moth	374
First eggs	450
Peak moths	631
Treatment period	800-1000

Second (Summer) Generation	DD
First moth	1400
First eggs	1450
Peak moths	1733
Treatment period	1550-2100

The values in the table represent averages of 5 years of data collected by J.W. Apple (formerly of the U.W. Entomology Department) at the Arlington Experimental Farm. Also shown in the table are the periods during which insecticides should be applied if treatment is warranted; the timing of treatments is important because once corn borer larvae bore into the plant, they are no longer vulnerable to insecticide applications.

Conclusion

Degree days, by combining time and temperature, provide a much more accurate means of measuring insect activity and development in the field than does calendar time alone. Because of this capability, degree days can be useful in the development of management programs for certain insect pest species.

There are, however, several potential problems in using degree days that should be mentioned. As discussed earlier, the degree day concept is based on the linear portion of the temperature-rate relationship. If temperatures are consistently either above or below the linear range, errors in prediction are likely to arise. Another potential problem is that temperatures used to calculate degree days generally are ambient (air) measurements, whereas the temperatures in the insects' microenvironment may be quite different than ambient. However, in most cases, degree day scales are calibrated in the field, so that discrepancies between microenvironmental and ambient conditions are accounted for in the scale. Finally and most pragmatically is the problem of where to obtain temperature data for calculating degree days. Ideally, temperatures should be recorded in or near the field where the pest population of interest occurs. Unfortunately, often this is not possible. The only advice that can be offered is that preliminary measurements be made to ensure that conditions between locations do not deviate significantly. Otherwise, there is the danger that the "wrong" temperature will be used.