① NRCIPM – 12-feb 1988 at new delhi.
↳ National Research Centre for Integrated Pest Management.

② Tree banding → use for control of mango mealy bug

③ DPPQ and S → Directorate of Plant Protection, Quarantine and storage.
↓
faridabad, Haryana 1946

④ IIBC → International Institute of Biological Control.
West Indies 1947.

⑤ IOBC → International Organization for Biological Control.
Zoric Switzerland.

⑥ NBAIR → National Bureau of Agricultural Insect Resources, Banglore.
↳ Rename in 12th five yr.

formerly called → National Bureau of Agriculturally Important Insects (NBAII).

⑦ CIBC → Commonwealth Institute of Biological Control 1957.

⑧ Silent Spring → Rachel carson
↳ Book.

⑨ Biological control of insect, pest and weed → Paul de Bach

⑩ Control of weed by Biological agent is called → Para Biological Control.

⑪ Destructive Insect Pest act → 1914.

⑫ Insecticide act was enacted by govt of India 1968 & came into force in 1st Jan 1971.

(13) CAZRI → Central arid zone research Institute 1959. New delhi.

(14) CIMAP → Central Institute of Medicinal & Aromatic Plants, Lucknow.

(15) FRI → Forest Research Institute (Dehradun)

(16) NBPGR → National Bureau of Plant Genetic Resources New delhi.

(17) IIPR → Indian Institute of Pulse Research (Kanpur)

(18) IARI - Indial Agricultural Research Institute. New delhi

(19) ICAR - Indian Council of Agricultural Research New delhi

Principles of Integrated Pest & Disease Management

Pest :- Any living organism which causes crop loss, economic loss of human welfare, including crop, livestock, dairy, etc.

- A pest is an organism which harms man or his property significantly or is likely to do so. ~ Woods, 1976.
- A pest is any organism which occurs in large numbers and conflict with man's welfare, convenience and profit.
- Pest are organisms which impose burdens on human population by causing :-
  1) Injury to crop plants, forest & ornamentals.
  2) Annoyance, injury and death to humans & domesticated animals
  3.) Destruction or value depreciation of stored products.

→ Pest include :- insects, nematodes, mites, snails, slugs, etc. & vertebrates like → rats, birds, etc.

→ Depending upon importance Pest may be → agricultural, household, forest, medical and ~~not~~ veterinary pests.

Parameters of Insect Population levels :-

1) **GEP :-** General Equilibrium Position
   - Average density of population over a long period around which pest population fluctuated by biotic & abiotic factor which is and in absence of permanent environmental change.
   - low population.
   - not harms.
   - abiotic factor - water, temperature, air, humidity, soil components
   - biotic factor - living organisms of biological components

2) **ETL :-** Economic Threshold Level
   - Population density at which control measures should be implemented to prevent an increasing pest population from reaching ETL. also called Action Threshold.

ETL = EIL - daily reproductive rate of insects.

- high population of pest.

3) EIL :- Economic Injury level.

- lowest population density that will cause economic damage.

4) DBL :- Damage Boundary

- The lowest level of damage which can be measured.

GEP > EIL > ETL.

- provides sufficient time for control measures.

Categories of Pests

1) On the basis of occurence / season & locality :-

(1) Regular Pest :- frequently occurs in a crop & have a close association with that particular crop.

eg :- • Rice stem borer.
• Brinjal shoot & fruit borer.

(2) Occasional Pest :- Infrequently occurs, and no close association with a particular crop.

eg :- • mango stem borer.
• rice ear worm

(3) Seasonal Pest :- occurs mostly during a particular part of a year. usually governed by climatic conditions.

eg :- • rice grasshopper - June - July.
• red chilly caterpillar on groundnut - June - July.

(4) Persistent Pest :- occurs on a crop throughout the year and is difficult to control.

eg - chilli thrips.

(5) Sporadic Pest :- Pest occurs in isolated localities.

eg - rice earhead bug.

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2) On basis of level of injectation

① **Epidemic Pest** :- sudden outbreak of a pest in a severe form in a region or locality at a particular season or time only.
eg- • Rice hispa
• Rice leaf roller.

② **Endemic Pest** :- occurs regularly and confined to a particular area & locality.
eg.- • rice gall midge in madurai district.
• rice stem borer cauvery delta.

3) On Basis of Damage Potential :-

① **Key Pests** :-
- There are most severely damaging pests.
- GEP > EIL always.
- human intervention may bring the population temporarily below EIL. but rises back rapidly.
- There are persistent pests.
- The environment must be changed to bring GEP below EIL.

eg- • cotton bollworm. } in cauliflower & cabbage.
• diamond backmoth

② **Major Pest** :- (EIL > ETL).
- population ~~to~~ crosses EIL quiet frequently.
- economic damage can be prevented by timely & repeated sprays.

eg- • rice stem borer
• cotton jassids.

③ **Minor Pest** :- EIL < ETL.
- pest with population rarely crosses EIL. & fluctuates around ETL.
- (5-10% damage) single application of insecticide is enough to control damage.

④ **Potential Pest** :- • These pest do not cause any economic damage.
• Any change in ecosystem may make them to cause economic damage.

5.) Sporadic Pest :- GEP < EIL generally.

- population is negligible.
- but under favorable cond" they appear in epidemic form. crossing many times over DB & EIL.
- pest has to be controlled by management strategies.
- These pest are → highly sensitive to abiotic conditions. eg- cut worm, grasshopper, hairy caterpillars.

History of IPM

1) "Integrated control" → Michelbacher & Bacon (1952).
2) defined "integrated control as" applied pest control which combines and integrates biological & chemical control" — Stern et al (1959).
3) ~~Geier~~ "Pest management" → Geier (1966).
4) Integrated Pest management → R.F Smith & R. van den Bosch. (1967).
5) IPM adapted for managing pest of landscape trees & shrubs in Urban areas. → 1970's - 1980's.
6) IPM task force → 1989.
7) IPM working group (IPMWG) was constituted to strengthen implementation of IPM at international level → 1990.
8) awarded world food Prize for pioneering work on implementation of IPM → Smith & Adkinson (1997).

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Definition of IPM by Food & Agricultural Organization (FAO, 1967)

IPM is a pest management system that, in the context of associated environment & population dynamics of pest species, utilizes all suitable techniques & methods in as compatible manner as possible & maintain pest population at levels below those causing economic injury.

3 aspects are ~~emphasized~~ :-

1) Multiple control tactics use in compatible manner.
2) The populations maintained below levels that cause economic damage
3) Socio-economic & eco-friendly to the environment.

Concepts of IPM :-

1) ~~Understanding the agricultural ecosystem~~ :-

IPM seeks to minimize the disadvantages associated with the use of pesticides & maximizing socio, economic and ecological advantages.

1) Understanding the agricultural ecosystem :-

An agro ecosystem contains a lesser diversity of animals and plant species than natural ecosystem like forests.

- A typical agro ecosystem contains only 1-4 major crop species and 6-10 major pest species.
- An agroecosystem is intensively manipulated by man & subject to sudden alterations such as ploughing, intercultivation, and treatment with pesticides.

2) Planning ~~and~~ of agricultural ecosystem :-

- growing susceptible varieties should be avoided & related crops should not be grown.
- eg - groundnut followed by soyabean increases incidence of leaf miner.

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3) Cost benefit Ratio :-

- Predicting pest problem and defining economic threshold level.
- Estimate benefit risk analysis and its impact on society as well as environment. relevant to its benefits.

4) Tolerance of Pest damage :- By estimating pest population.

* Castor crop can tolerate upto 25% defoliation.

a) ETL :- (or TL) Economic Threshold level :-

- The lowest population density at ~~which the pest~~ that will cause economic damage. ~ Stern et al 1959.

OR

- The pest level at which the damage can no longer be tolerated and therefore it is the level at or before which the control measures should be initiated.
- The amount of injury which will justify the artificial control measures is called as economic damage.
- expressed as. no. of insects / unit area.

b) Economic threshold level :- (ETL).

- It is defined as the population density at which control measures should be applied. to prevent increasing pest population from reaching the EIL ~ Stern et al (1959)
- Relationship b/w EIL and ETL → expressed as when no action is taken at ETL the population exceeds EIL.

eg - ETL value of BPH in rice is 25 insects / hill.

c) General Equilibrium Position (GEP) :-

- It is the average population density of insect over a long period of time unaffected by temporary interventions of pest control.
- EIL may be at any level, EIL > GEP or EIL < GEP. above or below GEP.

Importance of Pest Management :-

1) Fits better in National Economy :-

Pest control activities at present are mainly based on the application of chemical pesticides., large proportion of which has to be imported.
Thus a time has come where IPM is not only advisable but also inevitable.

2.) More efficient & cheaper method :-

- use of pesticides is an efficient method to control pest, but
- sometimes mechanical method like destruction of egg masses, collecting caterpillar stages. saves use of pesticide and money and foreign exchange & also destruction of pest before it has been able to inflict damage.

3) Avoid upsetting & balance of nature :-

- Chemical problems ~~~~ cause imbalance of nature and leads to formation of new pest problem which did not exist before.

for eg- resurgences of mites in many parts of world caused by use of DDT.

- so adopt IPM.

4.) Minimizes residue hazards of pesticides :-

- In an IPM, use of pesticides will be reduced, hence the pesticides residue hazards will automatically be reduced.

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5) Leaving a pest residue :-

- It is an important concept of pest management, to leave a permanent pest residue below ETL. So that natural enemies will survive.

6.) Timing of treatments :-

- Treatment of perticide spray should be need based.
- with minimum no. of sprays.
- Timely scheduled.
- Combined with improved techniques of pest monitoring & crop development.

eg- Use of pheromone traps for monitoring of pest population.

7) Public understanding and acceptance :-

Communication to people for effective pest management & acceptance of pest management practices.

- Should be economical & sustainable.

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Principles of IPM :-

1) Consideration of Ecosystem :- control of pest population is a control of ecosystem itself by means of natural enemies.
Study of individual behaviour to biotic factors in the environment is the prime importance.

2) Pest surveillance :-

- Surveillance / monitoring means constant observation of a subject. i.e. crop or pest.
- and recording the factors observed, compilation of information obtained & prediction of future events about pest population.

3 basic components :-

a) Determination of level of incidence of pest species.
b) Determination of what loss the incidence will cause
c) Determination of economic benefits control will provide

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3) Utilization of ETL :-
Pest population maintained at below those causing economic injury.

4.) Application of minimum selective hazards :-
to keep target pest population just below EIL
1) given in vulnerable life stage of pest
2) apply in such a way where it restrict its ~~destructi~~ distribution to the area where needed.

5.) Key pest Identification :-
Identify and prioritize the most damaging pest in the ecosystem, focusing control efforts on them.

6) Management strategies :-
biological - introduce natural predators / parasite to control pests
cultural - crop rotation, planting resistant varieties.
mechanical - traps, physical barriers.
chemical - only use pesticide when necessary, following IPM.

7) Assessment technique :-
Regularly monitoring & assess pest populations using traps, data collection, visual inspections.

8) Predictive pest models :-
use data and models to predict pest outbreaks based on factors like weather, crop type & historical data.

Requirements of successful pest management programme :-

1) correct identification of pests
2) life history & behaviour of pests
3) Natural enemies & weather factors affecting pest population.
4) Pest surveillance will provide above data
5) Finding out ETL for each pest in a crop
6) Government support
7) Farmer's awareness & participation.
8) Consumer awareness on use of pesticides free products.
9) Selection of suitable methods of control.
10) Need & Timing of control measure.
11) Analysis of benefit/risk & cost/benefit of each control measure
12) Predicting pest outbreak & pest forecasting.

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Economic Importance (Beneficial & harmful) of Insects

- They have adapted to survive in all kinds of environment & feed on any substance with nutritional value.
- Though we have mostly labelled insects as pests but in some parts of Asia & Latin America, insects like ants, crickets, grasshoppers, etc, → are essential food sources.
- The majority of insects grow in warm & moist places but also found in extreme climates like arctic woolly bear moth of arctic regions.

Insects make a crucial part of our ecosystem with important functions they carry out:-

- pollination, Soil aeration, feeding on harmful pests hence regulating their growth.
- With this, they make perfect economical tools for food, pharmaceutical & agricultural industries

Commercial aspects of insects in our life & how we benefit from them :-

I) Ecological importance of insects :-

- pollination, soil aeration, pest control → these functions of insects make them as beneficial purposes.
- Insects feed on dead organic matter & recycle nutrients in the environment. eg - beetles.
- act as decomposers → creates top soil layer with rich nutrient
- ants, beetles → dig the soil → creates water channel.
- bees, wasp, ants → Pollinate flowers.

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2) Essential Insects :-

- butterflies – • good indicator of healthy environment
  • pollinate flowering & citrus plants.
- Dragonflies – • natural pest controller of environment
  • great indicator of clean aquatic system.
- grasshoppers – • rich in protein (use by nutrient source by human).
  • prey by birds.
- Ants – • soil aerators, scavengers feeds on dead organic matter, helps in recycling nutrients.
- Honeybees – • great cross pollinator.
  • wild honey is widely commercialised as nutrient rich food source.

II) Economic Importance of Insects :-

- high imp. to nature as well as mankind.
- eg- honey, honey wax from honeybees (Apis spp) is cultured by humans.
- Silk from silkworms → for beautiful clothes, good for maintaining body temperature, good for skin.

→ Insects in food Industry :-

- Apitoxin and Melittin – from honeybees – relieve pain, swelling
- Cantharidin → fatty acid extracted from beetles – treat cutaneous warts.
  (tumor fighting substance that attacks infected cells).
- they are rich in protein, vitamins, minerals, fibres etc.
- processed insects into flour, pasta, snacks, fitness bars.
- Chitin & Chitosan – rich in dietary fibre.

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→ Insects in Pharmaceutical Industries :-

- Insects like mealworms (Tenebrio molitor), leafworms (Spodoptera littoralis), silkworms (Bombyx mori) observed to have angiotensin-converting enzyme (ACE) inhibitors which are use in drugs for treating high B.P.
- Antimicrobial peptides (AMP) like allojerous, defensin from ants, wasps → helps in fighting against bacterial, fungal & viral infections.
- Silkworm coccoon., formation protein fibroin → lowers obesity.
- Insects produce antioxidant enzyme ~~catalyses~~ catalase.
  ↳ helps in metabolism & in food storage.

→ Insects in the Cosmetics :-

↳ Mexico & S. America

- Carmine dye - red colour dye use in cosmetics.
  ↳ obtained from female insect Dactylopius coccus.
- Shellac - is a resin obtained from ~~co~~ lac insects - Laccifer lacca.
  ↳ in nail polish remover, mascara, hair spray, eyeliner. (Thailand & India).
- Beeswax & honey → soften, moisturise & heal skin tissues.
  ↳ in face wash, face scrub, lip balm, conditioners.
- A product "Point 68" → contain insect oil which improves skin hydration, cellular healing → from locusts, crickets, spider flies.

Insects in the agriculture :-

- World's agricultural production is damaged by :-
  (aphids) herbivorous insects → 18% (approx)
- Around 72% of world's crop depends on pollinator insects.
- * 2 Important roles insect play in the enhanced quality & production of crop → include → pest control &
  → pollination

Harmful Insects :-

1) Pest of plants, fruits & stored grains :-

- Insect feed on green plants & crops such as leaves, buds, flowers, stems, fruit, seed.
- Several stored products such as wool, feather, cigars damage by insects.
- eg - Locusts → damages whole crop in field.

2.) Household pests :-

- Several insects living in our houses like bedbugs, mosquitoes suck our blood.
- live in our house as unwanted guests & destruct our household products, ants, cockroaches, spider, termites, silverfish spoils food, damage cloth, book and woods of window, door.

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3) Injurious to domestic animals :-

- affect domestic animals as parasites, some are ectoparasites like → fleas, lice, bugs, mosquitoes.
- endoparasites → bolt fly larvae in sheep.
- bird lice feed on feathers of chicken, causing irritation & loss of flesh.
- spread food & water borne diseases in human
  ↳ housefly → contamination in food & water by eating / drinking this food causes cholera, diarrhea, etc.

4) Disease carriers or an intermediate host of several pathogens :-

- several insect act as host of several pathogens & transfer disease from one pathogen to human to another.
  ↳ this is called as Vector

Some insect which act as vector are :- / secondary host of pathogen

a) Anopheles mosquitoes :- female anopheles transfer malarial parasite "Plasmodium" from one human to other.
- If we control this mosquito we can control malaria.

b) Aedes mosquitoes :-
Spread yellow fever & dengue, means spread viral fever.

c) Culex mosquitoes :- filariasis spread by this mosquito.

d) Housefly (Musca) :- food & water borne diseases
Cholera, diarrhea etc.

Cultural method of Pest management :-

- The 1st reference on the use of cultural control practices in India is found in the Book :-
  "The Agricultural Pests of India & of Eastern and Southern Asia". ~ by Balfour (1887).

- Some other practices like mixed cropping, ~~hand~~ hoeing, use of trap crop, etc → by Maxwell-Lefroy in his book "The Indian Insect Pests". (1906)

- gave the pride of place to various cultural control practices - by Ayyar (1938) book → "Handbook of Economic Entomology for South India.

Cultural Practices :-

1) Tillage / Proper Preparatory cultivation :-
eg - cutworms, red hairy caterpillar
several insects which hide in soil get exposed to sun & predators like birds by ploughing / preparatory cultivation.

2) Growing Resistant varieties :-
eg - IR-36, IR-64, MTU-5249 → resistant to paddy BPH.

3) Seed Rate :- • use of high seed rate recommended in those crops where removal of infested plant is helpful in minimizing the insects.
eg - maize borer in maize.

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4) Planting time :- ~~Timely~~
• early planting reduces gall midge, leaf folder damage in rice.

5) Plant spacing :- closer spacing → increases the population of BPH, WBPH, leaf folder etc.

6) Fertility management :- high levels of N fertilizers increases insect pests like leaf folder, yellow stem borer, Hispa, BPH, WBPH, whorl maggot etc. in rice field.

7) Water management :-

flooding fields :- flooding of fields is recommended for reducing attack of cutworms, armyworms, termites etc.

draining fields :- draining rice fields for 3-4 days during infestation controls BPH & whorl maggot.

8.) Crop Rotation :- crop provides food for insect-pests. & if food is abundant all round the year pest will multiply & flourish.
• so adopt crop rotation
• eg - Cereals followed by pulses.

9) Intercropping :-
eg- Tomato intercrop with cabbage reduces egg laying of Diamondback moth.

10) Changes in system of cultivation :-
• change of banana from perennial to annual crop reduced the infestation of banana rhizome weevil Cosmopolites sordidus & also give increased yields.

11) Harvesting Practices :- Selective harvesting, strip harvesting suppress the variety of insect pests / conserving natural enemies.

16) Rouging - Removal of off type & volunteer plants.

12) Sanitation :-

Clean cultivation / weed management :- removal of weeds which act as alternate host, reduce insect pests.

eg - mealy bug in cotton removed by removal of weed which is alternate host of mealy bug.

13) Thinning & Topping :- Topping of cotton removes the eggs of Helothis ~~agm~~ armigera.

- Unhealthy & infested plants removed through thinning.

14) Burning / Removal of infect parts :-

Burning of dried branches of citrus eliminates scales & stem borer.

15) Trap cropping :- attract natral enemies thus having natral control.

can be of same or diff family than of main crop.

2 types of trap cropping

Border trap

- surrounds the main cash crop.
- prevent pest attack that come from all sides of main field.

eg - Trap crop cowpea, main crop groundnut, pest control leaf miner.

Row intercropping

- ~~Crop~~ planting trap crop in alternating rows within the main crop.

Advantage of Trap cropping -

1) lessen the use of pesticide
2) lowers pesticide cost
3) additional yield from trap crop
4) Improve crop quality
5) preserves indigenous natral enemies.

Tips for succesful trap cropping

1) monitor plants regularly
2) select trap crop that are more attractive to pest than main crop
3) be ready to sacrifice trap crop due to high infestation
4) destroy trap crops if infestation is high, otherwise they serve as a breeding ground & pest will attack rest of the field.

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CHEMICAL Control

- Control of insects with chemical is called as chemical control.
- **Pesticide**

chemicals which kill pests

eg- insect, animals, mites disease or even weeds

- includes nematicides kills nematodes

Insecticide

chemicals which kills insects.

- substance or mixture substances to kill insects.

Rodenticides- kills rats

Weedicides kills weeds.

Fungicides kills fungus.

general properties of insecticides-

- available in concentrated form which are to be diluted
- highly toxic available in different formulations.

Toxicity terms use to express the effect on mammals

1.) Acute toxicity - produced by single dose of toxicant

2) Chronic toxicity - produced by accumulation of small amounts of toxicant over a long period of time.

3) Oral toxicity - by consumption of pesticide orally.

4.) Dermal toxicity - produced when insecticide enters through skin.

5.) Inhalation toxicity - produced when poisonous fumes of insecticides are inhaled (fumigants).

(CHEMICAL control continues...)

Classification of Insecticides:-

① Based on Origin & Source of Supply:-

Inorganic
- mineral compounds & elemental sulphur.
- include Arsenate & flourine.
- Zn phosphide → as rodenticides.

Organic Insecticides
- Animal origin →

② On the basis of mode of entry of insecticides into the body of insect:-

into 4 types:-

Contact poisons
- enter into insect body through spiracles, trachea and cuticle & kills them.
- eg- HCH & Phoalone.

Fumigants:-
- Fumigation is a process of subjecting ingested material to toxic fumes/vapours/gas which have insecticidal properties.
- enters in body of insect through spiracles in trachea.
- chemical used in a fumigant in a airtight container/room is called as fumigation chamber/ fumigatorium.
  - eg- SO_2 by burning sulphur in godowns → SO_2 fumes are released.
  - 1) ethyl dibromide (EDB)
  - 2) EDCT → (Ethylene Dichloride Carbon Tetrachloride)

Stomach poisons
- enters the body of insect through food & kills it
- eg- Bacillus thuringiensis

systemic insecticides
- chemicals move into the vascular systems of plants irrespective of site of application & poisoning insect that feeds on plants.
- eg- Phosphamidon

Non-systemic insecticides:-
- do not possess systemic action
- they have ability to move from one surface of leaf to other.
- also called Trans-laminal insecticide.
- eg- Malathion, Diazinon.

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An ideal systemic insecticide quality are:-

1) Should have high intrinsic pesticidal activity
2) sufficiently soluble in H_2O for translocation through vascular system.
3) Should degrade to non-toxic form in reasonable time to avoid toxicity to consumer
4) toxicant should be stable for long period to exercise resideual effect
5) must be adequately liposoluble for it to be absorbed by plant system.

→ Systemic insecticide applied as:- seed dressing, sprays, granular formations., etc.

in leaf entry is by → stomata, cuticle.
on stem → lenticels, & cracks in cuticle.
in seed → seed coat (mycropyle).

→ it is highly useful against sap sucking, vectors like → thrips, aphids, leafhoppers, whiteflies.

(3.) Based on mode of action:-

1) Physical poisons:- kill insects by exerting physical effect.
eg- heavy oils, tar oils, etc cause → death by Asphyxiation.

2) Protoplasmic poisons:- kills by destruction of cellular protoplasm of mid gut epithelium cells.
eg- Mercury, Copper.

3) Respiratory poisons:- which block cellular respiration & inhibits the respiratory enzymes.
eg- HCN, CO, Rotenone, etc.

4.) Nerve poisons:- which block (AChE) Acetyl cholinesterase & effect nervous system leading death of insect.
eg- Organophosphorous, Carbamates.

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(5) Chitin Inhibators :- Interfere with process of synthesis of chitin due to normal moulting & development is disrupted.
eg- Novaluron, Lufenuron

6) General poisons :- compounds which include neurotoxic symptoms after some period & do not belong to above categories.
eg- Aldrin, Chlordane, Toxaphene.

(4) Based on Toxicity :- (Based on LD50).

Category of insecticide	symbol	oral LD50	dermal LD50	colour of label
1) Extremely toxic	Skull & ~~Poison~~ Poison	1-50	1-200	Red
2) Highly toxic poison	Poison	51-500	201-2000	Yellow
3) Moderately toxic	Danger	501-5000	2001-20,000	Blue
4) less toxic.	Caution	>5000	>20,000	Green

(5) Based on ~~Spec~~ Specificity :-
(1) Ovicides (2) Larvicides (3) Pupicides (4) Adulticides.

(6) Generation wise :-

generation	category of insect
First generation.	Inorganics & Botanicals
2nd "	Synthetic organics.
3rd "	IGR's like MH and JH mimics.
4th "	Anti JH, synthetic pyrethroids.

Toxicity Evaluation of Insecticides

LD 50 (Lethal Dose) :- * in 1952 → finney → gave computation methods.
- It is the amount of toxicant required to kill 50% of the test population
- expressed in (mg/kg) mg → substance of toxicant & kg → body weight of test animal (rat when treated orally / sometimes rabbit. Thats why called mammalian toxicity.
- This is criteria for acute toxicity also called as acute oral LD50.
- In case of insects - LD50 (Median Lethal Dose) → expressed in µg/g.
  µg → toxicant & g → body weight of insect
  eg - Phosphamidon - 28., HCN 1.0, Malathion - 2800.

* ↑ LD50, toxic nature of chemical ↓

BIOLOGICAL CONTROL

- The successful management of a pest by means of another living organism (parasitoids, predators, pathogens) that is encouraged & disseminated by man is called biological control.

* Biological control term was 1st used by → Smith in 1919 to signify the use of natural enemies to control insect-pests.

* Natural control :- The maintenance population numbers within certain upper & lower limits by the action of combination of biotic & abiotic factors as well as the characteristics of species under consideration is called as natural control.

* 1st time use of insect predators was in 900 AD, when Chinese citrus growers use red ant (Oecophylla smaragdina) on citrus trees to control citrus leaf chewing insects.

Techniques in biological control :-

① Introduction / Classical biological control :-

- introduction of natural enemies where they did not occur or originate (new locality) naturally.
- After their establishment in new are they are use to control insect pest population.

eg- Pest - cotton cushion scale, Icerya purchesi
Predator - n Vedalia beetle, Rodolia cardinalis

② Augmentation :-

- It is defined as the increase of population of natural enemies either by propagation and release or by environmental manipulation.

There are 2 approaches to augmentation :-

1) Inoculative release
- large no. of individuals are released only once during the season.
- natural enemies reproduce & increase their population for that growing season.
- hence, control is from the progeny or subsequent generations.

(2) Innudative release
- It involves mass multiplication & release of natural enemies periodically when pest population approach damaging levels.
- They are not expected to reproduce, control is by natural release.

(3.) Conservation of natural enemies :-

- It is defined as action to preserve and release natural enemies by environmental manipulations or by non-use of those pest control measures that destroy natural enemies.

Important conservation measures are :-

1) Preservation of inactive stages of natural enemies
2) Providing alternate hosts for natural enemies
3) Cultivation of varieties that favour colonization of natural enemies
4) Provide pollen & nector for adult natural enemies
5) Use selective insecticide which safe for natural enemies
6) Avoid cultural practices which harm natural enemies. & use favourable cultural practices.

Parasite :-

- is an organism smaller than the host.
- single individual usually doesn't kill the host.
- It is one which attatches itself to the body of other living organism either externally or internally & gets nourishment and shelter atleast for short period if not for its entire life cycle. eg (Lice).
- organism which is attacked by the parasite is calle host.

Parasitism :- It is the phenomenon of obtaining nourishment at the expense of the host to which the parasite is attatched.

Parasitoid :- It is an insect parasite of an arthropod, parasitic in only immature ~~eggs~~ stages, destroys its host in the process of development and free living as an adult. eg- Braconid wasps., Trichogramma japonicum

Primary parasite - such parasite attacks on Phytophagous insect (Beneficial to man)

Hyperparasite/Secondary parasite - attacks on primary parasite (harmful to man)

Autoparasite - in some species of insect, male insect attacks on female & insect of its own species

Qualities of a succesful parasitoid in Biological control Programme

1) Should be free from hyperparasitoids
2) Should have high sex ratio
3) Should bring down host population within 3yrs.
4) Should have good searching capacity of host
5) able to multiply faster than the host
6) life cycle must be shorter than host
7) quick dispersal of parasitoid in locality.
8) should be amendable for mass multiplication in labs
9) Should have more fecundity.
10) should be adaptable to environmental conditions in new locality
11) survive in all habitats of the host
12) Should be specific to particular species of host

Succesful / Classical examples of biological control:-

1) 1929-1930 - Rodolia cardinalis (Vedalia beetle) obtained from California & Egypt for control of Icerya purchasi (Cotton cushion scale) at Nilgiri
2) Gambusia fish against mosquitoes.
3) Duck against army worm & striped bug in rice.
4) Chrysopela carnea against Aphids.
5) Egg parasitoid Trichogramma australicum against early shoot borer of sugarcane.

Agri Gyaan Studies/Avi Jain notes

Classification of Parasites :-

① Depending on nature of host :-

i) Zoophagous – that attack animals (Cattle pests)
2) Phytophagous – attack plants (crop pests)
3) Entomophagous – attack insects (parasites)
4) Entomophagous insects - parasitoids.

② Based on specialization of site of parasitisation :-

Ectoparasites
eg - Head louse
- attaches host from outside of the body.
- mother parasite lays eggs in the body of the host and after eggs are hatched larvae feeds from host remaining outside only.

Endoparasites
eg - Braconids & Ichneumonids
- enters body of host & feed from them.
- mother parasite lay eggs either inside tissue of host body or on the food material

③ Depending on duration of attach :-

Transitory parasite
eg - Braconids & Ichneumonids.
- spends few stages of its life in one host and other stages in some other host or as free living organism.

Permanent Parasite
eg - Head louse.
- spends all the life stage on the same host

④ Depending on degree of Parasitization :-

Obligate
eg - Head louse, Bird lice.
- which can live only as a parasite cannot live away from host.

Facultative
eg - Fleas.
- which can live away from host aleast for shorter period.

⑤ Depending on food habits :-

Monophagous
eg - Cronizus nephantidis on Opisina arenosella
- has only one host species and cannot survive in another species.

Polyphagous
eg - Apanteles sp. in lepidopteran caterpillar
- develops on widely different host species.

Oligophagous
eg - Isotema javensis on sugarcane & sorghum borers.
- which has very few host (more than one host) both but all are closely related.

(6.) Based on stage of host :-

eg - host - cotton black headed caterpillar.

TAMGESTT.

(i) egg parasite - Trichogramma australicum
2) early larval parasite - Apanteles taragama
3) mid larval - Bracon hebtor
4) Pre-pupal parasite - Goniozus nephantidis
5) Pre-pupal parasite - Stomatocerus sulcatiscutellum
6) Pupal parasite - Tetrastichus ~~is~~ israeli

Kinds of Parasitism :-

1) Simple parasitism - eg - Apanteles taragamae in larva of Opisina arenosella attacks host only once.

2) Super :- eg - Trichospilus pupivora on Opisina arenosella
parasitization of host by more larval of single species that can mature in host

3) Multiple :- eg - Trichogramma attacks on paddy stem borer. ~~stem~~
simultaneous parasitization of host individual by 2 or more different species of primary parasites at same time.

4) Hyper parasitism - eg - Goniozus nephantidis parasitized by Tetrastichus israeli.
parasite itself is parasitized by another parasite.

Tertiary parasite - ~~eg~~ - hyperparasite attacking a secondary parasite (beneficial to man.)

Quaternary parasite - ~~eg~~ A parasite attacking tertiary parasite
(harmful to man)

Agri Groves studies/Avi Jain notes

Predators :- who hunts or kills other organisms for food.

Insect ~~prey~~ predator qualities :-

1) Many have ~~cryptive~~ cryptic colorations & deceptive markings.
2) feeds on many different species of prey (polyphagous nature)
3) well developed sense organ to locate the prey.
4) predator is large compared to its prey
5) consumes large no. of prey in its life time
6) develop separately from prey & may live in same habitat or adjacent habitats.
7) efficient in search of their prey.
8) capacity of swift movements
9) kill & consume their prey quickly
10) predator is ~~not~~ carnivorous in both its immature & adult stages & feed on same kind of prey in both the stages.

Predatism :- Based on degree of usefulness to man predators are classified as :-

1) Entirely predatory - eg- lace wings

2) Mainly predator but occasionally harmful :- eg - Odonata and mantids occasionaly attack honey bees.

3) Mainly harmful but partly predatory :- eg- cockroach feeds on termites

4) Mainly scavenging & partly predatory :- eg- earwigs feed on dead decaying matter.

5) Variable feeding habits of predator :- eg - ~~adult~~ omnivorous & carnivorous but damage by laying eggs.

6) Stinging predators :- eg- spider wasps
nests are constructed and stocked with preys which have been stung & paralysed by mother insect. on which eggs are laid. and then sealed up.

Predator

1) life cycle long.
2) very active in habits
3) stronger, larger, usually more intelligent than the prey.
4) attack on prey is casual & not well planned.
5) may attack several host in short period.
6) seizes & devours the prey rapidly.
7) mouth parts are well developed and organs of 100 common sense.
8) attack on prey for food for attaching predator itself.
9) Habitat is dependent of that of its prey.
10) generalized feeder

eg -

Parasite

1) short
2) sluggish usually
3) smaller, not more intelligent
4) planning is more evident
5) completes development in single host.
6) lives on or in the body of host killing it slowly.
7) not very well developed & sometimes reduced even. Oviposisor well developed & oviposition specialized.
8) It is for the provision of food for offspring.
9) habitat made & determined by the host.
10) exhibit host specialization.

eg -

Agri Grovestudies/Avi Jain notes

Biological control of weeds with insects :-

- Many insects feed upon unwanted weeds, just the same manner they do with cultivated plants.
- As they damage noxious weeds, these insects are beneficial to man. & called as weed killers
- Succesful eradication of weed due to specific insect is achieved

eg- Water hyacinth controlled by Bruchids.

A succesful weed killer :-

1) Should be effective in damaging & controlling the weed.
2) Should be able to multiply without being affected by parasitoids & predators.
3) Should preferably be a borer or internal feeder of weed.
4) Should not be itself a part of cultivated plants.

eg- control of Parthenium hysterophorus by beetle Zygogramma bicolorata

weed	bot. name	biotic agent	origin
Terrestrial weed			
1) Congress grass/ Carrot grass	Parthenium hysterophorus	Zygogramma bicolorata	Mexico
2) Lantana weed	Lantana camara	Ophiyomiya lantanae	Mexico.
3) Prickly pear.	Opuntia dillenii	Dactylopius opuntiae	USA
Aquatic weed.			
Water fern	Salvinia molesta	Cyrtobagus singularis	Australia.

Physical Control

- Modification & physical factors in the environment to minimize or prevent pests problems is called physical control.

(1) **Manipulation of temperature:-**
- Sun drying the seeds to kill eggs & hidden stored pests
- hot water treatment of paddy seeds at 50-55°C for 15 minutes to control rice white tip nematodes
- Cold storage of fruits & vegetables at 1-2°C for 10-12 days to kill fruit flies.

(2)
- Use of burning torch against hairy caterpillar
- Use of flame throwers against locusts.

(2) **Manipulation of air:-** increase CO_2 concentration in control atmosphere of stored grain to cause asphyxiation in stored product pests.

(3) **Manipulation of moisture:-**
- alternate drying & wetting of rice fields to manage BPH, in rice.
- drying of seeds below 10% moisture level. against rice weevil.

(4) **Manipulation of Light:-** behavioral orientation is influenced by light.
- reduced fertility (Indian meal moth).
- Use of light trap to attract positively Phototropic insects.
- Diapause disruption in all diapausing pests.

(5) **Use of irradiation:-** gamma radiation from Co^{60} use to sterilise insects in laboratory.
eg- Cattle screw worm.

Agri Grovestudies/Avi Jain notes

⑥ Use of abrasive dust :-

activated clay - Cause injury to insect wax layer resulting in loss of moisture. leading to death. Use against stored pests.

dri-die - it is porous finely divided Silica gel use against stored insects.

⑦ Radiant energies :-

1) Radio frequencies - high frequency of radio waves generate high temperature 80°C in grains to kill granary weevils in 15-20 seconds

2) Infrared - Kills insect by heating.

3) Visible & Ultraviolet (UV) :- By 3 ways :-

① By producing photo taxis :- +ve (to attract), or -ve (to repel)

② By inducing diapause by altering photoperiod - The field can be flood light to extend the day length & to prevent onset of diapause in insects.

③ By modifying behaviour - exposure of apple plants to artificial light interfered with egg laying of codling moths.

4) Ionising radiation :- X ray & gamma rays control pest. In stored grain

5) Use of sound energy :-

- fire crackers to scatter away fox, rats, squirrels etc.
- acetylene exploder / bird scarer frightens birds by its loud sound.

Mechanical Methods

- The reduction or suppression of insects population by means of manual devices / machines is called mechanical control.

① Collection & destruction:-

a) Manual forces:-

1) manual removal of pink ball worm attached rosette flowers
2) Pruning & destruction of infested shoots & flower parts
3) Passing rope across rice fields to dislodge case worm over standing water.
4) Clipping & destruction of aphid infested twigs of mustard helps in management of mustard aphids.
5) Winnowing the red flour beetle & rice weevil.
6) Hooking with iron hook to remove Rhinoceros beetle
7) Collection & destruction of fallen infested fruits effective against fruit borers
8) Destruction of infested cane stalks.
9) hand picking of caterpillar 1st & 2nd instar larvae Spodoptera, biharı hairy caterpillar, red hairy caterpillar.
10) egg masses of rice stem borer can be picked & destroyed.

b) Mechanical force:-

1) Screw crow
2) mechanical traps - rat trap
3) drumming
4) use of insect collection net
5) use of sticky slot
6) tillage implements. → expose soil borne insect like Red hairy caterpillar.
7) Entoleter - centrifugal force is used to break infested kernels & kills storage pest.

Preventive barriers (Mechanical exclusion) :-

a) **Wrapping the fruits** - covering with polythene bags against pomegranate fruit borer.

b) **Banding** - Banding with grease / polythene sheet on trunk of mango to prevent pest from climbing to tree top.

c) **Netting** - Use for mosquitoes & vector control in green houses.

d) **Trenching** - for trapping of marching larvae of red hairy caterpillar, army worms.

e) **Electric fencing** - fences around crop with low voltage will away rats, monkey, jackles etc.

f) **Tin barrier** - Tin bands are fixed over coconut palms to prevent damage by rats.

Trapping :-

1) **Light trap** - to attract nocturnal insects. which are strongly phototaxic.

2) **Sticky trap** - cotton white fly, aphids and thrips prefer yellow colour. yellow colour is painted on the tin boxes and sticky material like castor oil / grease is smeared on the surface.

Avi Jain notes / AgriGrovestudies

3) Bait trap - attractans are placed to attract insects & kill more using insecticide.

4) Fish meal trap - used against sorghum shoot fly.

5) Pit fall trap - trap insects moving about on the soil surface such as ground beetles.

6) Probe trap - can be inserted into the stored grains
eg - Rice weevil.

7) Pheromone trap - Pheromones are chemical substance produced by an organism to attract ~~opposite~~ member of its own species.
1) Sex pheromone - Synthetic sex pheromone attract opposite sex
2) Trail " - such activate others to follow.
3) Aggregate - to get aggresion response.
4) Alarm - to alarm.

Advantages :-

1) low cost equipment
2) have labor utilization.
3) No residue problem
4) high technical skill not required in adoption.

Disadvantages

1) required repeated and labour intensive,
2) practice in small area i.e. Kitchen garden