**Ecological Concept of Pest Management**

**Different Periods of Civilization & Beginning of IPM:**

1. Stone Age, Iron Age - dawn of civilization because of agriculture.

2. Switch from hunting to agriculture and cultural change about 10,000+ years ago.

3. Mechanical age (1700s)- rise of machines.

4. Chemical age - 1940s - Schradan, organophosphates, DDT & other chlorinated hydrocarbons like chlordane, lindane, etc.

5. Biological/Ecological Age - understanding of ecological processes, Beginning of Integrated Pest Management (IPM) - Organic Agriculture, identity preserved agriculture.

**Integrated Pest Management refers:**

1. Proper identification of pests in agroecosystem.

2. Defined management unit.

3. Develop pest management strategy based on goals (usually market driven).

4. Develop reliable monitoring techniques.

5. Establish Economic Threshold (ET).

6. Evolve predictive and descriptive models.

**Ecological Pest Management refers:**

1. Proper Identification of pests in agroecosystem or ecosystem.

2. Management unit - garden or ecosystem.

3. Pest Management strategy is to use naturally based controls to establish long term control of pests - ecological goal.

4. Develop reliable monitoring techniques.

5. Establish Economic Threshold. (ET)

6. Evolve predictive and descriptive models.

**Some related definitions for Pest Management:**

**Pest** - organism that competes with humans for some resource. Many insect/weed/disease pests are of foreign origin.

- not all pests are bad; and not all pest damage is bad

- tolerate pests - what level can we live with?

Pests can be managed.

Management is people oriented!

**Management** - ability to influence people; and in this case, it is the people who control the pest - farmers, landowners, park service personnel, etc.

**Pest Management** - intelligent selection and use of pest control tactics.It ensures favorable economic, ecological, and social consequences.

**Pest control tactics**:

1) Monitor pest populations

2) Import/Conservation/Release of Beneficials.

3) Pesticides are last resort! Use of selective, biorationals.

Or,

4)No action is necessary!

**Integrated Pest Management:**

Optimization of pest control in an ecologically and economically sound manner. Multiple tactics are used to keep pest damage below the Economic Injury Level (EIL) while protecting humans, animals, plants, and the ENVIRONMENT.Viable environment is primary.

**Actually happening for pest management:**

1. Actually, many people, from farmers to homeowners followed rigorous spray schedules based on the development of the crop; regardless of whether the pest was there or not - no sampling involved. This type of spraying is being killed the parasites, pathogens and predators - beneficials were eliminated and pests exploded; plus we got secondary pest resurgence. Pest resistance of many insect e.g. many Aedes mosquitoes - DDT, lindane, aldrin, dieldrin are being also evolved. All these factors\are responsible for environmental contamination.

**Pattern of Crop Protection**

1. Subsistence Phase: is the self-sufficiency farming in which farmers grow only enough food to feed their families

2. Exploitation Phase - farmers use chemicals to kill pests; become dependent upon pesticides

3. Crisis phase - resistance, secondary pest resurgence; increased production costs - pesticide treadmill

4. Disaster Phase - collapse of profit/market and also of the existing control program

5. Integrated Control Phase - accept ecological factors into the control plan

**Concepts of Pest Management**

**A. Agricultural Ecosystem understanding:** Detailed study about agroecosystem. Certain pests have alternate hosts and patterns of infestation that need to be considered.

**B. Planning the Agroecosystem :**

i. Anticipate pest problems

ii. Integrate crop production and protection

iii. Farmscaping, beneficial overwintering sites; cover crops and zero-tillage production schemes etc.

**C. Cost/Benefit and Benefit/Risk:**

**i.** Cost Benefit and Benefit/Risk - pest control decisions have a personal bias.

**ii.** Cost/Benefit - unnecessary treatments versus information - Pest scouting and Cooperative Extension Service Bulletins

**iii.** Information can reduce pesticide use and cost.

**iv.** Information can be substituted for pesticides

**v.** Scouting - more field time, but very effective.

vi. Highly toxic pesticides - risks to handlers, workers, environment, and society.

vi. Estimated environmental costs of pesticide

**D. Tolerance of Pest Damage:**

i. Economic Injury Level predicts yield loss based on present densities and damage.

ii. EIL=C/VID

EIL = # insects per production unit

C = cost of the management activity/production unit

V = market value per unit of yield ($/lb).

I = Injury units per pest production unit

D = damage per unit of injury.

iii. Economic Injury Level - is it a pest or not? Estimate of what density that can be tolerated without significant crop loss.

iv. EIL-lowest population density that will cause economic damage - loss caused by pest equals the cost of control

EIL=PC-EC/VDIK

PC = pesticide application costs

EC = environmental costs

D = yield loss as a function of total crop injury

I = crop injury per pest density

K = proportionate reduction in injury from pesticide use

v. EIL can vary from area to area, crop variety

vi.EIL goes down as crop value goes up; plus consumer standards. Tree fruits, sweet corn

viii. ET is always lower than the EIL

**E. Leaving a Pest Residue (residual population):**

i. Ecological Balance - increase numbers of natural enemies.

ii. Natural enemies have to have food in order to stick around - pest residue for natural enemies to be lower than the ET.

iii.Suppress pests but don’t annihilate it.

**F. Timing of Treatments:**

i. Public Understanding and Acceptance

ii. Routine - “spray by calendar” versus “treat when necessary” driven by data.

iii.Treatments based on NEED.

**G. Public Understanding and Acceptance:**

**i.** Educate the public about pest management

ii. Take advantage of what Extension has to offer.

iii. Scientific/Social Judgement - how should control be achieved?

iv. Education of clientele - most important challenge.

## The Economics of Pest Control

The scientific study of pests and pest control strategies is often called **economic entomology** in recognition of the financial impact insects have on industry, agriculture, and human society in general.   To be sure, economically important insects are not always pests; we have already stressed their value as pollinators, natural enemies, producers of silk, honey, etc.   But wherever pest populations develop, their impact always results in monetary loss, either directly or indirectly.   In most cases, losses from insect pests are directly proportional to the density of the pest population -- high density increases the extent or severity of damage and makes the need for control more critical.

Many people use the terms **"damage"** and **"injury"** interchangeably, but entomologists usually make an important distinction between them.

**Injury** is defined as the physical harm or destruction to a valued commodity caused by the presence or activities of a pest (e.g., consuming leaves, tunneling in wood, feeding on blood, etc.).

**Damage** is the monetary value lost to the commodity as a result of injury by the pest (e.g., spoilage, reduction in yield, loss of quality, etc.).

Any level of pest infestation causes injury, but not all levels of injury cause damage.   Plants often tolerate small injuries with no apparent damage.   A low level of injury may not cause enough damage to justify the time or expense of pest control operations.

Economic Injury Level

But at some point in the growth phase of a pest population it reaches a point where it begins to cause enough damage to justify the time and expense of control measures. But how does one know when this point is reached?   To a great extent, the answer depends on two fundamental pieces of economic information:

**A. How much financial loss is the pest causing?**   and

**B. How much will it cost to control the pest?**

A pest outbreak, by definition, occurs whenever the value of **"A"** is greater than the value of **"B"**.

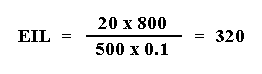
The economic injury level is usually expressed as a number of insects per unit area or per sampling unit.   Occasionally, when the insects themselves are difficult to count or detect, the economic threshold may be based on a measurement of injury (e.g., leaf area consumed or number of dead plants).

The break-even point, where **"A"="B"**, is known as the **economic injury level**.   This is the population density at which the cost to control the pest equals the amount of damage it inflicts (actual or potential).   Below the economic injury level, it is not cost-effective to control the pest population because the cost of treatment (labor plus materials) would exceed the amount of damage.   Above the economic injury level, however, the cost of control is compensated by an equal or greater reduction in damage by the pest.

The economic injury level (EIL) is often expressed mathematically by the formula:

|  |  |
| --- | --- |
| formula1 | where:  **"C"**   is the unit cost of controlling the pest    (e.g., $20/acre)  **"N"**   is the number of pests injuring the commodity unit    (e.g., 800/acre)  **"V"**   is the unit value of the commodity    (e.g., $500/acre)  **"I"**   is the percentage of the commodity unit injured    (e.g., 10% loss) |

For the example given above, the economic injury level would equal 320 insects per acre:



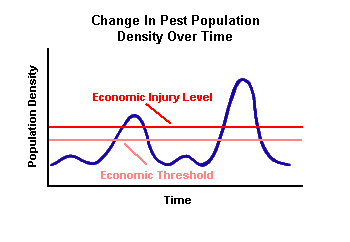
The economic injury level is usually expressed as a number of insects per unit area or per sampling unit.   Occasionally, when the insects themselves are difficult to count or detect, the economic threshold may be based on a measurement of injury (e.g., leaf area consumed or number of dead plants).

**Economic Thresholds**

Consequently, entomologists define a point below the economic injury level at which a decision is made to treat or not treat.   This decision point is called the [**economic threshold**](http://www.cals.ncsu.edu/course/ent425/tutorial/economics.html#2#2)**,** or sometimes the **action threshold**

The economic injury level is a useful concept because it quantifies the cost/benefit ratio that underlies all pest control decisions.   In practice, however, it is not always necessary or desirable to wait until a population reaches the economic injury level before initiating control operations.   Once it is determined that a population will reach outbreak status, prompt action can maximize the return on a control investment.   Since there is usually a lag time between the implementation of a control strategy and its effect on the pest population, it is always desirable to begin control operations before the pest actually reaches the economic injury level.

Consequently, entomologists define a point below the economic injury level at which a decision is made to treat or not treat.   This decision point is called the **economic threshold**, or sometimes the action threshold.   It is the decision point for action -- the pest density at which steps are first taken to ensure that a potential pest population never exceeds its economic injury level.   The economic threshold, like the economic injury level, is usually expressed in units of insect density or in terms of an injury measurement.   The economic threshold is always lower than the economic injury level in order to allow for sufficient time to enact control measures.



**Surveillance of Pest Populations**

Effective use of economic thresholds in the management of insect populations depends on accurate measurements of population density as well as reliable predictions of population growth trends.   Since it is not practical to count all the flies in the barnyard or all the boll weevils in the cotton field, entomologists depend on sampling strategies to estimate density and distribution.   Hundreds of sampling methods have been devised and entomologists continue to develop and refine their techniques.

An "ideal" sampling strategy requires minimal effort and gives an accurate and reproducible measure of the density and/or distribution of an insect population.   In practice, such "ideal" methods do not exist.   Every technique is inherently biased in some way.   One method may be better than another for a particular pest or situation, but no sampling process is totally random, objective, and repeatable.   The most widely used techniques, such as sweep nets or bait traps, do not measure absolute density of pest populations, they are only relative measures (yardsticks, in a sense) that may be used as estimates of population density once they are properly "calibrated" through exerimentation and comparison with other sampling techniques.

Sex pheromone traps, for example, may attract male peachtree borers from several miles downwind.   Without compensating for such immigration, trap catch data would greatly exaggerate the size of a local moth population.   Similarly, sweepnet samples of alfalfa weevils tend to underestimate the numbers of small larvae in a field (relative to adults and large larvae) because early instars hide within the plant's terminal growth and are not easily knocked out during sweeping.

**Analysis of Sampling Data**

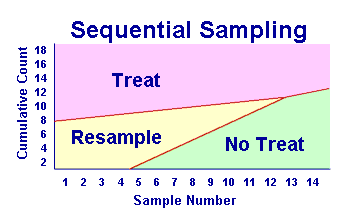
Simple, descriptive statistics are essential for interpreting data collected in any replicated sampling scheme.   Regardless of how data is gathered, whether as continuous measurements (e.g., leaf area consumed), in the form of numerical counts (e.g., number of beetles per plant), as ordinal ratings (e.g., on a scale from 1 to 10), or in binomial form (e.g., presence/absence), there is always some degree of uncertainty about its accuracy.   Statisticians call this uncertainty **"variance"**.   It arises both from **experimental error** (inability to precisely replicate all conditions in each sample) and from the **natural variability** that is a characteristic of all biological systems (e.g., the number of leafhoppers collected in 25 sweeps at dawn may be quite different from a similar sample taken that evening in the same field).   Good sampling strategies are designed to minimize variance in order to give the most reasonable "estimate" of population size.

The mean, variance, and standard error are the calculations most commonly used to evaluate sampling results.   The mean is simply an arithmetic average of data values.   It is one of several ways to describe a range of numbers.   The variance (sum of squared deviations from the mean divided by number of observations), and the standard error (square root of the variance divided by the mean) are measures of how far the other data values tend to stray from the mean.

**Sequential Sampling**

Although it is fairly easy to sample for some insects, many pest management systems utilize sampling protocols that are fairly time consuming and labor intensive.   Whenever large numbers of samples are needed to achieve an adequate level of confidence, it may be possible to use a sequential sampling system that saves time and effort by concentrating mostly on populations that are closest to the economic threshold.   Sequential sampling systems are relatively new in pest management, but they are based on well-established rules for determining confidence intervals for sample data.

Unlike regular sampling protocols that require a fixed number of replications (usually 10-100), sequential sampling systems are designed to evaluate the data at the end of each sampling step.   The total number of samples is variable, depending upon whether the cumulative data falls inside or outside of predetermined confidence intervals.   Relatively few samples would be needed to recognize that a population is very small (well below the economic threshold) or very large (well above the economic threshold).   But a larger number of samples (higher confidence) would be needed to decide whether an intermediate population should be treated or not treated.



In most sequential sampling systems, there are three different outcomes possible at the end of each sampling step:

1. If the cumulative total of pests exceeds an upper threshold value, then conclude that the population is large enough to warrant control actions.   Stop sampling and prepare to enact control measures.
2. If the cumulative total of pests is beneath a lower threshold value, then conclude that the population is small and warrants no control actions.   Stop sampling (at least for awhile) and leave the population untreated.
3. If the cumulative total of pests is between the upper and lower threshold values, then no conclusion is possible yet.   Sampling should continue until cumulative values reach the upper or lower threshold.

**Quarantine Basis of Pest Management- Sampling & Measures**

What is quarantine?

A period of time during which a vehicle, person, or material suspected of carrying a contagious disease is detained at a port of entry under enforced isolation to prevent disease from entering a country.

What is plant quarantine?

**Plant Quarantine** the effort to prevent entry of a foreign pest in the country through legal restriction on the movement of plants and plant products. The word Quarantum means forty; and the isolation period of 40 days appears to have a traditional rather than a factual background. It was originally applied to the period of detention for ships arriving from countries subject to epidemic diseases. Bangladesh became a member of the Asia and Pacific Plant Protection Commission (APPPC) in 1978. The existing plant quarantine legislation, known as "Destructive Insects and Pests Rules, 1966 (Plant Quarantine), was framed as per provisions delineated under sub-section (1) of section 3, section 4A and 4D of the Destructive Insect and Pest Act, 1914 (II of 1914).

When Bangladesh came into being in 1971, It was felt that the rapid change in agricultural, geographical, economical and allied circumstances meant that these rules needed modification to meet the requirements of the agricultural and industrial sectors. With the promulgation of the National Seed Policy, there arose the necessity for revising existing rules to facilitate the easy flow of high breed seed/planting materials into the country. Consequently, 'Plant Quarantine Rules, 1995' have been framed and submitted to the Government for approval and is under active consideration at present. In Bangladesh, plant quarantine stations are functioning in the following entry points: *Airports*: Hazrat Shah Jalal(R) International Airport, Dhaka; Amanat Shah International Airport, Chittagong; and Osmany International Airport, Sylhet. *Seaports*: Chittagong Seaport; and Mongla Seaport, Khulna. *Land Border Checkpost*: Benapole, Jessore; Burimari, Lalmonirhat; Tamabil, Sylhet; Darshana, Chuadanga; and Hili, Dinajpur. *Riverport*: Narayanganj. The headquarter of the Department of Agricultural Extension (Plant Protection Wing) at Khamarbari, Dhaka, has a glass house to carry out post-entry quarantine observations. Testing of imported (plant and plant products) and exportable goods including germplasm is carried out in the glass house.

**International Plant Protection Convention(IPPC)**

**PREAMBLE**   
The contracting parties, recognizing the usefulness of international cooperation in controlling pests of plants and plant products and in preventing their spread, and especially their introduction across national boundaries, and desiring to ensure close coordination of measures directed to these ends, have agreed as follows:

**ARTICLE I**   Purpose and responsibility

1.With the purpose of securing common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote measures for their control, the contracting parties undertake to adopt the legislative, technical and administrative measures specific in this Convention and in supplementary agreements pursuant to Article III.

2.Each contracting party shall assume responsibility for the fulfilment within its territories of all requirements under this Convention.

**ARTICLE II**   Scope

1.For the purpose of this Convention the term "plants" shall comprise living plants and parts thereof, including seeds in so far as the supervision of their importation under Article VI of the Convention or the issue of phytosanitary certificates in respect of them under Articles IV (1) (a) (IV) and V of this Convention may be deemed necessary by contracting parties; and the term "plant products" shall comprise unmanufactured material of plant origin (including seeds in so far as they are not included in the term "plants") and those manufactured products which, by their nature or that of their processing, may create a risk for the spread of pests.

2. For the purpose of this Convention, the term "pest" means any form of plant or animal life, or any pathogenic agent, injurious or potentially injurious to plants or plant products; and the term "quarantine pest" means a pest of potential national economic importance to the country endangered thereby and not yet present there, or present but not widely distributed and being actively controlled.

3. Where appropriate, the provisions of this Convention may be deemed by contracting parties to extend to storage places, conveyances, containers and any other object or material capable of harbouring or spreading plant pests, particularly where international transportation is involved.

4. This Convention applies mainly to quarantine pests involved with international trade.

5. The definitions set forth in this Article, being limited to the application of this Convention, shall not be deemed to affect definitions established under domestic laws or regulations of contracting parties.

**ARTICLE III**   Supplementary agreements

1.Supplementary agreements applicable to specific regions, to specific pests, to specific plants and plant products, to specific methods of international transportation of plants and plant products, or otherwise supplementing the provisions of this Convention, may be proposed by the Food and Agriculture Organization of the United Nations (hereinafter referred to as FAO) on the recommendation of a contracting party or on its own initiative, to meet special problems of plant protection which need particular attention or action.

2. Any such supplementary agreements shall come into force for each contracting party after acceptance in accordance with the provisions of the FAO Constitution and General Rules of the Organization.

**ARTICLE IV**   National organization for plant protection

1. Each contracting party shall make provision, as soon as possible and to the best of its ability, for

(a)an official plant protection organization with the following main functions

(i)the inspection of growing plants, of areas under cultivation (including fields, plantations, nurseries, gardens and greenhouses), and of plants and plant products in storage or in transportation, particularly with the object of reporting the existence, outbreak and spread of plant pests and of controlling those pests;

(ii) the inspection of consignments of plants and plant products moving in international traffic and, where appropriate, the inspection of consignments of other articles or commodities moving in international traffic under conditions where they may act incidentally as carriers of pests of plants and plant products, and the inspection and supervision of storage and transportation facilities of all kinds involved in international traffic whether of plants and plant products or of other commodities, particularly with the object of preventing the dissemination across national boundaries of pests of plants and plant products;

(iii) the disinfestation or disinfection of consignments of plants and plant products moving in international traffic, and their containers (including packing material or matter of any kind accompanying plants or plant products), storage places, or transportation facilities of all kinds employed;

(iv) the issuance of certificates relating to phytosanitary condition and origin of consignments of plants and plant products (hereinafter referred to as phytosanitary certificates);

(b) the distribution of information within the country regarding the pests of plants and plant products and the means of their prevention and control;

(c) research and investigation in the field of plant protection.

2. Each contracting party shall submit a description of the scope of its national organization for plant protection and of changes in such organization to the Director-General of FAO, who shall circulate such information to all contracting parties.

**ARTICLE V**   Phytosanitary certificates

1. Each contracting party shall make arrangements for the issuance of phytosanitary certificates to accord with the plant protection regulations of other contracting parties, and in conformity with the following provisions:

(a) Inspection shall be carried out and certificates issued only by or under the authority of technically qualified and duly authorized officers and in such circumstances and with such knowledge and information available to those officers that the authorities of importing countries may accept such certificates with confidence as dependable documents.

(b) Each certificate for the export or re-export of plants or plant products shall be as worded in the Annex to this Convention.

(c) Uncertified alterations or erasures shall invalidate the certificates.

2. Each contracting party undertakes not to require consignments of plants or plant products imported into its territories to be accompanied by phytosanitary certificates inconsistent with the models set out in the Annex to this Convention. Any requirement for additional declarations shall be kept to a minimum.

**ARTICLE VI**   Requirements in relation to imports

1. With the aim of preventing the introduction of pests of plants and plant products into their territories, contracting parties shall have full authority to regulate the entry of plants and plant products and, to this end, may:

1. prescribe restrictions or requirements concerning the importation of plants or plant products;
2. prohibit the importation of particular plants or plant products, or of particular consignments of plants or plant products;
3. inspect or detain particular consignments of plants or plant products;
4. treat, destroy or refuse entry to particular consignments of plants or plant products that do not comply with the requirements prescribed under subparagraph (a) or (b) of this paragraph, or require such consignments to be treated or destroyed or removed from the country;
5. list pests the introduction of which is prohibited or restricted because they are of potential economic importance to the country concerned.

2. In order to minimize interference with international trade, each contracting party undertakes to carry out the provisions referred to in paragraph I of this Article in conformity with the following:

1. Contracting parties shall not, under their plant protection legislation, take any of the measures specified in paragraph 1 of this Article unless such measures are made necessary by phytosanitary considerations.
2. If a contracting party prescribes any restrictions or requirements concerning the importation of plants and plant products into its territories, it shall publish the restrictions or requirements and communicate them immediately to FAO, any regional plant protection organization of which the contracting party is a member and all other contracting parties directly concerned.

(c)If a contracting party prohibits, under the provisions of its plant protection legislation, the importation of any plants or plant products, it shall publish its decision with reasons and shall immediately inform FAO, any regional plant protection organization of which the contracting party is a member and all other contracting parties directly concerned.

(d)If a contracting party requires consignments of particular plants or plant products to be imported only through specified points of entry, such points shall be so selected as not unnecessarily to impede international commerce. The contracting party shall publish a list of such points of entry and communicate it to FAO, any regional plant protection organization of which the contracting party is a member and all other contracting parties directly concerned. Such restrictions on points of entry shall not be made unless the plants or plant products concerned are required to be accompanied by phytosanitary certificates or to be submitted to inspection or treatment.

(e) Any inspection by the plant protection organization of a contracting party of consignments of plants or plant products offered for importation shall take place as promptly as possible with due regard to the perishability of the plants or plant products concerned. If any commercial or certified consignment of plants or plant products is found not to conform to the requirements of the plant protection legislation of the importing country, the plant protection organization of the importing country must ensure that the plant protection organization of the exporting country is properly and adequately informed. If the consignment is destroyed, in whole or in part, an official report shall be forwarded immediately to the plant protection organization of the exporting country.

1. Contracting parties shall make provisions which, without endangering their own plant production, will keep certification requirements to a minimum, particularly for plants or plant products not intended for planting, such as cereals, fruits, vegetables and cut flowers.
2. Contracting parties may make provisions, with adequate safeguards, for the importation for purposes of scientific research or education, of plants and plant products and of specimens of plant pests. Adequate safeguards likewise need to be taken when introducing biological control agents and organisms claimed to be beneficial

3.The measures specified in this Article shall not be applied to goods in transit throughout the territories of contracting parties unless such measures are necessary for the protection of their own plants.

4. FAO shall disseminate information received on importation restrictions, requirements, prohibitions and regulations (as specified in paragraph 2(b), (c) and (d) of this Article) at frequent intervals to all contracting parties and regional plant protection organizations.

**ARTICLE VII**   International cooperation

The contracting parties shall cooperate with one another to the fullest practicable extent in achieving the aims of this Convention, in particular as follows:

(a)Each contracting party agrees to cooperate with FAO in the establishment of a world reporting service on plant pests, making full use of the facilities and services of existing organizations for this purpose and, when this is established, to furnish FAO periodically, for distribution by FAO to the contracting parties, with the following information:

(i)reports on the existence, outbreak and spread of economically important pests of plants and plant products which may be of immediate or potential danger;

(ii) information on means found to be effective in controlling the pests of plants and plant products.

(b) Each contracting party shall, as far as is practicable, participate in any special campaigns for combating particular destructive pests that may seriously threaten crop production and need international action to meet the emergencies.

**ARTICLE VIII**   Regional plant protection organizations

1. The contracting parties undertake to cooperate with one another in establishing regional plant protection organizations in appropriate areas.

2. The regional plant protection organizations shall function as the coordinating bodies in the areas covered, shall participate in various activities to achieve the objectives of this Convention and, where appropriate, shall gather and disseminate information.

**ARTICLE IX**   Settlement of disputes

1. If there is any dispute regarding the interpretation or application of this Convention, or if a contracting party considers that any action by another contracting party is in conflict with the obligations of the latter under Articles V and VI of this Convention, especially regarding the basis of prohibiting or restricting the imports of plants or plant products coming from its territories, the government or governments concerned may request the Director-General of FAO to appoint a committee to consider the question in dispute.
2. The Director-General of FAO shall thereupon, after consultation with the governments concerned, appoint a committee of experts, which shall include representatives of those governments. This committee shall consider the question in dispute, taking into account all documents and other forms of evidence submitted by the governments concerned. This committee shall submit a report to the Director-General of FAO, who shall transmit it to the governments concerned and to the governments of other contracting parties.
3. The contracting parties agree that the recommendations of such a committee, while not binding in character, will become the basis for renewed consideration by the governments concerned of the matter out of which the disagreement arose.
4. The governments concerned shall share equally the expenses of the experts.

**ARTICLE X**   Substitution of prior agreements   
This Convention shall terminate and replace, between contracting parties, the International Convention respecting measures to be taken against the Phylloxera vastatrix of 3 November 1881, the additional Convention signed at Berne on 15 April 1889 and the International Convention for the protection of plants signed at Rome on 16 April 1929

**ARTICLE XI**   Territorial application

1. Any state may at the time of ratification or adherence or at any time thereafter communicate to the Director-General of FAO a declaration that this Convention shall extend to all or any of the territories for the international relations of which it is responsible and this Convention shall be applicable to all territories specified in the declaration as from the thirtieth day after the receipt of the declaration by the Director-General
2. Any state which has communicated to the Director-General of FAO a declaration in accordance with paragraph 1 of this Article may at any time communicate a further declaration modifying the scope of any former declaration or terminating the application of the provisions of the present Convention in respect of any territory. Such modification or termination shall take effect as from the thirtieth day after the receipt of the declaration by the Director-General.
3. The Director-General of FAO shall inform all signatory and adhering states of any declaration received under this Article.

**ARTICLE XII**   Ratification and adherence

1. This Convention shall be open for signature by all states until l May I 952 and shall be ratified at the earliest possible date. The instruments of ratification shall be deposited with the Director-General of FAO, who shall give notice of the date of deposit to each of the signatory states.
2. As soon as this Convention has come into force in accordance with Article XIV, it shall be open for adherence by non-signatory states. Adherence shall be effected by the deposit of an instrument of adherence with the Director-General of FAO, who shall notify all signatory and adhering states.

**ARTICLE XIII**   Amendment

1. Any proposal by a contracting party for the amendment of this Convention shall be communicated to the Director-General of FAO.
2. Any proposed amendment of this Convention received by the Director-General of FAO from a contracting party shall be presented to a regular or special session of the Conference of FAO for approval and, if the amendment involves important technical changes or imposes additional obligations on the contracting parties, it shall be considered by an advisory committee of specialists convened by FAO prior to the Conference
3. Notice of any proposed amendment of this Convention shall be transmitted to the contracting parties by the Director-General of FAO not later than the time when the agenda of the session of the Conference at which the matter is to be considered is dispatched
4. Any such proposed amendment of this Convention shall recquire the approval of the Conference of FAO and shall come into force as from the thirtieth day after acceptance by two-thirds of the contracting parties. Amendments involving new obligations for contracting parties, however, shall come into force in respect of each contracting party only on acceptance by it and as from the thirtieth day after such acceptance.
5. The instruments of acceptance of amendments involving new obligations shall be deposited with the Director-General of FAO, who shall inform all contracting parties of the receipt of acceptance and the entry into force of amendments.

**ARTICLE XIV**   Entry into force   
As soon as this Convention has been ratified by three signatory states it shall come into force between them. It shall come into force for each state ratifying or adhering thereafter from the date of deposit of its instrument of ratification or adherence.

**ARTICLE XV**   Denunciation

1. Any contracting party may at any time give notice of denunciation of this Convention by notification addressed to the Director-General of FAO. The Director-General shall at once inform all signatory and adhering states.

2.Denunciation shall take effect one year from the date of receipt of the notification by the Director-General of FAO.

Under the IPPC, information exchange is the responsibility of member countries’ [National Plant Protection Organizations](https://www.ippc.int/index.php?id=1110617) (NPPOs), the [IPPC Secretariat](https://www.ippc.int/index.php?id=13332) and [Regional Plant Protection Organizations](https://www.ippc.int/index.php?id=13310) (RPPOs).

Each member country should identify a contact point for all IPPC matters, provide a description of the NPPO, list points of entry under official control, list regulated pests, notify changes to its pest status, phytosanitary measures, regulations, and other relevant information.

Depending on circumstances, these notifications should be provided to other countries, to RPPOs and to the Secretariat through the IPPC website. For more information about reporting, see the [Convention](https://www.ippc.int/index.php?id=1110485&tx_publication_pi1%5bshowUid%5d=13742) and the reports of the sessions of the [Commission on Phytosanitary Measures](https://www.ippc.int/index.php?id=cpm&no_cache=1).

Sharing information about your pest status, phytosanitary measures, regulations and other information is vital to the future of the world’s plant resources and biodiversity, to safe trade in plants and plant products, and to food security.

Sharing information on regulations, pest outbreaks, control, surveillance and treatments builds cooperation and enhances member countries’ capacity to protect their plant resources. Countries use this information to assess the risks associated with moving plants and plant products across borders, and to manage those risks wisely.

Information exchange supports transparency and risk analysis by:

* promoting the control of pests and preventing their spread
* sharing technical information on which to base decisions
* using international standards
* promoting the harmonization of phytosanitary measures; and
* meeting the public information requirements of the Convention.

The Secretariat uses the information provided by member countries to coordinate the IPPC work programme, to review the state of plant protection around the world, to help in dispute avoidance and to inform CPM decisions. The Secretariat does this by:

* providing translation and documentation services for IPPC-related activities
* distributing IPPC and related documentation, such as ISPMs
* managing the IPPC Web site to communicate the Secretariat’s activities, to highlight RPPO and NPPO activities, to publish documentation relating to the IPPC, and to provide technical information on phytosanitary measures
* providing the forum for countries to develop and agree to ISPMs
* developing the network of IPPC contact points to provide fast, reliable exchange between member countries, and between member countries, the Secretariat and RPPOs
* informing member countries of meetings organized by the IPPC Secretariat and by RPPOs
* providing a global pest reporting system
* encouraging and emphasizing technical assistance on phytosanitary measures and providing technical assistance from the FAO
* organizing technical meetings to discuss emerging issues, to draft international standards or to clarify specific phytosanitary concerns
* providing training.

**The object of sampling according to the ISTA Rules**

**Objectives:**

1.The object of sampling is to obtain a sample of a size suitable for tests, in which the probability of a constituent being present is determined only by its level of occurrence in the seed lot.

* In other words, the object of sampling is to take a sample that represents the seed lot
* e.g. the proportion of number of other seeds, impurities and non-germinating seeds are equal in the sample and in the lot totally homogeneous seed lot
* One subsample from one place will result in a representative sample

**Reality in seed lots**

* Differences in seed weight, shape and flowing properties within the crop and between crop and impurities can cause separation => heterogeneity in a seed lot
* Seed lots are usually heterogeneous or in-homogeneous

=>The seed lot need to be as homogeneous as possible

Heterogeneous seed lot



In-homogeneous seed lot



**Benefits of systematic sampling**

* Simplicity of application
* Sample evenly across the seed lot
* Pitfall: if there is periodic variation in the seed lot and sampling happens to follow the variation, the result would be biased
* In practise, the patterns are usually clumped and irregular

**ISTA´s principle:**

one seed lot

one submitted sample

one certificate

**Definition of a seed lot**

A seed lot is a specified quantity of seed that is physically and uniquely identifiable.

- may not exceed a maximum lot size (e.g. 1000 kg for *Abies*, 500 kg for *Acer platanoides*)

- must be in sealed containers or under the control of a seed sampler

- shall be as uniform as possible

**Samples**

seed lot

primary samples

composite sample

submitted sample

**Sampling intensity**

* The sampling intensity in the ISTA Rules has been established to meet statistical requirements.
* Minimum numbers of primary samples have been defined for three different situations  
  - containers between 15 and 100 kg  
  - containers smaller than 15 kg  
  - containers larger than 100 kg.

**Sampling seed lots in containers smaller than 15 kg**

Containers are combined to sampling units of 100 kg and the sampling scheme for containers between 15 kg and 100 kg is followed by taking the sampling units as containers.

**Sampling seed lots in containers between 15 and 100 kg**

|  |  |
| --- | --- |
| ***Containers in the seed lot*** | ***Minimum number of primary samples*** |
| 1 – 4 containers | 3 primary samples from each container |
| 5 – 8 containers | 2 primary samples from each container |
| 9 – 15 containers | 1 primary samples from each container |
| 16 – 30 containers | 15 primary samples in total from the seed lot |
| 31 – 59 containers | 20 primary samples in total from the seed lot |
| 60 or more containers | 30 primary samples in total from the seed lot |

**Sampling seed lots in containers greater than 100 kg and from the seed stream**

|  |  |
| --- | --- |
| ***Lot size*** | ***Minimum number of primary samples to be taken*** |
| Up to 500 kg | At least five primary samples |
| 501 - 3 000 kg | One primary sample per 300 kg, but not less than five |
| 3001 - 20 000 kg | One primary sample for each 500 kg, but not less than 10 |
| 20 001 kg and above | One primary sample for each 700 kg, but not less than 40 |

Example

* A seed lot of 250 kg is in 0,5 kg containers.
* A sampler takes a sample.
* He combines the 0,5 kg containers to sampling units of 100 kg => three sampling units => 3 x 3 = 9 primary samples

The trier need to pierce into the middle of the container

**Instruments for taking samples from seed lots**



**Seed sample**

The submitted sample must be sealed and labelled in appropriate containers.

Seed sampler’s responsibilities

Seed sampler

* must follow the ISTA Rules and instructions given by the ISTA seed laboratory
* follow the sampling intensities
* is responsible for proper use and care for sampling equipment
* is responsible for sample reduction
* must refuse sampling in the case sampling cannot be done in a proper way

**Heterogeneity in a seed lot**

In case of obvious evidence of heterogeneity, sampling has to be refused.

In cases of doubt, a heterogeneity test can be made.

The object of heterogeneity testing is to detect the presence of heterogeneity which makes the seed lot technically unacceptable for sampling.

### Pest Management Strategies:

The first step in pest management is to identify the pest that is causing the problem. It then becomes essential to learn about the life cycle and behavior of the pest to facilitate the development of a plan to manage it; the goal might be eradication or merely the reduction or suppression of its damage potential.

A good pest management strategy incorporates some or all methods available to manage a given pest. This is called *integrated pest management, or IPM.* The goal should be to reduce pest populations and damage to economically and aesthetically tolerable levels. Complete eradication may not be possible, practical, or desirable.

Judicious selection of pest control methods should be aimed at reducing or eliminating pesticide use whenever possible. This is important because of concerns about personal and environmental safety. **The following methods should be considered in developing a pest management strategy**.

### Exclusion

One of the safest and most effective ways to manage pests in the home environment is to deny them access. This is called exclusion, or pest-proofing, and may be accomplished via one of the following options.

***Exclusion by Regulation***

Government embargoes and quarantines which prohibit the introduction of pests into one country from another--or into one locality from another--are methods of exclusion by regulation. A case in point is the quarantine that prevents pine trees infested with European pine shoot beetles from being transported into Indiana counties known to be free of that insect.

***Mechanical Exclusion***

Barriers and devices such as fences, traps, lights, row covers, and noisemakers are examples of mechanical exclusion methods used to keep pests away from garden plants and out of homes. For example, nuisance wildlife such as rabbits can be excluded from gardens and landscape plantings with fencing. and light traps that electrocute insects--have not been proven effective.

### Cultural Control

Most plants and animals resist pests best when they are in good health. Therefore, keeping a potential host healthy can help prevent pest damage.

***Plant Selection***

It is important to select species and cultivars of crops and ornamental plants recommended for the locale. Neighbors and professionals in the community should be consulted to determine which kinds of plants grow best and without significant pest problems. Avoid those that are known to have a questionable history and those recognized as marginally hardy. Cold temperatures can predispose tender woody and perennial plants to pest damage; choosing a hardier variety would be an example of cultural control through plant selection.

The European white birch tree is a beautiful tree and a popular choice for the residential landscape. However, it does not grow well in Indiana's climate; summer soil temperatures are too high, causing an unhealthy root system. The weakened tree then becomes susceptible to bronze birch borers that damage and usually kill it. Maintaining a European white birch tree in Indiana nearly always requires annual applications of an insecticide to control the borers. The frustration, expense, and hard work can be avoided by selecting a river birch, which is not susceptible to the borer, thereby eliminating the need for pesticide application. This, too, would constitute cultural control by plant selection.

Some plant cultivars resist or tolerate pest damage. Examples include tomato cultivars that are resistant to wilt diseases, apple cultivars resistant to scab diseases, and plants bred to produce more surface hairs that will discourage insect feeding. Cultivar selection should be based on the plants' known resistance to common pest problems, thus limiting loss potential and reducing the likelihood that a pesticide application might be needed.

***Planting Dates***

There are recommended planting intervals for most crops, and it is wise to recognize their importance. Careful selection of planting dates enhances crops' defenses against disease and insect infestations. Planting too early in the spring can result in plants weakened by cold, wet soil conditions; and late spring frosts can damage or kill crops planted too early. Root and seed rots usually can be avoided by choosing later planting dates that lend more favorable soil conditions. Certain insect pest problems can be avoided by choosing appropriate planting dates. Growing a combination of early, mid, and late season crops may decrease the potential for losses due to pests, based on the resulting staggered dates of maturity; i.e., a pest present at a given time wouldn't be apt to affect all three stages of growth. Careful selection of planting dates is a form of cultural control.

***Crop Rotation***

If space permits, crops should be rotated to different areas of the garden each year to prevent buildup of pests in the soil.

***Sanitation***

Sanitation is perhaps the most important cultural practice that can be used to help manage pests. It consists of removing plants or plant parts suspected of harboring insects or disease. For example, affected leaves, twigs, and branches of dogwoods infected with anthracnose should be removed and destroyed to help prevent the disease from spreading. Another example is the removal of certain plant parts that may be diseased, such as fallen rose leaves that are infected with black spot. It is important to always buy healthy seeds and plants known to be free of insects and disease. Examine 'gifts' from neighbors and tactfully decline those which obviously display pest symptoms. Remove garden weeds before they mature and produce seeds, and add them to your compost pile.

Sanitation is also important at the end of the growing season. Plant residue from annual crops, as well as the tops of herbaceous perennials, should be removed from the garden in the fall. Those not infested with insects or infected with disease can be added to a compost pile.

Other examples of cultural control through sanitation include removal of dead or diseased limbs from trees and shrubs; garbage management to discourage flies and rodents; careful attention to pet food areas; scrupulous cleanup of food crumbs in the home; and elimination of paper bags, newspapers, and other materials that provide food and shelter for pests such as cockroaches and rodents.

***Other Cultural Methods***

Good cultural practices include providing plants the best possible growing situation: proper spacing, watering, and fertilization. Weed control and the timely harvesting of produce also help to maintain healthy plants. The control of weeds with organic mulch is a good cultural practice, and mulch also contributes to plant health by moderating soil temperatures and conserving moisture.

Manipulation of a pest's environment also can be an effective method of cultural control. For example, venting the crawl space beneath a house will allow the space to dry, rendering the area unfavorable for the development of allergy-causing mildews and wood destroying organisms such as termites and decay fungi.

### Biological Control

Biological control utilizes the natural pathogens, predators, or parasites of a particular pest. One example is encouraging predatory lady beetles to destroy aphids in the garden. A biological approach might include growing certain plants as shelter or nectar sources for other predatory insects.

### Chemical Control

Chemicals have been used for hundreds of years to control pests. Pesticides are chemical compounds formulated to control pests. Household and industrial cleaning products that kill germs are also pesticides, as are common bleaches as well as chemicals used to sterilize surgical tools and surfaces in hospitals.

**Host Plant Resistance in Pest Management**

The role of host plant resistance as a direct control tactic in insect integrated pest management (IPM) .

**Ecological Results of Agriculture:** In contrast to natural ecosystems, most agricultural crop production systems are ecologically unstable, non-sustainable, and energy dependent. Man has gone through plant domestication and cultivation practices interfered in many ways with species diversity and natural defense mechanisms of plants. Cultivated crops originated from genetically diverse plant types. Defense mechanisms of plants are re-created in resistant plants. Plant defense mechanisms include escape in space and time, incompatible biological associations, physically and chemically derived barriers, and accommodation by replacement or repair of damaged plant parts. By re-creating plant defenses, genetic resistance to insect pests plays, in an environmentally compatible manner, a vital role in the attempt to enhance ecological stability in agricultural crops.

**An IPM Direct Control Tactic:** Plant resistance to insects is one of several cultural control methods. Cultural control methods involve use of agronomic practices to reduce insect pest abundance and damage below that which would have occurred if the practice had not been used. In IPM, plant resistance to insects refers to the use of resistant crop varieties to suppress insect pest damage. Plant resistance is intended to be used in conjunction with other direct control tactics.

**Definition of an Insect-Resistant Plant:** Definitions of an insect-resistant plant are many and varied. In the broadest sense, plant resistance is defined as "the consequence of heritable plant qualities that result in a plant being relatively less damaged than a plant without the qualities." In practical agricultural terms, an insect-resistant crop cultivar is one that yields more than a susceptible cultivar when confronted with insect pest invasion.

**Effect of Insect Pest-Plant Host Relationship:** Insect-resistant crop varieties suppress insect pest abundance or elevate the damage tolerance level of the plants. In other words, insect-resistant plants alter the relationship an insect pest has with its plant host. How the relationship between the insect and plant is affected depends on the kind of resistance, e.g.antibiosis,antixenosis(non-preference),ortolerance.   
  
***Antibiosis*** resistance affects the biology of the insect so pest abundance and subsequent damage is reduced compared to that which would have occurred if the insect was on a susceptible crop variety. Antibiosis resistance often results in increased mortality or reduced longevity and reproduction of the insect.   
  
***Antixenosis*** resistance affects the behavior of an insect pest and usually is expressed as non-preference of the insect for a resistant plant compared with a susceptible plant.   
  
***Tolerance*** is resistance in which a plant is able to withstand or recover from damage caused by insect pest abundance equal to that damaging a plant without resistance characters (susceptible). Tolerance is a plant response to an insect pest. Thus, tolerance resistance differs from antibiosis and antixenosis resistance in how it affects the insect-plant relationship. Antibiosis and antixenosis resistance cause an insect response when the insect attempts to use the resistant plant for food, oviposition, or shelter.  
  
**Advantages to the Use of Insect-Resistant Crop Varieties:** Use of insect-resistant crop varieties is economically, ecologically, and environmentally advantageous. Economic benefits occur because crop yields are saved from loss to insect pests and money is saved by not applying insecticides that would have been applied to susceptible varieties. In most cases, seed of insect-resistant cultivars costs no more, or little more, than for susceptible cultivars. Ecological and environmental benefits arise from increases in species diversity in the agroecosystem, in part because of reduced use of insecticides. Increases in species diversity increase ecosystem stability which promotes a more sustainable system far less polluted and detrimental to natural resources.

The IPM concept stresses the need to use multiple tactics to maintain insect pest abundance and damage below levels of economic significance. Thus, a major advantage to the use of insect-resistant crop varieties as a component of IPM arises from the ecological compatibility and compatibility with other direct control tactics. Insect-resistant cultivars synergize the effects of natural, biological, and cultural insect pest-suppression tactics. The "built-in" protection of resistant plants from insect pests functions at a very basic level, disrupting the normal association of the insect pest with its host plant. The compatible, complementary role plant resistance to insect pests plays with other direct control tactics is, in theory and practice, in concert with the objectives of IPM. All crop cultivars should contain resistance to insect pests.  
  
Plant resistance to insect pests has advantages over other direct control tactics. For example, plant resistance to insects is compatible with insecticide use, while biological control is not. Plant resistance to insects is not density dependent, whereas biological control is. Plant resistance is specific, only affecting the target pest. Often effects of use of insect-resistant cultivars are cumulative over time. Usually the effectiveness of resistant cultivars is long-lasting.

The role of plant resistance to insects in IPM has been well defined, at least in theory. However, the specific role a resistant cultivar plays in a particular IPM situation is crucial to successful deployment of the resistant cultivar. The impact of the resistant cultivar on standard cultural, biological, and insecticidal control methods should be well defined. Likewise, the impact of each of these control tactics on the resistant cultivar also must be defined.   
  
Several definitions have been used to convey the relative level of resistance in a plant. However, the problem of quantifying resistance continues to be a problem influencing farmer acceptance of insect-resistant cultivars. A better way to define resistance levels in agronomically improved resistant cultivars is through quantified comparisons of insect pest damage or plant yield loss of susceptible cultivars. Once insect pest abundance or damage to yield-loss relationships have been determined, economic threshold levels can be determined and combined with factors such as crop value and insect pest control costs to develop dynamic thresholds for use by producers. Dynamic thresholds provide a description of resistance and can reduce crop loss risk because limitations are known and remedial action can be taken when necessary. By using this system to define relative differences in insect pest resistance between cultivars, it may be possible to simply indicate that a resistant cultivar has a higher economic threshold level than a traditional susceptible cultivar.

**Future Possibilities*:***

Much interest in biotechnology relative to developing insect-resistant plants is in methods known collectively as genetic transformation, rDNA methods, or genetic engineering. These methods enable transfer of a resistance gene that could not be transferred by traditional sexual hybridization. As important, however, are evolving molecular genetic techniques that are providing exciting opportunities to better understand the genetic relationship between an insect and a resistant plant. DNA marker technology is currently used to map and identify specific gene structures conferring resistance traits in plants. Understanding the genetics of resistance in plants will provide the knowledge to improve resistance deployment strategies. However, it is becoming evident with regard to plant resistance to insects that it is equally, if not more, important to understand the genetics of the insect attacking the plant. However, regardless of the technology used to develop insect-resistant plants, the technology will have to be used as a component of IPM in the same way traditionally developed insect-resistant plants are used today.

As new technology has begun to be used, there is increasing concern over the likelihood of formation of insect pest biotypes that can overcome resistance. Many factors are associated with the ability of an insect to overcome plant resistance. A popular theory is that resistant plants exert selective pressure for virulent individuals that become predominant types (biotypes). This theory of biotype selection often is related to theories of evolutionary biology. For example, one evolutionary biology theory is that selection by insects causes plant populations to acquire resistance traits, and selection imposed by these resistance traits gives the insect the ability to exploit these plants. The implication is that insects with a long-term association with a host-plant species have the genetic plasticity to overcome defense strategies of the host plant. That is, resistance in plants that evolved with an insect could be susceptible to being overcome by genetic changes in the insect pest.

Theories on gene conservation and management are major subjects of scientific discussion and experimentation. Strategies for preservation of insect resistance in crop varieties include use of multiple resistance genes conferring different causes of resistance, sequential (time and space) deployment of resistance, and maintenance of refugia to support avirulent individuals to mate with virulent individuals in the insect population. Concern over insect biotypes probably will result in much wiser use of genetic opportunities that now are available or will be available in the future. A major mistake would be to attempt to use gene-altered plants as the sole control tactic for an insect pest rather than a component of IPM. To do so would be to repeat the mistakes of the insecticide era.

**BIOLOGICAL CONTROL**

Biological control is a tool to be considered in constructing an integrated pest management scheme for an interior environment. Biological control is a method of pest management in which a naturally occurring disease, parasite, or predatory organism is manipulated to control a pest.

**What is parasite?**

A [parasite](http://student.biology.arizona.edu/honors98/group15/glossary.htm#PARASITE) lives in a close relationship with another organism, its host, and causes it harm.  The parasite is dependent on its host for its life functions.  For example, viruses are common parasites.   The parasite has to be in its host to live, grow, and multiply.   Parasites rarely kill their hosts. A common, well-known type of a parasite is a [hookworm](http://student.biology.arizona.edu/honors98/group15/glossary.htm#HOOKWORM).  It is possible for humans or their pets to get them.  Hookworms attach themselves in the lining of the small intestine, and cause diseases, and malnutrition as well, as they eat the nutrients and keep them from going to the host.

**What is parasitoid?**

A **parasitoid** is an organism that spends a significant portion of its [life history](http://en.wikipedia.org/wiki/Biological_life_cycle) attached to or within a single [host](http://en.wikipedia.org/wiki/Host_(biology)) [organism](http://en.wikipedia.org/wiki/Organism), which it ultimately kills (and often consumes) in the process. Thus they are similar to typical [parasites](http://en.wikipedia.org/wiki/Parasite) except in the certain fate of the host. In a typical parasitic relationship, the parasite and host live side by side without lethal damage to the host. Typically, the parasite takes enough [nutrients](http://en.wikipedia.org/wiki/Nutrient) to thrive without preventing the host from reproducing. In a parasitoid relationship, the host is killed, normally before it can produce offspring. When treated as a form of [parasitism](http://en.wikipedia.org/wiki/Parasitism), the term **necrotroph** is sometimes (though rarely) used.

This type of relationship seems to occur only in organisms that have fast [reproduction](http://en.wikipedia.org/wiki/Reproduction) rates, such as [insects](http://en.wikipedia.org/wiki/Insect) or (rarely) [mites](http://en.wikipedia.org/wiki/Mite). Parasitoids are also often closely [coevolved](http://en.wikipedia.org/wiki/Coevolution) with their hosts.

The term *parasitoid* was coined in 1913 by the German writer O. M. Reuter(and adopted in English by his reviewer, W. M. Wheeler) to describe the strategy in which, during its development, the parasite lives in or on the body of a single host individual, eventually killing that host, the adult parasitoid being free-living.

## Types of parasitoids

**Idiobiont** parasitoids are those that prevent further development of the host after initial parasitization; this typically involves a host life stage that is immobile (e.g., an egg or [pupa](http://en.wikipedia.org/wiki/Pupa)), and almost without exception, they live outside the host.

**Koinobiont** parasitoids allow the host to continue its development and often do not kill or consume the host until the host is about to either pupate or become an adult; this therefore typically involves living within an active, mobile host. Koinobionts can be further subdivided into **endoparasitoids**, which develop inside of the prey, and **ectoparasitoids**, which develop outside the host body, though they are frequently attached or embedded in the host's tissues.

It is not uncommon for a parasitoid itself to serve as the host for another parasitoid's offspring. The latter is commonly termed a **hyperparasite**, but this term is slightly misleading, as both the host *and* the primary parasitoid are killed. A better term is **secondary parasitoid**, or **hyperparasitoid**; most such species known are in the insect order [Hymenoptera](http://en.wikipedia.org/wiki/Hymenoptera).

About 10% of described insect species are parasitoids. There are four insect orders that are particularly renowned for this type of life history. By far, the majority are in the order 1.[Hymenoptera](http://en.wikipedia.org/wiki/Hymenoptera). The largest and best-known group comprises the so-called "Parasitica" within the Hymenopteran suborder [Apocrita](http://en.wikipedia.org/wiki/Apocrita): the largest subgroups of these are the chalcidoid wasps (superfamily [Chalcidoidea](http://en.wikipedia.org/wiki/Chalcidoidea)) and the ichneumon wasps (superfamily [Ichneumonoidea](http://en.wikipedia.org/wiki/Ichneumonoidea)), followed by the [Proctotrupoidea](http://en.wikipedia.org/wiki/Proctotrupoidea) and [Platygastroidea](http://en.wikipedia.org/wiki/Platygastroidea).

2.The flies (order [Diptera](http://en.wikipedia.org/wiki/Diptera)) include several families of parasitoids, the largest of which is the family [Tachinidae](http://en.wikipedia.org/wiki/Tachinidae), and also smaller families such as [Pipunculidae](http://en.wikipedia.org/wiki/Pipunculidae), [Conopidae](http://en.wikipedia.org/wiki/Conopidae), and others.

3 & 4. The other two orders are the "twisted-wing parasites" (order [Strepsiptera](http://en.wikipedia.org/wiki/Strepsiptera)), which is a small group consisting entirely of parasitoids, and the beetles (order [Coleoptera](http://en.wikipedia.org/wiki/Coleoptera)), which includes at least two families, [Ripiphoridae](http://en.wikipedia.org/wiki/Ripiphoridae) and [Rhipiceridae](http://en.wikipedia.org/w/index.php?title=Rhipiceridae&action=edit&redlink=1), that are largely parasitoids, and [rove beetles](http://en.wikipedia.org/wiki/Rove_beetle) (family Staphylinidae) of the genus [*Aleochara*](http://en.wikipedia.org/wiki/Aleochara). Occasional members of other orders can be parasitoids; one of the more remarkable is the [moth](http://en.wikipedia.org/wiki/Moth) family [Epipyropidae](http://en.wikipedia.org/wiki/Epipyropidae), which are ectoparasitoids of [planthoppers](http://en.wikipedia.org/wiki/Planthopper).[Hymenopteran](http://en.wikipedia.org/wiki/Hymenopteran) parasitoids often have unique life cycles. In one family, the [Trigonalidae](http://en.wikipedia.org/wiki/Trigonalidae), the female wasps deposit eggs into small pockets they cut into the edge of leaves with their [ovipositor](http://en.wikipedia.org/wiki/Ovipositor). A caterpillar chewing these leaves may unknowingly swallow some of the eggs, and when they get into the caterpillar's gut, they hatch and burrow through the gut wall and into the body cavity. Later they search the caterpillar's body cavity for other parasitoid larvae, and it is these they attack and feed on. The parasitoid [**Encarsia pergandiella**](http://student.biology.arizona.edu/honors98/group15/glossary.htm#ENCARSIA) is a tiny wasp that lays its eggs in developing [whiteflies](http://student.biology.arizona.edu/honors98/group15/glossary.htm#WHITEFLY).  The wasp larva eventually kills the whitefly, and then emerges as free-living adults. This is why it is said that the wasps are parasitic.

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A **parasitic insect** grows on or feeds off another organism. Adult parasitic insects lay eggs inside or on the surface of a host insect. As the egg develops, it consumes the host. These parasitic organisms are typically limited to a very narrow range of insect pest, and results are not quickly apparent; pests may live much of their lives before dying.

The life cycle of a parasitic insect must coincide closely with that of their host to achieve optimum suppression of the pest. Timing the release of parasites to coincide with increasing damage levels may be tricky, but successful establishment consistently results in pest death. Braconid wasps are parasitic insects that have been used successfully in interiorscape environments.

**General definition of Predator:**

⏺carnivorous animal or destructive organism: a carnivorous animal that hunts, kills, and eats other animals in order to survive, or any other organism that behaves in a similar manner.

⏺Somebody who plunders or destroys: a person, group, company, or state that steals from others or destroys others for gain

⏺Ruthlessly aggressive person: an aggressive, determined, or persistent person

Predator’s synonym: marauder, [killer](http://www.bing.com/Dictionary/search?q=define+killer&form=DTPDIO), slayer, [hunter](http://www.bing.com/Dictionary/search?q=define+hunter&form=DTPDIO), pillager, raider

**Predatory insects** consume a large number of both adult and immature stages of a pest. These organisms feed on a wide range of prey. When the population of one prey declines, they will shift to feeding on an alternate prey species present in the area. Predatory organisms can consume a large number of pests daily and may act quite rapidly. In many instances a significant proportion of pest populations may be controlled by parasites and predators.

The life cycles of predatory insects do not have to coincide with their prey for successful establishment, but unless a population of prey exists, the beneficial organisms will disperse to find prey elsewhere. If predators are released before the pest population builds up, the beneficial insect or mite will starve or disperse.

Examples of predatory insects that have been used in the interiorscape environment include: mealybug destroyers, and predaceous mites. Natural enemies can be manipulated in many ways to control pest insects. Three definitions that are used to describe the manipulation of natural enemies are listed below. All three manipulation techniques can be used in interiorscape biological control pro

**Biological Control Definitions**

**Augmentation:** The periodic release of artificially produced natural enemies to supplement those that occur naturally.

**Conservation:** Managing an environment so that it provides  
the necessary requirements for natural enemies to survive and reproduce.

**Importation:** Introduction and permanent establishment of a naturally occurring enemy into an environment occupied by an insect pest.

**Biological Control Implementation**

Biological control can be an effective, environmentally sound method of managing pests. However, when using natural enemies it may be helpful to consider the following suggestions:

⮚Make sure you identify the pest correctly. All insect pests found in interiorscapes undergo metamorphosis. Larval and pupal forms of insects that undergo complete metamorphosis look entirely different from adult forms.

⮚Determine whether releases of natural enemies are appropriate for your specific situation. For example, if pest populations are already causing damage to plants, it may be advisable to use a pesticide.

⮚Any biological control products should be chosen carefully. The introduction of a beneficial insect, method of release, timing of the release, and number to release should be determined through consultation with a reliable source. Beneficial insects and other living control agents need to be handled and released in careful and specific ways.

⮚Monitor the population of undesirable insects after a release to assess the success of the release. Augmentation may be necessary for effective control.

⮚Once a decision has been made to use biological controls, conservation measures must be followed. Most predators and parasites are susceptible to many pesticides. Once the decision has been reached to use beneficial insects, the use of synthetic pesticides should be used with caution. Likewise, caution must be used when using non-synthetic pesticides. If you will be supplementing releases with the use of least-toxic chemicals such as insecticidal soaps, horticultural oils, pyrethrums, rotenone, or neem extract you need to be aware of the effect these chemicals may have on specific beneficial populations.

**Table 1. Natural Enemies for some Interiorscape Insect Pests**

|  |  |  |  |
| --- | --- | --- | --- |
| **PEST** | **NATURAL ENEMY** | **RATE** | **UNIQUE CHARACTERS** |
| Citrus Mealybug | **Mealybug Destroyer** *(Cryptolaemus  montrouzieri)* ladybeetle | 2-8/yard of foliage every 3-2 weeks, 2-4 times to maintain control | Mealybug destroyer larvae can be confused with mealybug larvae |
| Long-tailed **AND** Citrus Mealybug | **Mealybug Destroyer** *(Cryptolaemus  montrouzieri)* ladybeetle | As above. | Mealybug destroyers need cottony egg mass to lay their eggs in. Long-tailed mealybugs don't produce a cottony mass. |
| Long-tailed Mealybug | **Green Lacewing** *(Chrysoperla spp.)* aphid lions | 2-5/yard every 2 weeks, 2-3 times | Need to release lacewing **larvae.** |
| Spider Mite | **Anblyseius Mites** *(Amblyseius fallacis)* predatory mite | 10-32/yd, every 3-2 wks, 2-4 times. 3-6/yd/month to maintain | Effective under a variety of conditions. Can live on pollen as well as mites. |
| Scale (soft or armored) | **Harmonia** *(Harmonia axyridis)* multicolored Asian ladybeetle; halloween ladybeetle | 1-4/yard of foliage every 3-2 weeks, 2-4 times to start. 1-3/yd/quarter to maintain control | Release of lab-raised Harmonia in interiorscapes will not cause pest problem associated with wild populations of this beetle. |
| Fungus Gnats | **Soil Dwelling Mites** *(Hypoaspis miles)* predator, scavenger mite | 1-4/yard of foliage every 3-2 weeks, 2-4 times to start. 1-3/yd/quarter to maintain control | Will also feed on thrips pupae in the soil. |
| Aphids | **Aphidius** *(Aphidius matricarae)* parasite wasp | 2-8/yd/week, 2-4 times to start. 2-3/yd monthly to maintain control | Shipping as live adults, ready to parasitize aphids. |
|  | **Aphidoletes** *(Aphidoletes aphidomyza)* predatory midge | 2-5/yd every 2-1 weeks, 2-5 times to start. 2-3/yd monthly to maintain control | Drop from plants into soil to  pupate. If soil is not directly  beneath foliage, they will die. |
|  | **Ladybeetles** *Harmonia* **or**  *Hippodamia* | As above. |  |

**Selecting Natural Enemies**

If you decide to use biological control, you should choose your product and supplies carefully, as you would any consumer product. The number and rate of natural enemies to release, as well as the timing and method of application can be determined through consultation with a reliable supplier or your local [Cooperative Extension Service](http://www.ces.ncsu.edu/counties).

Using natural enemies in augmentative biological control will require a bit of experimentation on your part. Professional plant managers are used to experimenting with plant varieties, fertilizers, watering schedules, etc. What works and what doesn't is somewhat dependent on your situation. So, too, for natural enemies!

**Fungus Gnats**

Bacterial and nematode organisms can be readily integrated into a traditional pest management scheme, whereas others require a fairly high level of management. *Bacillus thuringiensis israelensis* and *Steinernema carpocapsae* nematodes suppress dark-winged fungus gnats. Except for *Bacillus thuringiensis* pesticides, the use of biological organisms is usually not compatible with the use of chemical sprays.

It is possible to integrate sprays of soaps and oils with *Encarsia formosa* by timing pesticide applications to coincide with the "black scale stage" of the parasite's development. Also the "brown mummy" stage of aphids infected with Aphytis wasps are resistant to soaps and oils.

**Table 2. Summary of Primary Predators and Parasites of Major Plant Pests**

|  |  |  |  |
| --- | --- | --- | --- |
| **Pest** | **Predator** | **Parasite** | **Comments** |
| Greenhouse Whitefly  (*Trialeurodes vaporariorum*) | None | *Encarsia formosa* | Size of a spider mite, readily available from insectories. |
| Green Peach Aphid  (Myzus persicae) | Various lady beetles. Some results with *Aphidoletes aphidimyza* a predaceous midge larva. | Braconid and Chalcid wasps | The adult midge lays 100-200 tiny orange eggs near the aphid colonies which hatch in two to three days. The larva is orange or red and depending on temperature and food supply, matures in three to five days. |
| Soft Scales  (Coccids) | *Chilocorus nigritus* and *Lindorus lophanthae* (two small lady beetles) | *Metaphycus helvolus,* a tiny black and yellow wasp. | Both beetles will control soft scale and ornamental scale. *Chilocorus nigritus* development time is approximately one month. |
| Twospotted Spider Mite  *(Tetranychus urticae)* | *Phytoseiulus persimilis*  *Typhlodromus occidentalis*  *Amblyseius californicus* | . | Adults can consume 5-20 eggs or mites per day. These mites avoid bright lights.  Tolerates both high and low temperatures. Effective on hairy- leaved plants.  Persists at low prey densities. |

**The Role of Pesticides in IPM**

Pesticides are chemicals that are used to destroy, repel, or otherwise lower pest infestations to protect crops from damage. Insecticides are pesticides used to control insects, herbicides are pesticides used to control weeds, fungicides are pesticides used to control fungi and nematicides are pesticides used to control nematodes.

**Though pesticides pose many potential risks, they also provide the following important advantages and benefits:**

1. Pesticides are readily available and easy to use.   
2. Where resistance is not a problem, pesticides are generally highly effective for controlling pests.   
3. Pesticide treatments can be rapidly implemented as needed with minimal lag time.   
4. Pesticides can be used over large areas to control large populations of pests.   
5. Pesticide treatments are often cost effective, especially if the alternatives require large increases in human labor.   
6. No effective, reliable, non-chemical alternatives are available for many pests and chemical pesticides are the last resort.

Pesticides are used in IPM programs when no effective alternatives are available or alternatives are not sufficient to keep pest populations from reaching damaging levels. The emphasis is to maximize the benefits and advantages that pesticides offer while minimizing any potential risks.

Whenever a pesticide treatment is needed, selection of the chemical should be consistent with the pesticide label. Additional considerations include: effectiveness against the target organism, compatibility with the host plant, effects on  
beneficial organisms, degree of environmental and user safety, and cost. Wherever possible, use a material that is least toxic to humans and other non-target organisms, and is least likely to contaminate ground and surface waters.

**Why Minimize Pesticide Use?**

Several problems and limitations have become apparent by relying solely on pesticides to control pests. Some of the problems include: pest resistance to pesticides; increased costs; toxicity to fish, wildlife, beneficial natural enemies of pests, and other non-target organisms; concerns about human health and safety; ground water contamination; and overall environmental quality.

**Problems with overuse of Pesticides:**

**Pesticide Resistances:**

In an attempt to achieve better or total pest control, resistance problems have increased because pesticides are applied more frequently and at higher dosage rates. These tactics have resulted in increased selection pressure. Naturally resistant individuals in a pest population are able to survive pesticide treatments. The survivors breed and pass on the resistance trait to their offspring. With each passing generation, the pest population becomes more difficult to control  
with the same pesticides as compared with earlier generations. Reducing pesticide use and alternating among classes of pesticides with different modes of action can help to lessen the possibility of pest resistance. Managing pest resistance is very important in helping to prolong the effective life of needed pesticides.

**Toxicity to Natural Enemies and Other Non-target Organisms*:***

Natural enemies of pest species can be very helpful in keeping pest populations at lower levels. These beneficial organisms include organisms that are predators, parasites, or competitors to the detriment of the pest species. For example, aphids do not reach pest levels every year because many different natural enemies help to keep them in check. Unfortunately, many broad-spectrum, non-selective pesticides are more detrimental to numerous beneficial species than to the pests. The use of such pesticides often causes a resurgence in pest populations and at a much faster rate compared to the natural enemies. Without the natural controls, primary (established) and secondary (new) pests are often free to reach damaging levels at faster rates. An increase in pest levels usually results in additional pesticide treatments, which further depresses or eliminates the natural enemies and further encourages the potential for pest resistance. Selecting effective alternatives that are less toxic to non-target organisms, will increase natural enemy survival, and overall effectiveness of pest control.

**Public Health and Environmental concerns:**

The public has become increasingly concerned about the use of pesticides and the possible adverse effects on human health, wildlife, ground water, and overall environmental quality. Pesticide exposure from drift to non-target areas; contamination of ground and surface waters; and residues on food are topics of concern to the general public. Applicators should be especially concerned because they may have the highest potential for exposure and thus, may have the greatest health risks. All applicators must be sensitive to public concerns about pesticide use and apply materials only in a safe and judicious manner

**Cost of Pesticides:**

The cost of developing new pesticides has risen at an increasingly rapid rate. Government regulations and more stringent registration requirements have also slowed the rate of development and increased the costs of new products. Concerns about potential product liability have discouraged companies from introducing new products. Increasing problems with pest resistance have likewise resulted in shorter market lives for many pesticides than in the past. All of these factors result in higher costs and potentially lower profits for chemical companies. In turn, this leads to higher prices for pesticide users. Maintaining the economic viability of agriculture is also one of the goals of Integrated Pest Management.

**Reduced Risk Pesticides**

EPA has established a category of pesticides called “Reduced Risk” pesticides to encourage the development, registration and use of products which could result in reduced risks to human health and the environment. New conventional pesticides are considered for “Reduced Risk” status if they have at least one or more of the following characteristics: low risk to human health, low toxicity to non-target organisms, low potential to contaminate ground water, surface water or other valued environmental resources and have the potential to expand the adoption and effectiveness of IPM.

# Pathogens in Pest Management

# Pathogens are disease-causing organisms including [bacteria](http://en.wikipedia.org/wiki/Bacteria), [fungi](http://en.wikipedia.org/wiki/Fungi), and [viruses](http://en.wikipedia.org/wiki/Viruses). They kill or debilitate their host and are relatively specific to certain insect groups. There are three basic types of biological control strategies; conservation, classical biological control, and augmentation.

In the other words a **pathogen**, (from Greek word pathos means "suffering, passion", and gen means "I give birth to") an **infectious agent**, or more commonly **germ**, is a [biological agent](http://en.wikipedia.org/wiki/Biological_agent) that causes [disease](http://en.wikipedia.org/wiki/Disease) to its [host](http://en.wikipedia.org/wiki/Host_(biology)).There are several substrates and *pathways* whereby pathogens can invade a host; the principal pathways have different episodic time frames, but [soil contamination](http://en.wikipedia.org/wiki/Soil_contamination) has the longest or most persistent potential for harboring a pathogen.

The body contains many natural orders of defense against some of the common pathogens such as [*Pneumocystis*](http://en.wikipedia.org/wiki/Pneumocystis) in the form of the human [immune system](http://en.wikipedia.org/wiki/Immune_system) and some "helpful" [bacteria](http://en.wikipedia.org/wiki/Bacteria) present in the human body. However, if the immune system or "good" bacteria is damaged in any way (such as by [chemotherapy](http://en.wikipedia.org/wiki/Chemotherapy), [human immunodeficiency virus](http://en.wikipedia.org/wiki/HIV) (HIV), or [antibiotics](http://en.wikipedia.org/wiki/Antibiotic) being taken to kill other pathogens) can proliferate and cause harm to the host. Such cases are called [opportunistic infection](http://en.wikipedia.org/wiki/Opportunistic_infection).

Some pathogens (such as the bacterium [*Yersinia pestis*](http://en.wikipedia.org/wiki/Yersinia_pestis), which may have caused the [Black Plague](http://en.wikipedia.org/wiki/Black_Plague), the [*Variola*](http://en.wikipedia.org/wiki/Variola) virus, and the [Malaria](http://en.wikipedia.org/wiki/Malaria) protozoa) have been responsible for massive numbers of casualties and have had numerous effects on afflicted groups. Of particular note in modern times is HIV, which is known to have infected several million humans globally, along with the [Influenza](http://en.wikipedia.org/wiki/Influenza) virus

Not all pathogens are negative. In [entomology](http://en.wikipedia.org/wiki/Entomology), pathogens are one of the "Three P's" ([predators](http://en.wikipedia.org/wiki/Predator), pathogens, and [parasitoids](http://en.wikipedia.org/wiki/Parasitoids)) that serve as natural or introduced [biological controls](http://en.wikipedia.org/wiki/Biological_control) to suppress [arthropod](http://en.wikipedia.org/wiki/Arthropod) [pest](http://en.wikipedia.org/wiki/Pest_(organism)) populations. Virus Bacteria Fungi and many other pathogen may act as a good biological control agent in the field of entomology.

## *Types of pathogen*

## *Viral*

Pathogenic viruses are mainly those of the families of: [Adenoviridae](http://en.wikipedia.org/wiki/Adenoviridae), [Picornaviridae](http://en.wikipedia.org/wiki/Picornaviridae), [Herpesviridae](http://en.wikipedia.org/wiki/Herpesviridae), [Hepadnaviridae](http://en.wikipedia.org/wiki/Hepadnaviridae), [Flaviviridae](http://en.wikipedia.org/wiki/Flaviviridae), [Retroviridae](http://en.wikipedia.org/wiki/Retroviridae), [Orthomyxoviridae](http://en.wikipedia.org/wiki/Orthomyxoviridae), [Paramyxoviridae](http://en.wikipedia.org/wiki/Paramyxoviridae), [Papovaviridae](http://en.wikipedia.org/wiki/Papovaviridae), [Polyomavirus](http://en.wikipedia.org/wiki/Polyomavirus), [Rhabdoviridae](http://en.wikipedia.org/wiki/Rhabdoviridae), [Togaviridae](http://en.wikipedia.org/wiki/Togaviridae). Some notable pathogenic viruses cause: smallpox, influenza, mumps, measles, [chickenpox](http://en.wikipedia.org/wiki/Chickenpox), ebola, and rubella. Viruses typically range between 20-300 nanometers in length.

### Bacterial

Although the vast majority of bacteria are harmless or beneficial, a few pathogenic bacteria can cause infectious diseases. The most common bacterial disease is [tuberculosis](http://en.wikipedia.org/wiki/Tuberculosis), caused by the bacterium [*Mycobacterium tuberculosis*](http://en.wikipedia.org/wiki/Mycobacterium_tuberculosis), which affects about 2 million people mostly in sub-Saharan Africa. Pathogenic bacteria contribute to other globally important diseases, such as [pneumonia](http://en.wikipedia.org/wiki/Pneumonia), which can be caused by bacteria such as [*Streptococcus*](http://en.wikipedia.org/wiki/Streptococcus) and [*Pseudomonas*](http://en.wikipedia.org/wiki/Pseudomonas), and foodborne illnesses, which can be caused by bacteria such as [*Shigella*](http://en.wikipedia.org/wiki/Shigella), [*Campylobacter*](http://en.wikipedia.org/wiki/Campylobacter) and [*Salmonella*](http://en.wikipedia.org/wiki/Salmonella). Pathogenic bacteria also cause infections such as [tetanus](http://en.wikipedia.org/wiki/Tetanus), [typhoid fever](http://en.wikipedia.org/wiki/Typhoid_fever), [diphtheria](http://en.wikipedia.org/wiki/Diphtheria), [syphilis](http://en.wikipedia.org/wiki/Syphilis) and [Hansen's disease](http://en.wikipedia.org/wiki/Hansen%27s_disease). Bacteria can often be killed by antibiotics. They typically range between 1-5 micrometers in length.

### Fungal

Fungi comprise a eukaryotic kingdom of microbes that are usually saprophytes but can cause diseases in humans, animals and plants. Fungi are the most common cause of diseases in crops and other plants. Life threatening fungal infections in humans most often occur in immunocompromised patients or vulnerable people with a weakened immune system, although fungi are common problems in the immunocompetent population as the causative agents of skin, nail or yeast infections. Most antibiotics that function on bacterial pathogens cannot be used to treat fungal infections due to the fact that fungi and their hosts both have eukaryotic cells. Most clinical fungicides belong to the azole group. The typical fungal spore size is 1-40 micrometer in length.

### Other parasites

Some eukaryotic organisms, such as [protists](http://en.wikipedia.org/wiki/Protists) and [helminths](http://en.wikipedia.org/wiki/Helminths), cause disease. One of the best known diseases caused by protists in the genus *Plasmodium* is [malaria](http://en.wikipedia.org/wiki/Malaria).

**Prionic**

Prions are infectious pathogens that do not contain [nucleic acids](http://en.wikipedia.org/wiki/Nucleic_acid). Prions are abnormal proteins whose presence causes some Diseases such as [scrapie](http://en.wikipedia.org/wiki/Scrapie), [bovine spongiform encephalopathy](http://en.wikipedia.org/wiki/Bovine_spongiform_encephalopathy) (mad cow disease) and [Creutzfeldt–Jakob disease](http://en.wikipedia.org/wiki/Creutzfeldt%E2%80%93Jakob_disease).

## *Management of insects with pathogens/ micro-organisms:*

Various [microbial](http://en.wikipedia.org/wiki/Microbial) insect diseases occur naturally, but may also be used as [biological pesticides](http://en.wikipedia.org/wiki/Biological_pesticide). When naturally occurring, these outbreaks are density dependent in that they generally only occur as insect populations become denser.

### Bacteria and biological control

Bacteria used for biological control infect insects via their digestive tracts, so insects with sucking mouth parts like aphids and scale insects are difficult to control with bacterial biological control.[*Bacillus thuringiensis*](http://en.wikipedia.org/wiki/Bacillus_thuringiensis) is the most widely applied species of bacteria used for biological control, with at least four sub-species used to control [Lepidopteran](http://en.wikipedia.org/wiki/Lepidoptera) ([moth](http://en.wikipedia.org/wiki/Moth), [butterfly](http://en.wikipedia.org/wiki/Butterfly)), [Coleopteran](http://en.wikipedia.org/wiki/Coleoptera) (beetle) and [Dipteran](http://en.wikipedia.org/wiki/Diptera) (true flies) insect pests.

### Fungi and biological control

Fungi that cause disease in insects are known as [entomopathogenic fungi](http://en.wikipedia.org/wiki/Entomopathogenic_fungi), including at least fourteen species of entomophthoraceous fungi attack aphids.Species in the genus [*Trichoderma*](http://en.wikipedia.org/wiki/Trichoderma) are used to manage some soilborne plant pathogens. [*Beauveria bassiana*](http://en.wikipedia.org/wiki/Beauveria_bassiana) is used to manage different types of pest such whiteflies, thrips, aphids and weevils.

Examples of [entomopathogenic fungi](http://en.wikipedia.org/wiki/Entomopathogenic_fungi):

* [*Beauveria bassiana*](http://en.wikipedia.org/wiki/Beauveria_bassiana) (against white flies, [thrips](http://en.wikipedia.org/wiki/Thrip), aphids and weevils)
* [*Paecilomyces fumosoroseus*](http://en.wikipedia.org/w/index.php?title=Paecilomyces_fumosoroseus&action=edit&redlink=1) (against white flies, [thrips](http://en.wikipedia.org/wiki/Thrip) and aphids)
* [*Metarhizium anisopliae*](http://en.wikipedia.org/wiki/Metarhizium_anisopliae) (against spider mites)[[8]](http://en.wikipedia.org/wiki/Biological_pest_control#cite_note-7#cite_note-7)
* [*Verticillium lecanii*](http://en.wikipedia.org/wiki/Verticillium_lecanii)

*Bacillus thuringiensis (Bt)*. Bt is an effective control for many types of butterfly and moth larvae including some, such as cabbage loopers, which are hard to control by other means. Bt products are generally considered safe for people, bees, predatory and parasitic insects, predatory mites and spiders, and the environment in general. These products are usually exempt from residue tolerance restrictions, days-to-harvest restrictions, and re-entry restrictions.

Commercial Bt products are prepared from either *Bacillus thuringiensis* var.

or *Bacillus thuringiensis* var. *azawa*, but various genetically manipulated strains of Bt are also available. Below is a summary of some of the available Bt products. All these bacteria produce crystalline spores and proteins. Caterpillars that eat these die within 2 to 5 days because of toxins released when the spores and protein crystals are dissolved by digestion in the insect midgut. Caterpillars stop eating within minutes after ingesting the Bt so they must receive a lethal dose within a few bites.

**Summary of Bt products generally available** :

|  |  |  |  |
| --- | --- | --- | --- |
| **Bt Strain** | **Name** | **Pest controlled** | **Producer** |
| **kurstaki** | **Biobit** | **Lepidopterous larvae** | **Dupont** |
| **kurstaki** | **Dipel** | **Lepidopterous larvae** | **Abbott** |
| **kurstaki** | **Javelin** | **Lepidopterous larvae** | **Sandoz** |
| **kurstaki** | **Cutlass** | **Lepidopterous larvae** | **Ecogen** |
| **kurstaki** | **Cutlass** | **esp. diamondback moth** | **Ecogen** |
| **kurstaki** | **Foil** | **esp. diamondback moth** | **Ecogen** |
| **kurstaki** | **Foil** | **esp. Col. potato beetle** | **Ecogen** |
| **kurstaki** | **Foil** | **some Euro. corn borer** | **Ecogen** |
| **kurstaki** | **Foil** | **diamondback moth** | **Mycogen** |
| **san diego** | **M-Trak** | **Col. potato beetle** | **Mycogen** |
| **tennebrionis** | **TridentII** | **Col. potato beetle** | **Sandoz** |
| **tennebrionis** | **Novodor** | **Col. potato beetle** | **Novo Nordisk** |
| **azawa** | **Xentari** | **diamondback moth** | **Abbott** |
| **azawa** | **Agree** | **diamondback moth** | **Ciba-Geigy** |
| **israelensis** | **Gnatrol** | **fungus gnats** | **Abbott** |

Caterpillars controlled by Bt include European corn borer (on corn), cabbage looper, imported cabbageworm, diamondback moth, and tomato/tobacco hornworm. Corn earworm on tomato and pepper is controlled with Bt, but corn earworm on corn and the squash vine borer are not controlled since larvae do not feed long enough on the plant surface to be reached by Bt sprays. Due to increased industry emphasis, improved Bt products are being developed which work on insects other than butterfly and moth larvae. *Bacillus thuringiensis* var. *israelensis* kills larvae of mosquito, black flies, and fungus gnats but requires community-wide application for greatest effectiveness. *Bacillus thuringiensis* var. *san diego* controls young Colorado potato beetle larvae. M-Trak® is a type of Bt var. *san diego* that is encapsulated in killed bacteria cell (Pseudomonas fluorescens). It is only active against first and second instar larvae of the Colorado potato beetle and some beetle pests of trees. Applications need to be repeated and M-Trak® is washed off by rain.

Bt works best when applied to young caterpillars less than ½ inch long, and it is only effective for one or two days after application. Since it is deactivated by sunlight, spraying in late afternoon or evening or on cloudy days is most effective. Alkaline water (pH of 7.8) or acid water will also deactivate the crystals. Repeat applications every three to five days are necessary, especially when there are lots of caterpillars present. The toxin is not spread by infected caterpillars, and the bacteria do not multiply on their own. Good coverage of leaf tissue is essential. Bt should not be applied through irrigation systems, nor is it compatible with oils, sulfur, copper fungicides, or malathion. In fact, it is recommended that Bt not be mixed with any other insecticides since this encourages the development of multiple insecticide resistant insects. If plants are stressed by high temperature, too much or too little water, or high light following overcast conditions, application of Bt, like most sprays, can damage the foliage.

Insects may develop resistance to Bt as they have with so many other insecticides. Resistance to Bt has been found in Colorado potato beetle in the lab but not yet in the field. Resistance to Bt has been found in diamondback moth in Hawaii, Texas, Florida and on transplants raised in Florida. Newer Bt products, contain a different type of crystals produced by another Bt strain, Bt var. *azawa*, rather than the commonly used var. *kurstaki*. At this point, the diamondback moth is not resistant to the azawa strain. There are over 2000 other strains of Bt available, plus genetically altered strains to be used in future formulations. Development of resistances to particular strains, or even cross-resistances, are hard to predict, however, especially if the ability to synthesize Bt toxins is widely incorporated into crop plants, as is being proposed. Some argue, however, argues that transgenic plants will not only be more effective than sprays in protecting plants, but will delay resistance buildup. Dependence on Bt or any other material should supplement rather than replace other aspects of an IPM program. Improved Bts and transgenic plants have the potential advantages of improved efficacy, speed of kill, broader host range and increased residuals.

*Nosema locustae. Nosema locustae* is a protozoan that will control crickets and the Melanoplus group of grasshoppers. Most effective if applied early and over large areas, Nosema is commercially available in a wheat bran formulation. Grasshoppers die after feeding on Nosema-laced wheat bran spread as bait or after feeding on their own dead. There is some Nosema carryover the next year.

*Paecilomyces fumorosoroseus*. The fungi *Paecilomyces fumorosoroseus* (PFR) has been used to control the silverleaf whitefly.

⮳*A* ***microorganism*** *also spelled* ***micro organism*** *or* ***micro-organism*** *or* ***microbe*** *is an* [*organism*](http://en.wikipedia.org/wiki/Organism) *that is* [*microscopic*](http://en.wikipedia.org/wiki/Microscopic) *. Microorganisms are very diverse; they include* [*bacteria*](http://en.wikipedia.org/wiki/Bacteria)*,* [*fungi*](http://en.wikipedia.org/wiki/Fungi)*,* [*archaea*](http://en.wikipedia.org/wiki/Archaea)*, and* [*protists*](http://en.wikipedia.org/wiki/Protist)*; microscopic* [*plants*](http://en.wikipedia.org/wiki/Plants) *(*[*green algae*](http://en.wikipedia.org/wiki/Green_algae)*); and* [*animals*](http://en.wikipedia.org/wiki/Micro-animals) *such as* [*plankton*](http://en.wikipedia.org/wiki/Plankton) *and the* [*planarian*](http://en.wikipedia.org/wiki/Planarian)*. Some microbiologists also include* [*viruses*](http://en.wikipedia.org/wiki/Virus)*, but others consider these as non-living.Most microorganisms are unicellular (single-celled), but this is not universal, since some* [*multicellular*](http://en.wikipedia.org/wiki/Multicellular) *organisms are* [*microscopic*](http://en.wikipedia.org/wiki/Microscopic)*, while some unicellular protists and bacteria, like* [*Thiomargarita namibiensis*](http://en.wikipedia.org/wiki/Thiomargarita_namibiensis)*, are* [*macroscopic*](http://en.wikipedia.org/wiki/Macroscopic) *and visible to the naked eye.Microorganisms live in all parts of the* [*biosphere*](http://en.wikipedia.org/wiki/Biosphere) *where there is liquid* [*water*](http://en.wikipedia.org/wiki/Water)*, including* [*soil*](http://en.wikipedia.org/wiki/Soil)*,* [*hot springs*](http://en.wikipedia.org/wiki/Hot_spring)*, on the* [*ocean*](http://en.wikipedia.org/wiki/Ocean) *floor, high in the* [*atmosphere*](http://en.wikipedia.org/wiki/Atmosphere) *and deep inside rocks within the Earth's* [*crust*](http://en.wikipedia.org/wiki/Crust)*. Microorganisms are critical to nutrient recycling in* [*ecosystems*](http://en.wikipedia.org/wiki/Ecosystems) *as they act as* [*decomposers*](http://en.wikipedia.org/wiki/Decomposer)*. As some microorganisms can* [*fix nitrogen*](http://en.wikipedia.org/wiki/Nitrogen_fixation)*, they are a vital part of the* [*nitrogen cycle*](http://en.wikipedia.org/wiki/Nitrogen_cycle)*, and recent studies indicate that airborne microbes may play a role in* [*precipitation*](http://en.wikipedia.org/wiki/Precipitation_(meteorology)) *and* weather.

⮳*Biopesticides, key components of integrated pest management (IPM) programs, are receiving much practical attention as a means to reduce the load of synthetic chemical products being used to control plant diseases. In most cropping systems, biopesticides should not necessarily be viewed as wholesale replacements for chemical control of plant diseases, but rather as a growing category of efficacious supplements that can be used as rotation agents to retard the onset of resistance to chemical pesticides and improve sustainability. In organic cropping systems, biopesticides can represent valuable tools that further supplement the rich collection of cultural practices that ensure against crop loss to diseases. Biopesticides for use against crop diseases have already established themselves on a variety of crops. For example, biopesticides already play an important role in controlling downy mildew diseases. Their benefits include: a 0-Day PreHarvest Interval, the ability to use under moderate to severe disease pressure, and the ability to use as a tank mix or in a rotational program with other registered fungicides. Because some market studies estimate that as much as 20% of global fungicide sales are directed at downy mildew diseases, the integration of biofungicides into grape production has substantial benefits in terms of extending the useful life of other fungicides, especially those in the reduced-risk category..A major growth area for biopesticides is in the area of seed treatments and soil amendments. Fungicidal and biofungicidal seed treatments are used to control soil borne fungal pathogens that cause seed rots, damping-off, root rot and seedling blights. They can also be used to control internal seed–borne fungal pathogens as well as fungal pathogens that are on the surface of the seed. Many biofungicidal products also show capacities to stimulate plant host defenses and other physiological processes that can make treated crops more resistant to a variety of biotic and abiotic stresses..The Manual of Biocontrol Agents*[*[1]*](http://en.wikipedia.org/wiki/Biological_pesticide#cite_note-0#cite_note-0) *gives a review of the available biological insecticide (and other biology-based control) products. In order to implement these environmentally-friendly pest control agents, it is often especially important to pay attention to their* [*formulation*](http://en.wikipedia.org/wiki/Pesticide_formulation)[*[2]*](http://en.wikipedia.org/wiki/Biological_pesticide#cite_note-1#cite_note-1) *and* [*application*](http://en.wikipedia.org/wiki/Pesticide_application)*. One well-known insecticide example is* [*Bacillus thuringiensis*](http://en.wikipedia.org/wiki/Bacillus_thuringiensis)*, a bacterial disease of* [*Lepidoptera*](http://en.wikipedia.org/wiki/Lepidoptera)*,* [*Coleoptera*](http://en.wikipedia.org/wiki/Coleoptera) *and* [*Diptera*](http://en.wikipedia.org/wiki/Diptera)*. Because it has little effect on other* [*organisms*](http://en.wikipedia.org/wiki/Organism)*, it is considered more* [*environmentally friendly*](http://en.wikipedia.org/wiki/Environmentally_friendly) *than synthetic pesticides. The toxin from* [*Bacillus thuringiensis*](http://en.wikipedia.org/wiki/Bacillus_thuringiensis) *(*[*Bt toxin*](http://en.wikipedia.org/wiki/Bt_toxin)*) has been incorporated directly into plants through the use of* [*genetic engineering*](http://en.wikipedia.org/wiki/Genetic_engineering)*..Biological* [*insecticides*](http://en.wikipedia.org/wiki/Insecticides) *include products based on:*[*entomopathogenic fungi*](http://en.wikipedia.org/wiki/Entomopathogenic_fungi) *(e.g.*[*Beauveria bassiana*](http://en.wikipedia.org/wiki/Beauveria_bassiana)*,* [*Metarhizium anisopliae*](http://en.wikipedia.org/wiki/Metarhizium_anisopliae)*),* [*entomopathogenic nematodes*](http://en.wikipedia.org/wiki/Entomopathogenic_nematode) *(e.g. Steinernema feltiae) and entomopathogenic* [*viruses*](http://en.wikipedia.org/wiki/Virus#Applications) *(e.g.. Cydia pomonella granuloviru..*

**Analysis in pest Management**

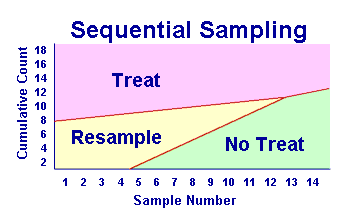
Simple, descriptive statistics are essential for interpreting data collected in any replicated sampling scheme.   Regardless of how data is gathered, whether as continuous measurements (e.g., leaf area consumed), in the form of numerical counts (e.g., number of beetles per plant), as ordinal ratings (e.g., on a scale from 1 to 10), or in binomial form (e.g., presence/absence), there is always some degree of uncertainty about its accuracy.   Statisticians call this uncertainty **"variance"**.   It arises both from **experimental error** (inability to precisely replicate all conditions in each sample) and from the **natural variability** that is a characteristic of all biological systems (e.g., the number of leafhoppers collected in 25 sweeps at dawn may be quite different from a similar sample taken that evening in the same field).   Good sampling strategies are designed to minimize variance in order to give the most reasonable "estimate" of population size.

The mean, variance, and standard error are the calculations most commonly used to evaluate sampling results.   The mean is simply an arithmetic average of data values.   It is one of several ways to describe a range of numbers.   The variance (sum of squared deviations from the mean divided by number of observations), and the standard error (square root of the variance divided by the mean) are measures of how far the other data values tend to stray from the mean.

**Sequential Sampling**

Although it is fairly easy to sample for some insects, many pest management systems utilize sampling protocols that are fairly time consuming and labor intensive.   Whenever large numbers of samples are needed to achieve an adequate level of confidence, it may be possible to use a sequential sampling system that saves time and effort by concentrating mostly on populations that are closest to the economic threshold.   Sequential sampling systems are relatively new in pest management, but they are based on well-established rules for determining confidence intervals for sample data.

Unlike regular sampling protocols that require a fixed number of replications (usually 10-100), sequential sampling systems are designed to evaluate the data at the end of each sampling step.   The total number of samples is variable, depending upon whether the cumulative data falls inside or outside of predetermined confidence intervals.   Relatively few samples would be needed to recognize that a population is very small (well below the economic threshold) or very large (well above the economic threshold).   But a larger number of samples (higher confidence) would be needed to decide whether an intermediate population should be treated or not treated.



In most sequential sampling systems, there are three different outcomes possible at the end of each sampling step:

1. If the cumulative total of pests exceeds an upper threshold value, then conclude that the population is large enough to warrant control actions.   Stop sampling and prepare to enact control measures.
2. If the cumulative total of pests is beneath a lower threshold value, then conclude that the population is small and warrants no control actions.   Stop sampling (at least for awhile) and leave the population untreated.
3. If the cumulative total of pests is between the upper and lower threshold values, then no conclusion is possible yet.   Sampling should continue until cumulative values reach the upper or lower threshold.

**Modeling in Pest Management**

**Pest causes grossly:**

⏵Damage the crops.

⏵One third crop losses due to pest attack.

**Current pest control methods:**

⏵Mainly chemical control.

**Disadvantages of Chemical control:**

1. Pest Resistance
2. Non-selective
3. Pest resurgence
4. Environmental pollution

**Role of Integrated Pest Management(IPM) research:**

“The goal of IPM research is to design systems for controlling pest damage that are appropriate for the site while reducing reliance on chemical pesticides.”

-USDA

**Mathematical modeling:**

⏵ Optimize Chemical control.

⏵ Schedule pest application.

⏵Release sterile male.

⏵ Predict pest population.

⏵Crop system design.

**Crop System Design**: Lotka-Volterra

**Functional Response:**

b=time predator takes to handle prey

G(h)=average number of prey eaten in a random patch

S(h)=average amount of time spent search in a random patch

f(h)/h=risk each prey has of being eaten

Conclusion of crop system design:

⏵Mathematical design offers a wide variety of tools.

⏵Mostly theoretical.

⏵unlikely general theory created.

⏵Each problem requires in depth study.

⏵Used increasingly in the future as pesticide use becomes limited.

**Present status & Future of IPM in Bangladesh**

Agriculture is the backbone of Bangladesh economy, which contributes about one third to thecountry’s gross domestic product (GDP). Approximately 84 percent of the country's total population is directly or indirectly dependent on agriculture for their livelihood. About 63 percent of the labour force is employed in agriculture sector of which about 57 percent is engaged in the crop sub-sector alone.

One of the main constraints to increasing agricultural production in Bangladesh is the insect pests, diseases, rodents and other vertebrate pests that cause serious yield loss. A conservative estimate puts the annual loss of rice yield due to the above pests at 10 -15%. In Bangladesh, chemical control has been the primary method of pest control in the past. Over dependence on synthetic pesticides, in the endeavour to control the pests and diseases, is not only expensive but also leads to negative environmental consequences in addition to increased health hazards to the growers and consumers of crop products. Although there has been an increase in the food grain production in recent year, the country has to further increase its good grain production on a sustainable basis to feed the population.

Thus, considering the facts that (a) Bangladesh needs to increase its food production on a

sustainable basis, (b) pests and diseases continue to cause serious crop losses, (c) the use of pesticides is the main means of pest management, and d) continued reliance on chemicals for pest control would lead to serious environmental and human health problems, pest resurgence, new pest problems etc., there is a need for an alternative method rather than to rely solely on pesticides. The Integrated Pest Management (IPM) has now been considered as the most appropriate one in this respect.

In Bangladesh, IPM started in rice in 1981 on a small scale. In 1989 some thrust was given on IPM through FAO’s Inter-Country Program. Based on the success of FAO Inter-country Program, and also to provide IPM training to more field level agricultural extension workers of the Government, NGO personnel and farmers, two projects–Integrated Pest Management project [funded by UNDP] and Strengthening Plant Protection Services (SPPS) project [funded by DANIDA] started in 1996 and 1997 respectively. Both the projects are being executed by the Department of Agricultural Extension (DAE). IPM has also become a  component of Command Area Development project funded by Asian Development Bank (ADB). The executing agency of this project is Water Development Board, but the IPM component is being executed by DAE. NGOs like CARE Bangladesh and AID–Comilla have also started their program on IPM. All these projects are mainly working on rice IPM except that the SPPS project is working both on rice and vegetable IPM. The emphasis on vegetable IPM is progressively increasing. Of late CARE also has started work on vegetable IPM.

**Organization and Funding Arrangements:**

In Bangladesh, IPM activities first started in 1981 with the introduction of the first phase of FAO’s inter-country programme (ICP) on IPM in rice crop. However, it was in 1987 that IPM activities began to expand and became a popular topic among people from all walks of life. From 1989 to 1995, the ICP played a strong catalytic role in promoting the IPM concept and approach among the government officials and donor community. This programme provided IPM training to build the training capacity of the Department of Agricultural Extension (DAE) and introduced Farmer Field Schools (FFS) for training of farmers. A number of persons from the non-government organizations (NGOs) were also given training on IPM. As a result of the success of this programme and on the basis of the need for IPM in Bangladesh, a number of IPM projects in rice and vegetables have started. At present there are eight-IPM projects/programmes operating in Bangladesh. These projects are being implemented either by the Government or NGOs with funds received from different donors.The projects are now in operation listed below:

1. DAE-UNDP/FAO IPM Project (BGD/95/003)

2. DAE-DANIDA Strengthening Plant Protection Services (SPPS) Project

3. Command Area Development Project(CAD)

4. CARE-New Options for Pest Management (NOPEST)

5. CARE-Integrated Rice & Fish Project (INTERFISH)

6. AID-Comilla's Integrated Pest Management Project

7. USAID funded IPM Collaborative Research Support Programme (IPM CRSP)

8. FAO's Regional Cotton IPM Project

Of these projects / Programmes, the IPM CRSP is the only IPM research project in Bangladesh and its major research emphasis is on vegetables. The other IPM projects arenextension oriented and their major emphasis is given to develop the IPM trainers through the Season-Long Training of Trainers (SLTOT) and these trainers impart training to farmers through Farmer Field Schools. They follow a set of curriculum for SLTOT and also for FFS.

**A brief description of these projects are given below:**

**DAE-UNDP/FAO IPM Project:** The DAE-UNDP/FAO IPM Project (BGD/95/003) started functioning from May 1996 and funded by UNDP with technical assistance from FAO. The project is solely working on rice IPM. The Government of Bangladesh (GOB) has also contributed to the project. It is a nationally executed project of UNDP. The National Project Director (NPD) is the coordinator of the project. There were one expatriate IPM Advisor/Team Leader and 4 national experts (with different level of efforts) working in the project. All of them have left the project after the completion of their assignment except the IPM training expert. One admin./accounts assistant one secretary and two computer operators are also working. In addition there were 26 Master Trainers but they were available only during Season Long Training of Trainers (TOT). The project has two main objectives as follows:

a) to develop the capacity of DAE and selected NGOs to undertake effective IPMbtraining in an initial 122 selected upazilas of 41 districts, and

b) to develop a National IPM Policy and a National IPM Program Framework supported by a medium-term action plan to promote and facilitate expansion of IPM activities nationwide. The project will be ending in December this year. The project is considered as one of the most successful projects funded by UNDP in Bangladesh. Its both physical & technical progress are found to be very satisfactory. The project has made remarkable progress in building up the capacity of DAE in providing IPM training by producing a large number of DAE and farmer trainers. Besides, it has provided direct training to farmers, introduced community IPM concept in Bangladesh, which serves as a model to other projects in the country. Though the variety of activities the project has created a great awareness on IPM in the country. The project has also developed a draft IPM policy and a national IPM framework. Thus, the project has played a leading role in the building up a strong IPM base in Bangladesh.

**Strengthening Plant Protection Services (SPPS) Project:** Strengthening Plant Protection Services (SPPS) Project funded by DANIDA and GOB started functioning from July, 1997. The project administration is controlled by the Project Director (PD). This project has one Chief Technical Adviser (CTA), one expatriate training expert, one local training expert, 10 full time master trainers and about 109 other Departmental Officers & Staff are involved with this project. The project has five components:

1. Integrated Pest Management (IPM) in Rice and Vegetables,

2. Pest Surveillance, Forecasting and Early Warning System,

3. Pesticide Administration and Quality Control,

4. Pest Management Practices that are Compatible with IPM, and

5. Strengthening Plant Quarantine Services (Supported only by GoB Contribution)

In relation to IPM, the SPPS project has three main objectives:

1. to develop the capacity within Bangladesh to undertake effective IPM training in an initial 137 upazilas of 47 districts,

2. to support DAE-UNDP/FAO IPM Project to develop a National Policy and National

Program Framework on Integrated Pest Management, and

3. to develop the capacity of DAE to deal with pest Problems in a manner compatible with IPM practices.

**Command Area Development Project:** Under the Command Area Development Project one upazila of Chandpur district and three upazilas of Pabna district was selected for IPM activities funded by ADB. This Project was functioning from October 1997 and ended on September 2000. A total of 115 DAE officials, 10 officials of Bangladesh Water Development Board (BWDB) and 5 staffs of NGO have been given season long ToT course.Through FFSs this Project has given direct training to 9000 farmers and IPM exposure to 90000 farmers by field day.

**CARE Bangladesh:** Through the joint effort of DAE and FAO-ICP, 156 officers of CARE received training on IPM. These trained personnel are engaged in establishing FFS in their working places. Currently CARE Bangladesh is working on two projects on rice IPM and these are the Integrated Rice and Fish Project (INTERFISH) and the New Options of Pest Management (NOPEST). INTERFISH began in July 1993 and NOPEST in July 1995. INTERFISH is funded by the ODA and NOPEST by the EC. These projects are being implemented with several hundreds of FFS groups in Rangpur, Jessore, Naogaon, Bogra, Comilla, Sherpur, Kishoreganj, Mymensingh and Rajshahi districts. The overall goal of these projects initiative to increase the productivity of the rice field by improving the decision making ability of the farmers. A total of 240500 rice farmers have been targeted to participate in these projects.

**AID Comilla**: A local NGO has also started working on IPM from June 1999 in 9 upazilas of Noakhali, Feni, and Laxmipur districts. It is funded by DANIDA. The target of the project is to establish 288 FFS and train 8640 farmers on rice IPM.

C**ollaborative Research Support Project (CRSP):** This is a research project funded by

USAID through Virginia Poly Tech, USA, and working in collaboration with the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Agricultural Research Council (BARC). The project coordinator is attached with the Horticultural Centre (HRC) at BARI, Gazipur. The major emphasis of the project is on vegetable IPM.

**FAO' Regional Cotton IPM Project:** An IPM Programme has been under taken on Cotton from July 2000 executed by Cotton Development Board funded by European Commission and technical support will be rendered by FAO. The curriculum development workshop was held in June 2001. The first ToT programme has been started from July 2001 for seven months duration. Through this project 400 FFSs will be established and 20000 farmers will be trained.

**Training Achievements:**

The achievement of training given in this report is mainly of three IPM Projects (DAEUNDP/ FAO IPM Project, DAE-DANIDA SPPS Project and CAD Project) implemented byDAE. A total of 1252 DAE field level staff have been trained through season long training and 119 NGO people also received season long training from these three projects. Project wise season long training target and achievement, are shown in table 1a, 1b and 1c. Till date the DAE field level trained personnel have been able to establish 8043 farmers field schools in 263 upazilas of 64 districts from which 202762 farmers received direct training in IPM and 1802786 farmers were given exposure to IPM through field days. The details of FFS and farmers training under the three projects are given in table 2a, 2b &2c.

Table 1a. **Season Long Training in Rice IPM by DAE UNDP/FAO IPM Project (BGD/95/003).**

|  |  |  |
| --- | --- | --- |
| Category | Target | Achievement  as of November 2001 |
| SMO/AEO | 120 | 134\* |
| JAEO | 40 | 36 |
| PPI | 120 | 105 |
| BS | 200 | 236 |
| Total | 480 | 511 |
| NGO | 120 | 39 |

**\*Includes 11 SMOs trained in vegetable IPM**

Table 1b. **Season Long Training in Rice IPM under SPPS Project**

|  |  |  |
| --- | --- | --- |
| **Category** | **Target** | **Achievement(To date)** |
| AEO/AAO | 120 | 127 |
| PPI | 120 | 126 |
| BS | 340 | 358 |
| Other DAE Staffs | - | 15 |
| Total | 580 | 626 |
| NGO | 120 | 75 |

Table 1c. **Season Long Training in Rice IPM under CAD Project**

|  |  |  |
| --- | --- | --- |
| Category | Target | Achievement |
| SMO/AEO | 8 | 6 |
| AAEO | 4 | 2 |
| JAEO | 4 | 3 |
| PPI | 4 | 4 |
| BS | 95 | 100 |
| Total | 115 | 115 |
| NGO | 5 | 5 |
| BWDB | 10 | 10 |

Table 2a. **IPM Training to Farmers through Farmers Field School (FFS) by DAE-UNDP/FAOP IPM Project (BGD/95/003)**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Target**  **upto June 2000** | **Achievement**  **As Of November 2001** |
| **FFS** | **3200** | **3914** |
| **Direct Training of Farmers** | **80,000** | **97,850** |
| **Farmers exposed to IPM** | **6,40,000** | **6,73,400** |

Table 2b. **IPM Training to Farmers through Farmers Field School (FFS)Under SPPS Project**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Particulars | Crop | Target | Achievement  (To date) | Current  Activities | Future  Plan |
| FFS | Rice | 3200 | 2443 | 622  (T.Aman/01) | 350  (Boro/02) |
| Direct training to farmers | Rice | 80000 | 61075 | 15700 | 8750 |
| farmers exposure to IPM | Rice | 800000 | 678454 | 157000 | 87500 |

Table 2c. **IPM Training to Farmers through Farmers Field School (FFS)Under CAD Project**

|  |  |  |
| --- | --- | --- |
| Particulars | Target | Achievement |
| FFS | 300 | 300 |
| Direct training to farmers | 9000 | 9000 |
| Farmers exposure to IPM | 90000 | 90000 |

In addition to IPM activities in rice, the FAO inter-country program and SPPS project are also working on vegetable IPM in Bangladesh. The vegetable IPM activities conducted in Bangladesh since the commencement of FAO Intercountry Program in South and Southeast Asia (Vegetable IPM-CP) fall under eight headings:

Curriculum Development Workshop (2)

Training of Trainers course (2)

Farmers Field Schools (59 by DAE-UNDP/FAO and 758 by DAE-DANIDA)

Field Studies (Two series in Jessore)

Support for CARE, DANIDA and UNDP IPM program

Special IPM Workshops

Capacity Building within the DAE

Study Tours

The FAO inter-country vegetable IPM program conducted two TOTs on vegetables and a total of 62 DAE staff and 2 NGO staff received Season Long Training on Vegetable IPM. Till to date the SPPS project established 758 FFSs on vegetable and 19139 farmers received direct training on vegetable IPM through the FFS (Table 3 and 4). DAE-UNDP/FAO IPM Project also established 59 FFS on vegetable IPM in 11 upazilas

Table 3. **Season Long Training in Vegetable IPM under in-country IPM program**

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Target** | **Achievement**  **until May 99** | **Future Plan** |
| DAE STAFF**/**SMO | **62** | **62** |  |
| **NGO** | **2** | **2** |  |

Table 4. **Season Long Training in Vegetable IPM Training to Farmers through Farmers Field School under SPPS Project**

|  |  |  |  |
| --- | --- | --- | --- |
| **Particulars** | **Target** | **Achievement**  **till to date** | **Current**  **Activities** |
| FFS | **1000** | **758** | 272(Winter 2001) |
| DIRECT TRAINING TO  FARMERS | 25000 | 19139 | 6800 |
| FARMERS EXPOSURE TO IPM THROUGH FIELD DAY | 250000 | 203932 | 68000 |

**Impact on IPM Training:**

The impact of the IPM training to farmers for DAE-UNDP/FAO IPM Project was assessed by the Planning and Evaluation wing of DAE. The findings showed that the knowledge on rice pests, parasites and predators of these rice pests, rice ecosystem, effective pest management practices, adverse effects of pesticides on health and environment, and farmers ability to take crop management decisions have increased tremendously among the trained farmers. It also revealed that the IPM trained farmers have reduced their pesticide use by 86%, which reduces the cost of pest management.

**Policy Developments:**

At present a number of IPM projects are underway in Bangladesh. Since many agencies and projects are actively involved in IPM and more IPM programs covering a range of agricultural crops are forthcoming, a National IPM Policy needs to be developed and strategies for the coordination of IPM activities have to be worked out.In the meantime, IPM has created much awareness among the farmers, Policy makers,Politicians and the general public in the country. As a result, the Government of Bangladesh is giving due importance to IPM, which has been reflected in the Fifth-Five Year Plan and also in the National Agricultural Policy (NAP). The Government is actively considering to formulate a National IPM Policy. The goal of the Policy is *"to enable farmers to grow* *healthy crops in an increased manner and thereby increase their income on a sustainable* *basis while improving the environment and community health."* A draft IPM Policy has been prepared jointly by the DAE-UNDP/FAO IPM Project and DAE-DANIDA's SPPS Project. Several working groups were formed for the draft policy. A national workshop was also organized to discuss on the draft policy. The draft policy is now with the Ministry of Agriculture for the approval of the Government of Bangladesh.

**Developments in Community IPM:**

Over the last decade, there has been a significant shift in the emphasis of IPM programmesthroughout Asia, towards a more participatory, decentralized, community-based approach,termed as community IPM in which the farmers become the initiators, implementers and promoters of IPM and not just the recipients. In community IPM, farmers organize, manage and implement their own IPM activities, analyze problems, design field studies and carry out experiments and undertake efficient farming practices.By producing a significant number of IPM trainers from DAE and by creating great awareness on IPM, the project has helped to lay a solid foundation for IPM in Bangladesh. It is now the right time to begin to concentrate on the matters related to expansion and sustainability of IPM. To this effect, both the DAE implemented projects have been giving emphasis upon community IPM. These project have already started several IPM training activities related to community IPM some of which are described below : **Farmer-Farmer Training:** Farmer-Farmer training is considered to be a cost effective, decentralized, community based, farmer first approach that will promote sustainability and expansion of IPM. It will help strengthen the interaction between farmers, the DAE trained field staff and NGOs and set a stage for the continuation of IPM activities beyond the present phase of the project.

In order to train the farmers to become farmer-trainers (FTs), the projects, taking into consideration of the Bangladesh conditions, designed a training programme, conducted curriculum development workshops and FT-TOTs. The projects have already produced 829 farmer trainers. These trainers are currently running FT-FFS.

**IPM in Schools:** Student Field School (SFS) is viewed as a means to promote lateral spread of IPM knowledge from the school children to their families and ultimately to the community.The SFS participating students are learning the integrated crop management practices through practically doing in the field. They can easily identify Bandhu (friendly insects) and Shatru Poka (pests of crops) in the rice field. Also they know the biology of major insect pests, the damage symptom caused by pests, predation and parasitization and about the agro-ecosystem analysis (AESA). SFS has created a lot of interest among local farmers in the area, parent-farmers, school children, teachers and the public. Last year, one SFS even received a visit from the Honourable Minister for Agriculture ***.***The projects so far conducted 20 SFS and the performance of these SFS was found to be highly satisfactory.

**IPM Clubs/IPM Congress:** In many places in the country, the IPM trained farmers have spontaneously started IPM clubs. Owing to the close interaction of the club members with the grass-root DAE staff, local leaders and farmer groups in the community, IPM clubs are proving to be a key factor for the promotion and sustainability of Community IPM in Bangladesh.The range of activities varies among clubs but all are engaged in providing some sort of IPM training to the neighbours and this includes training through season-long FFS. Selected members of some clubs have already completed their Farmer-Trainer training provided by the project and they will continue to establish FFS using the club funds.

Many clubs have their own ways of generating funds which include pest management in rice fields (of club and non-club members) on a contract basis, production of seeds of improved varieties, fish cultivation in rice fields, etc.

In a number of localities, impressed by the IPM training at the FFS, the members of the parliament and other local elites (e.g. Chairman of Union Parishad) have come forward to donate money to build club houses, to buy TV and radio sets, running FFS, etc. In other places, the Upazila Nirbahi Officers (UNO) have willingly provided financial support fromAnnual Upazila Agricultural Development Programme (AUDP) fund for the club to start more FFS and train farmers. Women participation in IPM clubs is also widely observed as a very positive step in many ways.These projects have taken a number of initiatives to promote the formation of IPM clubs in the project Upazilas. The DTs and FTs have been respectively requested to help the FFS alumni to start IPM clubs. In addition, the DAE-UNDP/FAO IPM project has been directly involved with selected four IPM clubs with a view to develop them as model clubs. In this regards, the project has organized regular planning and technical meetings with these four clubs, gave basic support for Participatory Action Research (PAR) activities, and provided training to selected club members to become FTs. The DAE-UNDP/FAO IPM project assisted four IPM clubs (Sarkhola, Jessore; Uttarchalk, Pabna; Fatepur, Rangpur; and Ashrabpur, Mymensingh) to organise IPM congress at upazila level in T. Aman season 2000 where all FFS farmers, upazila and district level officers of DAE, Upazila Nirbahi Officer and even Deputy Commissioner attended. The Member of the Parliament of the respective upazila was the chief guest in the congress. This congress is first of its kind in Bangladesh. Through DAE-DANIDA SPPS Project 173 IPM clubs have been established and more numbers of IPM clubs are going to be established during the Project period. From the SPPS Project, one Radio, IPM component poster, folders, leaflets and training materials were supplied to the all IPM clubs.

**Other Developments:**

In addition to the on going IPM projects under DAE, Small holder Agricultural Project (SAIP) funded by IFAD and North West Crop Diversification Project funded by ADB are planning to operate IPM activities in their project areas in a small scale.

**Future Plans and Priorities:**

At present, the Plant Protection Wing of DAE is directly involved in the implementation of IPM activities. No national IPM programme set up exists. In order to address the questions related to promotion, expansion, coordination and sustainability of IPM and to ensure the proper implementation of a national IPM programme, an organizational set up is needed. A proposal for such a set up is proposed in the IPM policy .The proposed institutional set up for the national IPM programme was thoroughly discussed by the working group and also in the national IPM workshop. The draft Policy is now with the Ministry of Agriculture for necessary action. Action may be taken for GOB's approval of IPM policy to ensure that the system for the implementation of the national IPM programme together with the necessary institutional set up for its implementation is established and functioning as soon as possible.

The first phase of DAE-DANIDA SPPS Project is going to over by the end of June 2002. Considering the performance of project activities DANIDA has agreed to extend the component of IPM programme.

# Vegetable IPM in Bangladesh

Bangladesh, a country with subtropical climate located between 20°34' and 26°38' north latitude and 88°01' and 92°41' east longitude in the northeastern part of South Asia produces a number of vegetables including eggplant, cucurbits, country bean, cabbage, cauliflower, tomato as important ones. Most of the vegetables are grown in winter spanning over September to February while very few are grown in summer spanning over March to September. The vegetable cultivation covers an area of 4,98,073 acres and provides an ample opportunity for men and women folk of the disadvantaged groups. But the yield per unit area is quite low since the insect pests cause 30 – 40% losses in general and even 100% losses in case of menace if no control measure is applied. A conservative estimate puts about annual yield losses in vegetables at 25% due to insect pests a lone.

Until recently insecticides were the major means of insect control in all crops including vegetables in Bangladesh. The use of insecticides in Bangladesh was started date back in 1957/58 with the grant receipt of 3 metric tons of endrin , which reached 14,312 metric tons in 2004 through import and marketing of several brands across 5 era of systems, and is still on the increasing trend. More than 80% of the insecticides are used in controlling the insect pests of rice. Such use of pesticides in rice caused several problems including insect pest resurgence, secondary pest outbreak etc. Recently, the use of insecticides has considerably increased in vegetables like eggplant, country bean, cucurbits, yard long bean etc particularly in their intensive growing areas. In a growing season of 4 to 6 months in Jessore district, as many as 150 applications of insecticides with at least once a day during peak period were required to suppress the insect pests in eggplant. As many as 30 sprays of insecticides have been reported in country bean. Even in several instances farmers were reported to use cocktails of 3 to 5 insecticides to control the eggplant shoot and fruit borers, which indicated the development of resistance, destruction of natural enemies, resurgence and harmful residues in edible fruits. These situations have prompted to shift the practice of sole reliance on insecticide to integrated insect pest management (IPM) practice. The IPM activity in Bangladesh, in fact, was initiated in 1981 through the FAO inter-country IPM project in rice in South and South East Asia, which subsequently expanded through other projects like ADB funded DAE – CAD (Department of Agricultural Extension – Command Area Development) in 1997 – 2000, FAO – EC- CDB Regional Cotton IPM program in 1999 in 1999, CARE Bangladesh INTERFISH (Integrated Rice and Fish) program in 1993 and the NOPEST (New Options in Pest Management) program in 1995, DANIDA - DAE – SPPS (Strengthening Plant Protection Services) project phase 1 in 1997 – 2002, DANIDA funded AID-Comilla (Association for Integrated Development) project in 1999 – 2001. All these projects mostly concentrated on rice IPM. These projects have developed IPM technologies for rice insect pests and undertaken programmes for their dissemination through T & V system and then lastly by establishing the Farmers Field Schools (FFSs) across the country. The process is still ongoing for enhancing the adoption by general farmers. Subsequently efforts were undertaken to develop vegetable IPM through the Vegetable IPM-ICP project in 1996 -1999, UNDP/FAO -DAE IPM project in 1996 - 2001, DANIDA - DAE – SPPS (Strengthening Plant Protection Services) project phase 2 in 2002 to 2006, and USAID - IPMCRSP (IPM Collaborative Research and Supportive Programme) in 1993 – 1998 – to date. The IPM activities have created significant awareness in the country and have made significant impact in reducing the use of pesticides by the IPM trained farmers. But the IPM tactics so far tested under these projects have covered only very few insect pests of only few vegetables and have not been adopted as a common practice by the general vegetable farmers. However, efforts are underway to address both these situations. Nevertheless significant achievements have been made in developing the IPM tactics for the insect pests particularly the fruit fly of cucurbits and the shoot and fruit borer of eggplant among the vegetables.

Under the above backdrop, the key pests of some major vegetables including eggplant and cucurbits, and their IPM tactics or control measures so far developed and used by the IPM farmers are discussed below in brief:

## IPM of Eggplant

Eggplant, Solanum melongena is one of the most common and popular vegetable crops cultivated in Bangladesh. It is grown year-round having two major growing seasons such as summer and winter. Eggplant is one of the rare vegetables, which can be grown also in summer. It covers an area of 74,711 acres, which is about 15% of total vegetable areas of the country. Although the crop is grown throughout the country, it is intensively and commercially grown in Jessore, Narsinghdi, Dhaka, Comilla and Bogra districts. Its annual production is about 191,525 metric tons with an average yield of 2.56 metric tons per acre. One of the major factors of low yield of eggplant is insect pest. At least fifteen insect pests and one mite pest attack eggplant. Among them, eggplant shoot and fruit borers, leafhoppers and epilachna beetles cause serious damage to the crop. However, none of the insect pests build up populations equally in every season and in all growing regions. The incidence and infestation of insect pests predominate in summer season.

**Cutworm**, Agrotis ipsilon (Rottenburg): Noctuidae, Lepidoptera

**Description:** The adult moths are medium sized with wing expanse 45 – 55mm, dark greenish-brown with reddish tinges and have grayish-brown wavy lines and spots on fore wings, hind wings hyaline having dark terminal fringe. A female lays up to 800 eggs in batches of 30 – 50 on the lower surface of leaves, on the parts of the stem touching the ground and in moist soil surface of the crop field. Eggs hatch out within 2 – 9 days depending upon temperature. The very young larvae feed on the fallen leaves or on leaves touching the ground. The larvae become full-grown in 28 – 34 days and pupate in the soil within earthen cells. The pupal stage lasts for 10 – 30 days depending on weather condition.

**Damage:** The larvae remain hidden under the soil during daytime and come out in the night to damage the eggplant seedlings by cutting at the base of their stems little below the ground level. Cut seedlings are found fallen on the ground of the infested filed. In case of heavy infestation replanting of the crop becomes necessary. The insect hardly causes any damage to the crop in summer and rainy season.

**IPM tactics and Control Measures:** (i) Irrigating with kerosene oil (5-7 liter kerosene / ha), (ii) using of poison bait made of 2.0 g of Sevin 85 WP or Padan 50 SP in 100 kg rice / wheat bran in sufficient water to make a non-sticky mixture for 1 ha or (iii) spraying of Dursban / Pyriphos 20 EC at 5.0 ml / liter of water on the soil around the seedling in the evening.

**Epilachna Beetle**, Epilachna vigintioctopunctata Fab. and E. dodecstigma: Coccineliidae, Coleoptera

**Description:** The adult insect looks oval shaped possessing black spots on back and often found along with grubs. A female lays yellow eggs in batches of 60 – 90 during summer and 20 – 30 during winter on the dorsal surface of leaves. Eggs hatch out within 3 – 4 days. The larvae after 8 – 10 days of feeding and moulting three times become full grown measuring 6 mm long, then pupate on the leaves or stems. The life cycle lasts for 15 - 20 days and completes few generations in the same season.

**Damage:** Both grubs and adults of the insect feed on the leaves by scraping the leaf surface leaving the midrib. They also feed on the epidermis of leaves. As a result, the infested leaves dry and fall off. They may also feed on the fruit surface or make small bores in fruits.

**IPM tactics and Control Measures:** (i) Hand-picking and destruction of eggs, grubs and adults (ii) clean cultivation by removing and destroying plant debris, infested leaves, infested fruits etc. and (iii) in case of severe infestation spraying of Sevin / Carbaryl 85 WP @ 2.0 g / liter of water on the affected leaves at an interval of 15 days.

**Jassid**, Amrasca biguttula biguttula, Distant: Jassidae, Homoptera



**Description:** The slender pointed bodied greenish yellow adult insect measures 1 – 3 mm long and has tow distinct black spots at distal end of wings. The legs are provided with few rows of sharp thorns. They have about 5 - 7 weeks longevity. A female lays 15 – 20 eggs within the main veins and at the lower surface of leaves. Incubation and nymphal periods range from 4 – 10 and 7 – 21 days respectively. The insect completes it life cycle within 11 – 31 days with 10 – 12 overlapping generations.

**Damage:** Both the nymphs and adults of the hopper cause serious damage to the leaves by sucking the cell sap. The small nymphs suck sap from the lower surface of the leaves. The infested leaves wrinkle through the blades, the blades turn yellow and show burn symptom and ultimately the whole leaf turns yellow. Heavily infested leaves appear stunted, show yellow mosaic and subsequently dry up. The fruit bearing declines seriously in heavily affected plants.

**IPM tactics and Control Measures:** (i) Growing resistant varieties viz. ISD006, BL114 & BL095(2), (ii) Conservation of natural enemies by minimizing chemical pesticides spraying and (iii) in case of severe infestation, Spraying of neembicidine @ 4 ml/l of water or neem oil @ 20 ml/l of water.

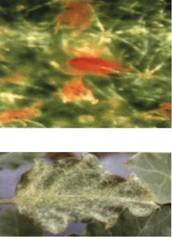
**Leaf Roller**, Eublemma olivacea, Gi.: Noctuidae, Lepidoptera

**Description:** The adult insect measures 1 – 3 mm long, velvety greenish moth. A female lays eggs in batches of 8 – 22 on the ventral surface of leaves. Eggs hatch into violet-brown larvae having several creamy raised heaps on back and long hairs on back and surrounding areas. The caterpillar pupates within rolled leaf in about 4 weeks. The insect may have 3 – 4 generations in a year under favourable weather conditions.

**Damage:** The caterpillars feed by chewing within young rolled leaves. The affected young leaves appear silky networked and rolled. The rolled leaves initially turn brown and ultimately dry up. Under severe condition the entire plant turn brown and leaves droop off.

**IPM tactics and Control Measures:** Not available.

**Red Mite**, Tetranychus urticae: Acarina

**Description:** The mite is very small, red in colour and hard to find with naked eye. They are mainly found underneath the leaves but move to upper surface of leaves, stems and flowers when enormous in number. The female mites lay invisible miniature eggs on the lower surface of leaves. Eggs hatch into orange larvae, which feed on the lower surface of leaves and develop within a week into deep orange or red adult mites resembling spider.

**Damage:** The mite affected leaves show yellowish clumpy spots. In case of severe infestation, the leaves wrinkle, turn complete yellow to brown and ultimately droop off.

**IPM tactics and Control Measures:** (i) Collection and destruction of the affected leaves along with mites (ii) in case of severe infestation spraying of Ethion or Nuron or Tork 550 SC@ 2 ml/L of water at 10 days interval.

**Thrips**, Thrips palmi : Thripidae, Thysanoptera

**Description:** Thrips look pointed and slender. The insects are minute and fragile but can be found with naked eye. The adult insect is reddish yellow with two pairs of fringed wings and two long brown spots on back. They are very fast and fly off just at leaf touch. Immature insects are white or yellow in colour. The female adults lay eggs deep into the leaf tissue. Eggs hatch into larvae within few days and pupate generally in soil at plant base.

**Damage:** Both nymphs and adults lacerate the leaf tissues and lap the oozing sap. As a result, white silvery sheens appear on the infested leaves. In case of severe infestation, the leaves start drying from tip downwards.

**IPM tactics and Control Measures:** Described in case of country bean.

**Aphids**, Aphis gossypii Glover: Aphididae, Homoptera

**Description:** The aphids are soft bodied yellowish insects each measuring 1.0 – 1.5 mm with two cornicles at the abdomen. Initially they are found on the lower surface of the leaves but move to the upper surface, stem and flower when they increase in enormous number. They multiply by parthenogenesis instead of reproducing through eggs. These immature insects develop into adult aphid within a week and start producing next generation.

**Damage:**At the initial stage the affected leaves generally turn yellow. At severe infestation, the young leaves wrinkle downward. The upper surface of leaves become covered with a sticky black mould known as sooty mould. This causes stunted growth of the plant and the plant remains dwarf.

**IPM tactics and Control Measures:** Described in case of country bean.

**White Fly**, Bemisia tabaci Genn.: Aleurodidae, Homoptera

**Description:** The adult white fly measures slightly longer than 1 mm and live on the lower surface of leaves. The adult insects upon slight disturbance fly away short distance. The female adults lay oval shaped miniature eggs up to 160 in few batches on the lower surface of leaves. Eggs hatch into flat oval shaped nymph. The full-grown nymphs measure less than 1 mm. The nymphs suck cell saps, and are sessile at feeding. The insect completes as many as 15 generations in each crop season.

**Damage:** The affected leaves show yellowish clumpy spots. In case of numerous insects, several clumpy spots coalesce together and the leaves along with green midribs turn yellow. The nymphs during feeding secrete sticky honey like substance that cover-up the upper parts of the leaves and flowers. The plants become stunted. The insect does more harm by disseminating diseases than does by feeding.

**IPM tactics and Control Measures:** Not available.

**Eggplant Shoot and Fruit Borer**, Leucinodes orbonalis Guen.: Pyralidae, Lepidoptera

**Description:** The adult insect is a white moth having brown spots on wing. A female moth lays 10 - 60 creamy white eggs singly on shoots, flower buds, near the peduncle of fruits and on the lower surface of leaves during the later part of the night to the early hours of the morning. The eggs hatch into dark white larvae and gradually become light rose with ages.

The full-grown larvae measure 15 - 18 mm and come out of the infested shoots and fruits for pupation in the dried shoots and leaves or in plant debris fallen on the ground. The incubation, larval and pupal periods are 3 - 5, 12 - 15 and 7 - 10 days during summer, while it is 7 - 8, 14 - 22 and 13 - 15 days during winter season.



**Damage:** This is the most serious pest of eggplant. The larva starts infesting eggplant from its very young stage and continues up to the last day of the crop’s life. In the vegetative phase of the plant, the larvae bore into the young shoots, petioles and midribs of the large leaves and feed on the internal tissues from within the attacked plant part. The infested shoots droop down and subsequently wither. In the reproductive phase when the plants start bearing flower and fruits, the larvae bore into the flower buds and fruits. The infested flower buds drop and fruits show the sign of infestation from the oozed out frass of the larvae through the holes made on the fruit by the larvae prior to their jumping out of the fruits upon attaining maturity. The larvae while feeding on the internal soft tissues of the fruit often make tunnels inside the fruit and make the fruit unfit for consumption.

**IPM tactics and Control Measures:** As the eggplant is grown year-round in almost every corner of the country and the pest has overlapping generations, it is really difficult to manage the pest by a single method. A combination of methods is of paramount importance to keep the pest population below economic injury level for minimizing the yield loss. The combination of methods include the followings: (i) cultivation of tolerant eggplant varieties such as ISD006, BL114 & BL095(2), or growing grafted seedlings, (ii) growing healthy seedlings raised in plots covered with cloth nets or grown in pest free area, (iii) practicing adequate field sanitary measures particularly removing the fallen leaves, buds or debris, (iv) clipping off and destroying the infested shoots and fruits once in a week starting immediately after 2 - 3 weeks of planting and continuing up to final crop harvest, (v) undertaking weekly field checking to spot out the presence of the insect in the field, (vi) placing sex pheromone ((E)-11-hexadecenyl acetate and (E)-11-hexadecen-1-ol, mixed in 10:1 ratio} traps each at 10 - 15 cm distance and just above the crop canopy covering the entire plot starting after 3 - 4 weeks of planting and continuing up to final harvest for reducing the pest population through mating disruption as well as mass catching, (vii) conservation of natural control agents such as Trathala flavo-orbitalis, Camponotus compressus, earwig, lady beetle, mantid and spider by avoiding the prophylactic application of insecticides, (viii) application of insecticides (such as carbosulfan, cypermethrin etc.) only if the infestation is too high even after the above adoption of measures and (ix) ensuring of community approach for all the suggested tactics to maximize benefits.

#### Brief Description of Sex Pheromone Water Trap

The sex pheromone bait trap comprises the pheromone bait and the locally fabricated water trough. The whole system consists of a 3-liter capacity, 22 cm tall rectangular or round clear plastic container and sex pheromone. Two triangular openings each one of 10-12cm heights is cut 4-5cm away from the bottom on opposite side of the plastic container. Soapy water of 3-4cm height is maintained inside the container throughout the season. A plastic tube containing the pheromones (E)-11-hexadecenyl acetate and (E)-11-hexadecen-1-ol mixed in 10:1 ratio, is hung through the center of the lid of the plastic container by means of a thin wire in such a way that the tube remains only 2-3cm above the soapy water. The traps thus prepared should be placed at 10 – 15 cm distance and just above the crop canopy covering the entire plot starting after 3 – 4 weeks of planting and continuing up to final harvest for reducing the pest population through mating disruption as well as mass catching. Such plastic pheromone traps, if carefully used, may remain useful for 2-3 crop seasons.

#### Natural Control Agents of Eggplant Shoot and Fruit Borer

|  |  |  |
| --- | --- | --- |
| image026 | rahman4 | |
| Female | Male | Lady beetle adult and grub |

|  |  |  |
| --- | --- | --- |
| image028 | image030 | image032 |
| Earwig adult | Mantid adult | Spider adult |

**Integrated Insect Pest Management:** Among the insect pests mentioned above, the Epilachna beetle and red mites other than the most severe pest eggplant shoot and fruit borer cause significant crop damage. But so far management or control measures are not available for the key pests of eggplant considered altogether.

## IPM of Cucurbits

Cucurbits form the largest group of vegetables including sweet gourd, bitter gourd, ribbed gourd, sponge gourd, teasel gourd, white gourd, ash gourd and cucumber as the major ones. The insect pests that infest all cucurbits are almost common. However, their infestation intensity may vary to some extent in different cucurbits. Among all, Fruit fly is the severe pest common to all cucurbits. The other major insect pests of cucurbits are Epilachna beetle and Pumpkin beetle.

**Epilachna Beetle:** Same as described under eggplant.

**Pumpkin Beetle**, Raphidopalpa (Aulacophora) foveicollis (Lucus), R. abdominalis (F.) and R. frontalis (Baly): Chrysomelidae, Coleoptera

**Description:** Adult beetles are 6 – 8 mm long, having glistering yellowish-red to yellowish-brown elytra that are uniformly covered with fine punctures. A female adult lays 150 – 300 eggs. Eggs are laid in the moist soil usually around the host plant. Eggs are spherical in shape and yellowish-pink in colour. Freshly hatched grubs are dirty white in colour while full-grown ones are creamy-yellow and about 22mm long. Pupae are pale white and are found in earthen cells 15 – 25mm deep in the soil.

**Damage:** The adult beetles cause damage to young seedlings by feeding on leaves making shot holes. On hatching, the grubs start feeding on the roots. They live in the soil and cause damage to seedlings and mature plants feeding on roots. The damage at the young stage may even kill the seedlings.

**IPM tactics and Control Measures:** (i) Scouting the plot in the morning for collecting and destroying the adults, (ii) spraying of Sevin/Carbaryl 85WP at 2.0g/litre of water at 7 days interval and (iii) in case of severe infestation, applying Diazinon 14G @ 5g/plant and mixing with soil around the plant followed by light irrigation.

**Melon Fruit Fly**, Bactrocera cucurbitae Coquillett: Tephritidae, Diptera

**Description:** The fruit fly adults are free living, reddish brown with lemon yellow in colour, having curved vertical markings and fuscous shading on the outer margin of the wings. The adult female lay eggs usually just below the epidermis of the fruits by inserting their ovipositor. The eggs are laid singly or in clusters of 4 to 10. A single adult can lay 42 to 58 eggs. The eggs hatch within 18 hours in summer and 3 – 4 days in winter. Soon after hatching the young larvae (maggots) bore into the flower buds or into the fruits and start feeding. The full-grown maggots measure 9 – 10 mm long and 2 mm broad across the thorax and are cream or pale white in colour. The full-grown larvae develop into barrel shaped, light brown or pale colour pupae in 0.5 to 3 inches deep in soil within 7 – 14 days. The pupae emerge into adults within 5- 8 days in summer and within about 3 weeks in winter.

**Damage:** Generally fruit flies attack the young and tender fruits of various cucurbits like snake gourd, cucumber, sweet gourd, bitter gourd, ribbed gourd, ash gourd etc. Watery juices that come out at the point of puncture later appear as a solidified material. The larvae (maggots) hatched inside the fruits eat away the pulpy tissues inside and make tunnels in fruits and destroy the fruits. The infested fruits are completely destroyed. The damage ranges up to 60% varying significantly in different cucurbits.

**IPM tactics and Control Measures:** A combination of methods such as (i) plowing well the soil to expose the pupae to birds, (ii) removing and destroying the infested fruits and fallen fruits regularly, (iii) covering of fruits immediately after fruit-set with polythene bag having pin-holes and (iv) spraying cypermethrin at 10 days interval or spraying bait spray made of 1.0 g Dipterex 80SP and 100 g molasses per litre of water or (v) placing above the crop canopy with the support of bamboo sticks the pheromone bait traps each consisting of a 2.5x1.5 cm cotton wad having soaked 15-20 drops of a pheromone bait “Cuelure” {4-(p-acetoxyphenyl)-2 butane} or {4-(3-oxobutyl-phenylacetate)} and hung by a thin wire through the center of a 3-litre capacity and 22cm tall rectangular or round plastic container having two opposite cut holes and containing soapy water of 3-4cm height with a gap of 3-4cm from the hung cotton wad above (vi) using poison bait traps @ 20 to 40 per hectare, each trap made of 100g mashed ripe sweet gourd (MSG) with 0.25g Mipcin 75WP or Sevin 85WP or Dipterex 80SP in 100 ml water placed in a lower smaller earthen pot at 50cm height above ground with another slightly bigger flat earthen plate placed upside-down at 20cm above it as cover, and both placed in a three split bamboo stick erected up anchored in soil. The bait materials i.e. MSG and insecticides should be changed at every 4 days interval.

#### Brief Description of Pheromone Bait Trap

The pheromone bait trap comprises the pheromone bait and the locally fabricated water trough. The whole system consists of a 3-liter capacity, 22 cm tall rectangular or round clear plastic container. A triangular opening is cut in any two opposite sides starting 3-4cm from the bottom. Soapy water of 3-4cm height is maintained inside the container (trap) throughout the season. A cotton wad measuring 2.5x1.5cm and soaked with 15-20 drops of “cuelure” 4-(p-acetoxyphenyl)-2 butane} or {4-(3-oxobutyl-phenylacetate)} is hung through the center of the lid of the plastic container by means of a thin wire in such a way that the cotton wad remains 3-4cm above the soapy water. The trap is then placed just above the crop canopy by means of a bamboo support. The pheromone remains active and continues to attract flies for 2-3 months.

#### Brief Description of MSG Poison Bait Trap

The poison MSG bait is prepared by taking 100g of sliced and smashed ripe sweet gourd in an earthen small container and mixed with 0.25g Mipcin 75WP or Sevin 85WP or Dipterex 80WP and 100ml water. The earthen container, with the above bait materials, is then placed in a cucurbit crop field by mounting it on three bamboo sticks in such a way that the container remains about 50cm above the ground. Finally a flat earthen plate, slightly bigger than the bait containing earthen container, is placed at the top of the three bamboo sticks to protect the bait materials from getting dried by solar heat or wet from rains. A small amount of water should be added to the bait if it gets dried. The MSG bait remains effective for 3-4 days at which time the bait should be replaced with newly prepared MSG.

## IPM of Country Bean

Country bean, Dolichos lablab is a popular vegetable grown in winter season and some varieties (IPSA 1 and 2) grown in summer also. Several insect pests infest country bean but the bean pod borer only cause severe damage. The other major insect pests are bean aphids, red mites and thrips.  
  
**Bean Thrips**, Magalurothrips usitatus (Bagnall): Thripidae, Thysanoptera

**Description:** Females lay eggs inside the leaf tissue. The hatched larvae feed on leaves and flowers. The full-grown larvae drop on soil and pupate inside soil. They have continuous.

**Damage:** The insects suck cell sap from reproductive parts and prefer to feed on the flower. They also feed on pollen. Flower and flower parts become brown, dried and in severe case flowers drop or are completely destroyed. The petioles and leaves show tiny holes surrounded by discolored areas. Pods are deformed and yields are reduced.

**IPM tactics and Control Measures:** (i) Spraying of plain water, (ii) in case of severe infestation, spraying of Pirimor 50 DP at 1.0-1.5 g / liter or Malathion 57 EC @ 2.0 ml / liter of water at 15 days interval.  
  
**Black Aphids**, Aphis craccivora Koch: Aphididae, Homoptera

**Description:** The aphids are soft bodied pear-shaped shiny black insects each measuring 1.0 – 1.5 mm with two appendages at the abdomen. Initially they are found on the lower surface of the leaves but move to the upper surface, stem and flower when they increase in enormous number. They multiply by parthenogenesis instead of reproducing through eggs.

These immature insects develop into adult aphid within a week and start producing next generation.

**Damage:** Both adults and nymphs cause damage to plants by sucking the plant sap from leaves, flowers and young fruits. Leaves crinkle or exhibit a yellowish, mottled, or mosaic coloration. They become sticky with patches of black sooty mold growing on them.

**IPM tactics and Control Measures:** (i) Conservation of natural enemies especially different ladybird beetles, (ii) in case of severe infestation having >50 aphids / plant, spraying of Pirimor 50 DP at 1.0-1.5 g / liter of water or Malathion 57 EC @ 2.0 ml / liter of water at 15 days interval.

**Red Mites:** same as described under eggplant

**Bean Pod Borer**, Maruca (testulalis) vitrata Geyer: Pyralidae, Lepidoptera

**Description:** The moths are small, dark gray in colour with white brown patterns of the wings. The colour patterns can be more conspicuous on the forewings, with a silvery white brown spot at the apical margin, than on the hind wings. The males measure about 13 mm in length and 9 mm in width with a wing expansion of about 26 mm. The females have brownish abdomen with bifid hairy ovipositors. The females measure about 11 mm in length and 8 mm in width with a wing expansion of about 23 mm. A female usually oviposits up to 400 eggs during her lifetime, and these eggs are normally deposited in batches of 2 – 6. Eggs are normally deposited on floral buds and flowers, and also on leaves, leaf axils, terminal shoots, and pods. Eggs hatched into larvae within 3 days. The larvae are creamy white in colour, with dark brown head and prothoracic segment. The full-grown larvae measure 15 – 18 mm long with grayish-green or brownish head and yellowish-white body. At night, it emerges from the pods and crawls about. It then descends to the soil and pupates beneath leaf debris. There are two peak periods of abundance of the moths. One is from June to early July and the other, from November to January.

**Damage:** On hatching the young caterpillar feed on flower buds, flowers and move from one flower to another. Later they web the inflorescence with the adjacent leaves and developing pods and feed within by boring into flowers and pods. The infested flowers either drop, form clusters or/and do not develop into pods while the affected pods become malformed because these are not able to grow normally due to webbing and feeding damage.

**IPM tactics and Control Measures:** (i) Conservation of predatory black ants that often feed on the eggs and neonate larvae of the pest, (ii) hand picking of infested flowers and pods at alternative days, (iii) spraying of Neem oil @ 3ml/L of water or Cymbush 10 EC @ 1ml/L of water at seven days interval or application of Sumialpha at a single flower infestation per inflorescence.

## IPM of Tomato

Tomato is grown in winter. But recently some varieties are also grown in summer. Tomato is infested by a number of insect pests, which include cutworm, white fly and fruit borer as the major insect pests.

**Cutworm and White fly:** Same as described under eggplant.

**Fruit Borer**, Helicoverpa armigera (Hubner): Noctuidae, Lepidoptera.

**Description:** Adult moths are medium sized with wing expanse 30 – 44mm, stout, ochreous with pale-brown or reddish-brown tinge, fore wings are olive-green to pale brown in colour with a dark brown circular spot in the center and indistinct double waved antmedial lines, hind wings are pale smoky-white with a broad blackish outer border. A female lays 1200 - 1600 eggs. Eggs hatch within 2 – 4 days. Freshly hatched larvae are yellowish-white in colour but gradually change and acquire greenish tinge. Full-grown larvae are 40 – 48mm long, apple-green in colour with whitish and dark-gray broken longitudinal stripes. Pupae are dark brown in colour. Larval and pupal stages last for 15 – 24 and 10 – 14 days respectively. The full-grown larvae drop down from the plant and burrow in the soil where they pupate.

**Damage:** The hatched larvae feed on leaves and flowers. The advanced stage larvae bore circular holes and thrust only a part of their body inside the fruit and eat the inner contents. If the fruit is bigger in size, only part of it is damaged by the caterpillar. The larvae move from one fruit to another and a single caterpillar may eat and destroy 2 – 8 fruits.

**IPM tactics and Control Measures:** (i) Field sanitation removing the plant debris and infested fruits, (ii) in case of severe infestation, spraying of Cypermethrin 10 EC @ 1 ml / liter of water or Fenvalerate 20 EC @ 0.5 ml / liter of water at 15 days interval.

## IPM of Okra

Okra is grown in summer and winter. The crop is infested by a number of insect pests, which include Jassid, white fly, and shoot and fruit borer as the major insect pests.

**Jassid and White fly:** Same as described under eggplant.

**Shoot and Fruit Borer**, Earias vittella (Feb.): Noctuidae, Lepidoptera.

**Description:** It is a nocturnal insect. The adult moth measures 13 – 15mm long with wing expanse 30 – 34mm, head and thorax ochreous-white, fore wings pale white with a broad wedge-shaped horizontal green patch in the middle and hind wings silvery-creamy-white in colour. A female lays 65 - 695 eggs. The eggs are usually laid singly on buds and flowers and occasionally on fruits and shoot tips. The eggs hatched into larvae within 3 – 9 days. The full-grown caterpillar measures 18 – 24mm. Rain and high humidity directly influence its population development. It needs around a month to complete its life cycle and thus has 12 generations.

**Damage:** The larvae bore into the tender shoots and tunnel downwards. The infested shoots wither, droop down and ultimately the growing points are killed. The caterpillars then bore into the buds and fruits and feed inside them. The damaged buds and flowers wither and fall down. The affected fruits have bores seen externally; they decay inside, become deformed in shape and remain stunted in growth.

**IPM tactics and Control Measures:** (i) Clean cultivation removing and destroying the plant debris and infested fruits, (ii) removal of alternate host, especially cotton near the lady's finger field, (iii) conservation of Trichogramma evanescens West and Apantalis parasitoids, and (iv) in case of severe infestation, spraying of Cypermenthrin 10 EC @ 1 ml / liter of water or Fenvalerate 20 EC @ 0.5 ml / liter of water at 15 days interval.

## IPM of Cabbage and Cauliflower

Cabbage and cauliflower are grown in winter. The crops are infested by a number of insect pests, which include cutworm, tobacco caterpillar and diamondback moth as the major insect pests.

**Cutworm**, Same as described under eggplant.

**Tobacco Caterpillar**, Spodoptera litura (Fab.): Noctuidae, Lepidoptera

**Description:** It is a nocturnal insect. The adult moths are stout with wing expanse 35 – 45mm, pale ochreous suffused with dark-brown. A female lays on an average 400 eggs in batches of 80 – 150 eggs. The eggs hatched into larvae within 3 - 5 days. The full-grown caterpillar measures 40 – 50mm. The larvae are found aggregated in lower leaves. Pupation takes place in rough earthen cocoons in soil. Pupal stage lasts for 7 – 11 days. The entire life cycle occupies 30 – 40 days in summer and 18 – 20 weeks in winter. Adult longevity is 10 – 24 days.

**Damage:** Many larvae in gregarious form feed inside the infested cabbage head. It at times also tunnels into soft tissues such as soft stems, midribs, leaf stalks etc.

**IPM tactics and Control Measures:** (i) Hand picking of the egg mass and caterpillars two times, (ii) spraying of Sumithion 50EC, Diazinon 60EC or Dursban 20 EC @ 2ml/L of water before head formation or soon after observing tiny caterpillars on leaves and (iii) for crops to be harvested within 15 days spraying malathion 57EC @ 1.5 to 2.0 ml/liter of water.

**Diamondback Moth**, Plutella xylostela (Linn.): Plutellidae, Lepidoptera

**Description:** It is a cosmopolitan insect and a major pest of cruciferous crops but prefer cabbage and cauliflower. The adult measures 8 – 10mm long, grayish-brown in colour. There are three pale whitish triangular markings on hind margins of each fore wing and when at rest, a dorsal median patch of three diamond-shaped yellowish-white spots is clearly visible by joining both fore wings-hence called “diamond back”. A female lays 40 – 60 eggs. The eggs hatch into larvae within 3 - 8 days. The full-grown caterpillar measures 8 – 12mm long. Pupation takes place in beautiful transparent cocoons that are fastened to the ventral side of leaves. Longevity of adults is 16 – 18 days. There are 8 – 10 overlapping generations in a year.

**Damage:** On hatching, the young larvae feed by scrapping epidermal leaf tissues and thus produce typical whitish patches. Advance stage larvae bite holes in the leaves. The infestation is more severe during dry season. It causes retardation of growth resulting in undersized cabbage heads and cauliflower.

**IPM tactics and Control Measures:** (i) field sanitation by removing and destroying all remnants, plant debris after crop harvest and plowing well, (ii) hand picking of the egg mass and caterpillars two times, (iii) spraying of Bacillus thuringiensis formulation or Cypermethrin 10EC or Fenvalerate 20EC @ 1.0 ml/liter of water.

**Cabbage Butterfly**, Pieris brassica

**Description:** The adult butterflies have snow-white forewings with wing expanse 60 – 70mm. The hind wings are also pure white with black apical spots. A female lays only 2 – 3 egg-masses of 50 – 80 eggs each. The eggs are laid in clusters on upper surface of leaves. The eggs hatch into larvae within 3 – 4 days. The full-grown caterpillar measures 38 – 44mm long, velvety bluish-green in colour. Pupation takes place on leaves and stems.

**Damage:** It is an oligophagous pest of cruciferous crops but prefers cabbage and cauliflower. On hatching, the young larvae feed gregariously on leaves for a couple of days. The infested leaves are skeletonized, sometimes the caterpillars bore into the heads of cabbage and cauliflower.

**IPM tactics and Control Measures:** Same as for Tobacco