Chapter: 1 General Introduction

Anyone engaged in agricultural, horticultural or medicinal entomology needs to know something about the insects that commonly affects plants, animals or humans. The effects may be beneficial or harmful. The beneficial effects need to be improved upon whereas harmful insects need to be controlled. In most cases this knowledge should be sufficient to enable common pest problems to be recognized & dealt with sensibly (Fenemore, 1992).

General introduction to pest and its types:

Organism that causes damage to human health, wealth also causes annoyance called as Pest. Pests are broadly grouped as Invertebrates and vertebrates. Invertebrates includes insects, Nematodes, Parasites, Gastropods, plant pathogens etc. While vertebrate pests are mostly mammals and birds.

The crop pest can be categories an,

**a. key pest:**

Are those insects which cause unacceptable damage frequently and requires being controlled. These are the pests of major importance on specific crops.

**b. Occasional pest:**

A pest in this category occurs only occasionally in damaging numbers (above the damage threshold). For long periods of time populations remain low and insignificant but often, on either a regular or sporadic basis they increase to damaging levels & cause a problem. The reason for fluctuations in population of occasional pests are often climatic, or due to biological factors such as the incidence of natural enemies, but in many cases the details are as yet to be known.

**c. Potential pest:**

Pests that fall within this category have the potential to reach pest status but are normally suppressed by naturally regulating factors. Potential pests are usually recognized only when their natural control is interfered with & they become elevated to actual pest status. For e.g. European red mite fall in this Category of crop pests and their population levels with respect to damage
threshold. To most people effective control of a pest probably means its total elimination from an area, but complete eradication is rarely attainable. The damage threshold for a pest was defined as population density below which detectable reduction of yield or quality of a crop does not occur. Effective pest control may therefore be described as reduction or maintenance of a pest population below damage threshold (Fenemore, 2006).

**Various control measures, advantages and disadvantages:**

Pest control for the past several decades has relied heavily on the application of chemical insecticides valuable through these substances are, many problems have arisen in their use such as the appearance of resistance strains of pests and harmful effects on non-target organisms, resistance often developed, often toxic to users and may present residue problems. Moreover high cost & recurring as control is not permanent (Stenersen, 2004).

Cultural control may be defined as manipulation of culture practices such as crop rotation, soil cultivation, time of sowing, irrigation etc. to the disadvantage of pests. Any change in cultural methods, for whatever reasons make conditions less favorable for some pests but possibly more favorable for others depending on their individual biological requirements. So for effective cultural control significant information about the pest is required. Cultural methods of pest control present no toxicity or residue problems and harmful effect on non-target organisms are minimal. Unfortunately the applicability or cultural methods for some pests is limited and because cultural control is often preventative in nature, it is usually necessary to plan ahead to prevent a pest problem using rather than take action after it has developed (Wood,1974; Fenemore,2006).

The use of natural enemies to supper pest species is called as biological control. Natural enemy concerned principally to parasites and predators but may also include disease organisms. Sometimes it is called microbial control. The three distinct types of biological control procedures that can be applied using parasites, predators and disease microorganisms are as follows:

1. **Inoculation:** Involves the introduction of new species of parasite predators as disease micro-organisms into areas where they did not previously occur.
2. **Mass rearing & release**: (augmentation) deals with rearing large number of a parasite or predator already present in an area and relating them into field situations at appropriate times to give short form local control.

3. **Conservation & encouragement**: Conservation of inoculated natural enemies of pest by careful selection of insecticide which will be more harmful to predators than that of pest. It will lead to rapid depletion in number of predators.

   Encouragement for development of predators for successful (manipulation) pest control is very much important. For example parasitic wasp requires nectar for their successful reproduction. For that some suitable flowering plants should be made available.

   In biological control sometimes insect pathogens are also used for successful pest control. Though Biological control plays important role in modern pest control program but can provide control against indigenous pests. A further difficulty is that the degree of control provided by natural enemies is rarely adequate for pests which cause injury directly to the harvested portions of crop. Horticultural produce in particular must be blemish free for market acceptability and the high standards of pest control necessary to achieve this cannot usually be provided by biological means. In other situations however particularly in indirect agricultural production systems lacks many of the problems associated with chemical control procedures (Eilenberg and Hokkanen, 2007; Fenemore, 1992).

   Plant resistance is another form of pest control. It is particularly attractive approach to pest problems. In low value crops which may not generate sufficient profit to justify more costly measures. Plant persistence provides only partial control which enable the number of insecticide applications normally applied to a crop to be reduced by half or more, resulting in considerable cost saving. It also provides acceptable level of control by Biological control.

   In addition to the main methods of dealing with pests there are another methods like mechanical control, physical control, the sterility principle in pest control. The mechanical Control deals with mechanically trapping or killing insects or the provision of barriers to prevent insects gaining access to plants or other materials for
e.g. Man milling mechanical means of pest control are obviously of limited application but can be highly effective in appropriate circumstances.

In physical control where some physical factor in the environment may be mediated to prevent or minimize a pest problem for e.g. light traps in night flying insects.

Another one is sterility principle in pest control. In this the insect’s pests are reared & then large no of sterile individuals are released so that the used population is outnumbered & suppressed. Methods used for sterilization are irradiation and various forms or genetic incompatibility (Woods, 1974).

Plant & animal quarantine programs for control is deals with application of restrictions on the international movement of plant & animal material to minimize further spread of pests (Fenemore, 2006).

**Integrated pest management (IPM):**

In 1956 B.R.Bartlett coined the term integrated control. In 1979, Brader define “Pest management as a system that is associated with environment and population dynamics of the pest species utilizes all suitable techniques and methods in as compatible manner as possible and maintains pest population at levels below those causing economic injuries”.

“Integrated pest management” in short called as IPM is really no different meaning from the shorter term pest management. IPM in the broadest sense embraces all “pests” of a given crop-insects, weeds, nematodes and plant diseases. It considers the interacting factors of the environment, including effects of adjacent crops and cultural practices, upon the crop and its pests.

Pest management is fundamentally different from the other approaches to pest control in that it aims-

a) To utilize two or more control techniques together in an integrated fashion,

b) Utilization of natural mortality factors, and

c) To apply specific control when necessary.

An essential feature of the pest management is regular sampling of pest and beneficial species and monitoring the crop developmental factors.

Necessity for the integrated pest management is because following reasons-
1. Development of resistance to chemicals in pest populations
2. Outbreaks of secondary pests,
3. Resurgence of treated populations,
4. Unacceptable residue problems,
5. Destruction of beneficial predators, parasites and pollinators,
6. Hazards to personnel involved in insecticide application, domestic animals and wildlife, and
7. Expense of pesticides, involving the cost of material and labor and maintenance of equipments.

The essential components of the pest management are as follows-

- a. Understanding agro ecosystem:
- b. The determination of pest damage thresholds and economic thresholds.
- d. A decision making framework to determine action to be taken.

**Plants as ecofriendly Pesticides:**

Pesticides are substances which can be used to control various types of pests.

There are various types of pesticides; each is responsible for controlling specific pest. The term ‘Pesticide’ can be split into two words,

- 1. Pest: Any organism which causes harm to human health as well as its wealth and
- 2. Cide: means to kill,

So, it means that pesticides are those substances which are used to kill various types of pest. Such pesticides are grouped as Biological and Chemical. These pesticides can be grouped into seven on the basis of the pest they control, insecticides (insects), Herbicides (plants), Rodenticides (Rodents), Bactericides (Bacteria), Fungicides (Fungi) and Larvicides (Larva).

These pesticides kills pest by entering in their body through dermal, oral and respiratory tract. For e.g. insect’s breaths by their spiracles, so the pesticide will enter through their spiracles and kills them. These pesticides mostly used are chemical in
origin. These causes various problems viz. pest resurgence, pest resistance, effect on useful organisms etc.

Thus to solve the problem of long term effects of synthetic pesticides; there is need to search an ecofriendly and cheaper; natural pesticides while maintaining crop fields.

This forced researches towards natural products which can be used as pesticides. It revealed that medicinal plant can be excellent alternative to such synthetic pesticides. They are safe and eco friendly. These are also biodegradable and environment friendly (Isman and Machial, 2006).

Volatile oils, having components which smells strongly, give specific odor, flavor as well as scent to herbs is called as Essential oils. These are also called as secondary metabolites of plants which are volatile. These shows following characteristics;
1. Insect attractant/repellent,
2. Heat and cold protectant, and
3. Defensive due to chemical constituents in it (Koul et al., 2008)

In Mediterranean region and in southern Asia, various plants are used for protection of storage products. The interest in oils was increased after the discovery of fumigation technique because of their insecticidal activities (Isman, 2000). Some of oils showed the rapid action which suggest neurotoxic mode of action. These oils are non-harmful to mammals, Pisces as well as aves (Strohe et al., 1998)

Several oils such as lemon grass, rosemary, clove and thyme has pest control properties. Other oils such as peppermint; spearmint and basil are effective repellent and also effective against fungal pests (Kordali et al, 2005).

For more than fifty years citronella essential oil were used as insect repellent and animal repellent, combination of citronella with other found to be effective against indoor insect pests. This insecticidal activity of citronella is due monoterpenic components (Zaridah et al., 2003).

Catnip (Nepeleacateria) most effective essential oils against mosquitoes; bees and other flying insects as repellent than DEET.Nepetalactone was found to be its active ingredient that acts as effective repellent. It is also effective against; yellow fever causing mosquito; Aedesaegypti, Larvicidal activity (LC50=93.19-150.0 ppm) was found
against *A. aegypti* and *Culexquinquefasciatus* say after treatment by oil of *Trachyspermum* sp. (Vrushali et al., 2001)

Similarly essential oils of *Ocimum sanctum; Satorrejahortensis; Thymus serpyllum* and *Origanumcreticum* found effective as larvicide against *S.litura* (Sharma, et.al, 2001; Isman, et.al, 2000). Similar studies on *S. litura* done by sharda et al. (2000) and Tripathi et al., (2003) using *Agerantumconyzoides* and *Aeglemarmelos* essential oils respectively.

Oil obtained from turmeric (*Curcuma longa*) leaves rich in d- phellandren which acts as inhibitor of growth and larvae killer against *S.obliqua* (Agrawal et al., 1999). In combination with ginger oils growth inhibitor activity against mycelia of a fungus *R.solani* was found.

**Insecticides and Growth Inhibitors:**

Insecticides are those substances which kill insects while growth inhibitors are endogenous or exogenous substances which inhibit the normal growth of cells or microorganisms. Lipophilic compounds are primary constituents of essential oils acting toxis, feeding and egg laying inhibitor to various insect pests.

Monoterpenoids with insecticidal properties found effective against *M.domestica* and other couple of insect pest have been reported (Rice and Coats, 1994). Monoterpenoid toxicity against *Coptotermes formosanus* (a subterranean termite) was evaluated by Cornelius et al., (1997).

Ugenol, safrole, isosafrole etc. were best toxic agents and repellents compared to monoterpen. Insecticidal and antigonodal action of *Acoruscalamus* is due its components (Koul et al. 1990: Koul, 1995). Unutilized parts of Turmeric plant, has 2-phellandrene (70%) as active ingredient which acts as growth inhibitor of *S. oblique*.

**Fumigants:**

Are those which produce gas or vapor intended to destroy pests in the region where they are active.

To explore the potential of essential oils as fumigants several studies have been undertaken. Being volatile monoterpenes are most useful fumigant. Linalylarelate and
linalool from *Mentha citrata* oil has good potential as fumigant against rice weevils (Singh et al., 1989).

In comparison with larvae; adults were more susceptible. These studies suggest that Ketones are more effective as fumigants.

**Antifeedants:**

Antifeedants are chemicals that either repells insects without any contact or suppress. Against tobacco cut worm (*S. litura*) citronellal, terpineol etc. are found to be good feeding deterrent (Hummel brunner and Isman 2001). 1,8 – cineole has been also tested for antifeedant activity against *T. castaneum* (Tripati et al. 2001).

Monoterpenes; carvone and dihydrocarvone found in *Curcuma longa* exhibited effective antifeedant activity against grain bovver; *S. oryzae*, red flower beetle, *T. castaneum* (Tripathi et al., 2003). *C. longa* and *Z. officinale* were found good as inhibitor of feeding activity in insects (Chaudhary et al. 2000; Agarwal et al., 2000). Best feeding inhibition found against larval stages of *S. liturawas shown by E.densa; E.piulosa* etc. (Shishir et al., 2004).

**Repellents:**

Insect repellents are substances which repels pest to provide protection to host. These are used against insects such as mosquitoes, ticks, fleas and some flies. DEET (N,N-diethyl-meta-toluamide) found to be most effective insect repellent. These substances works by blocking insect odor receptors for compounds present in certain substances of host such as human sweat.

Only few plants derivatives have been found effective though many of them are tested for their repellency potential (Cockcroft, et.al., 1998). In Laboratory repellency potential against *I. ricinus* was tested by using lemon, eucalyptus, geranium oils (Jaenson, et.al., 2006).

Various plant oils with monoterpenic components have been tested against mosquitoes (*Culex* species) for repellency. Active ingredients such as eugenol, cineole
and citronellal, obtained from essential oils were best against mosquito (A. aegypti) (coats, et.al. 1991).

The important components of C.longa rhizome powder oil are found to be good repellent against pests of stored grains. Constituents found are a Turmerone and ar-turmerone (Chahal,et.al., 2005).

**Oviposition Inhibitors and Ovicides:**

Oviposition is a process of laying eggs via ovipositor. Selection of oviposition site depends upon chemoreceptors. Both stimulatory as well as inhibitory stimuli determine the oviposition behavior of insect (Females). Females directly lay their eggs on food material suitable for their larvae. Ovicides are those substances which Kill eggs of insects and mites.

Plant products were found good when compared to similar structured alcohols. 1-Carvone was found to suppress emergence of larvae from eggs of T.casteneum completely at 7.22 mg/cm² dose.

Manny compounds such as carvacrol, carveol, geraniol, linsloolfenchone; methons, aironellal were tested.

**Attractants:**

Attractants are substances which are used to attract the insect pest so they can be killed to achieve pest control goal. 1,8 cineole, a major essential oil components found to have attractant property against western flower thrips (Katerinopoulos et al.,2005). Lemon essential oil constituents such as terpenes; geraniol found to have attractant effects against various insects.

Greenhouse whitefly has shown high attractiveness towards natural essential oils. While fly reacted vigorously to chandan, basil and grape fruit oil (Gorski, 2004).

**Antifungal Agents:**
Agents which destroy or prevents growth of fungi. Certain active ingredients of some essential oils have been tested for Antifungal activities and found effective.

**Antiviral agents:**

Similarly, CPMV (cowpea mosaic virus), MBMV (mung bean mosaic virus), SBMV (Southern bean mosaic virus) were inhibited by essential oils of *Ageratum conyzoides; callistemon lancedatus, carumcopticum, ocimum sanctum* and *peperomia pellucid* (Rao et al., 1986). Twenty nine constituent found in carrot leaves found to have inhibitory action upto 62% against tobacco mosaic virus (Khanna et al., 1990).

From all above discussion it can be concluded that these plant products can be effectively used in insect pest/vector management. So, in present endeavor some medicinal plants are selected to study their bioactivities against couple of insect pest/vector. These selected plants and insect pest/vectors are as follows:

1. Selected medicinal plants:
   a) *Withania somnifera* (Ashwagandha)
   b) *Curcuma longa* (Turmeric)
   c) *Zingiber officinalis* (Ginger)
   d) *Pelargonium graveolens* (geranium)

2. Selected insect pest/vector:
   a) *Phthorimaea operculella* Zeller. (potato tuber moth-PTM)
   b) *Musca domestica* L. (House Fly)

The selected plant oils known to have medicinal properties hence are safer. Also these do not possess the problem of persistence. If they prove best then there will be duel benefit and help cultivators. These oils were obtained from fromR.K.Aromas, Mazgaon, Mumbai, Maharashtra, India.
Table 1: Selected plant oils

<table>
<thead>
<tr>
<th>Botanical name of plant</th>
<th>Common Name</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelargonium graveolens</td>
<td>Geranium</td>
<td>Antimicrobial, prohibit-inflammation, sedative, Local anesthetic properties (Ghannadi et al., 2012)</td>
</tr>
<tr>
<td>Curcuma longa</td>
<td>Turmeric</td>
<td>Prohibit inflammatory, Spasmolytic, Kills parasites, Kills bacterias, Prohibits arthritics, caminative, Laxative, Tonic, Diuretic (Warrier et al, 1994)</td>
</tr>
<tr>
<td>Withania somnifera</td>
<td>Ashwagandha</td>
<td>Antioxidant, Antimicrobial, Adaptogen, Aphrodisial, Liver tonic, Anti-inflammatory, Antibacterial (Mehrotra et al, 2011)</td>
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Musca Domestica (House Fly):

Vector Musca domestica L. which commonly called housefly is a worldwide known for causing public health problems. Mainly diseases related to digestive tract are caused due to the defecation and regurgitation habit on animal and human food (West, 1951; Howard, 1911). Mainly E.coli, Shigella and Salmonella spp. Which causes disease are spread by house fly (Ahmad et al., 2007; Holt et al., 2007; Nayduch and Stuzenberger, 2001). Houseflies found in nearby area of human habitation and activity as well as animal waste matter (Mian et al., 2002; Sulaiman et al., 2000).

Life Cycle and Description:

The house fly shows Egg, larva, pupa and adults stages during its development, showing complete metamorphosis.

Egg:

Each female lays eggs nearly five hundred in 75-150 batches. Occasionally layssingly. Eggs are white. Measures about 1.2 mm in length. Size and temperature are deciding factors for fecundity of female. Eggs hatch in 8-20 hours. Deposited eggs are kept moist so they can hatch.

Larva:

After 8-20 hours of incubation period eggs hatch into larvae which is also called maggots. Newly hatch larvae are 3-9 mm in length. Dark hook is observed in head region. These creamish white larvae are apodus, cylindrical, tapering towards the head. After emergence they start feeding on a material on which eggs are laid. Larva reaches to its maximum length up to 7-12 mm after passing through three instars. Mature larva is cream colored. Temperature of 35-38°C is good for larval development. In 13 days larvae complete their development. Fully grown the maggot crawl to suitable place for pupation.

Pupa:
Mature larva undergoes pupation to form 8 mm long pupa which is enclosed in pupal case. Pupal case shows various color as it ages. It is rounded at both ends. In two to six days are required by pupa to complete its development. With the help of ptilinum (Swelling and shrinking sac) adult escapes from pupal case.

Adult:

The male and female adult flies can be identified by measuring distance between eyes (males eyes are very closely placed). Adult house fly measures 6-7 mm in length. Female is larger compare to male. Head contains reddish eyes and sponging and lapping types of mouth parts. Thorax has four narrow black stripes, abdomen is gray or yellowish. Adults live about 15-25 days. These flies are active during day time.
Phthorimaea operculella Zeller. (Potato tuber moth-PTM)

Potato tuber moth belonging to Lepidoptera order was reported first in Australia (1854) damaging potatoes. Even though there are some quarantine measures it found to occur in more than 90 countries. PTM is distributed all over the world. 6-8 are observed in summer on field.

Life Cycle and Description:

In life cycle of potato tuber moth four stages are included are:


Silver grey body color, wings with brown grey pattern can be observed in adult potato tuber moth. It has 10 cm body length and 12 mm the wingspan. Mainly at dusk moths are active while at day they can be observed flying spontaneously within potato crop.

On the underside of potato leaves oval eggs are laid singly. Eggs can be seen laid open potato tubers also. At beginning eggs are white which gradually changes to yellow and finally turns black.

The larvae is also called caterpillar. The caterpillar is 1-2 mm long when hatched and reaches to 15-20 mm in length after 4 instars. Grey or yellow white color observed in young larvae. While mature, healthy larvae show slightly pinkish or green color. All caterpillars have brownish head. Silken cocoons with pupae inside shows camouflage for protection. They are covered with soil particles. Pupation takes place between falls leaves of potatoes, insoil or even in stored potatoes.

Table 2: Life cycle period of Potato tuber moth.

<table>
<thead>
<tr>
<th>Egg</th>
<th>1st Instar</th>
<th>2nd Instar</th>
<th>3rd Instar</th>
<th>4th Instar</th>
<th>Pupa</th>
<th>Oviposition</th>
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<tbody>
<tr>
<td>4-5 days</td>
<td>3-4 days</td>
<td>2-3 days</td>
<td>3-4 days</td>
<td>3-4 days</td>
<td>5-6 days</td>
<td>15-20 days</td>
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Host plant range is limited to Solanacea family. It is a major pest of potato which is economically important crop. It can be observed on other plants such as tobacco, eggplant, sometimes on tamarillo leaves.

Larvae found to damage extensively to both foliage as well as tubers. They spend their entire lives on leaves and tubers. Only in case of total foliage destruction larvae are forced to search tubers. Thus foliage destruction leads to destruction of plant. These larvae enter tubers through eyes and destruct the tuber by extensive tunneling. These infested tubers show mounds of dropping at the entrance of tunnels. Higher infection occurs during summer season. In stored potatoes these moth breeds throughout the year. The length of life cycle is found to depend on temperature.