In duration: long duration crops are highly suitable

In biocontrol, pest population is reduced to a level, that no longer of economic or health concern, yet leaves sufficient pest to allow survival of the control organisms. The biocontrol organism maintain its own population and prevents the pest from reaching to damaging level. Factors governing Biological Control: i. Tolerance limit of injury: It is successful in crops with high tolerance limit. ii. Crop value: It is successful in crops with high economic value. iii. Crop duration: Long duration crops are highly suitable e.

g. Sugarcane, fruit trees. iv. Indigenous or exotic nature of pest: e. g. for cotton pests identify indigenous natural enemy by survey.

v. Level of control provided by the natural enemy on different stages of the pest (Egg-larval-pupal). vi. Nature of pest complex (seasonal pest or perennial pest) vii. Availability of selective insecticides. viii. Insecticide resistant strains of natural enemies.

ix. Identical situation for successful control. Qualities of an Effective Natural Enemy: i. Host searching capacity ii. Host specificity iii. Adaptability iv.

Dispersal ability v. Amenability to culturing vi. Ability to withstand competition vii. Ability to out number the pest viii. Survival capacity Steps Involved in Classical Biological Control: i. Conservation and encouragement of indigenous natural enemies ii. Importation of exotic natural enemies iii. Augmentation (mass rearing and release)

Microbial Control:

Definition: “ The control of pests by the use of microorganisms such as viruses, bacteria, protozoa, fungi, rickettsia and nematodes or their by-products” is known as microbial control.

These microbes can be grouped as ingested microbes (bacteria, viruses, rickettsia and protozoa) which enter insect body along with food (like stomach insecticide) and penetrating microbes (nematode and fungi) that enter by penetrating the integument (like contact insecticide). Desirable Attributes: i. Pathogen should be highly virulent, able to cause disease in short period and spread from one insect to another.

ii. Host specificity. iii. Cost effective and economical. iv.

Harmless to other forms of life (Safe to non-target organisms and man). v. Rapid prevention of pest feeding. Viruses: Viruses are submicroscopic, obligate, intracellular, pathogenic entities. These are pathogenic to arthropods belongs to atleast eleven families. Nuclear Polyhedrosis Virus (NPV): Important features of NPV are — i. Occluded (rod shaped) singly or in groups in polyhedral (many sides) inclusion bodies.

ii. Site of multiplication is cell nucleus of epidermis, fat body, blood cells and trachea. iii. Tree top disease: Diseased larvae not able to feed, move to the top of the tree or plant and hang inverterdly and die. (e. g.) NPV of Spodoptera, Helicoverpa, Mode of Entry: The virus should be ingested to produce the disease. Due to alkaline gut juice, the virions are liberated from the polyhedral coat which attack nuclei of cells of tissues viz.

, fat body tracheal matrix, haemocytes, sarcolemma of muscles, neurilemma and nerve cells of anglion and brain. Symptoms: Insects become dull in colour, feeding rate is reduced and larvae become pinkish white especially in the ventral side due to accumulation of polyhedra. In advanced stage larvae become flaccid, the skin becomes very fragile and eventually ruptures.

Diseased larvae hang upside down from the plants. This is called tree top disease. Incubation period: 4- 6 days depending upon the stage of the infection, weather conditions and dose of virus.

HPR in Pest Management:

Methods of developing resistant varieties screening of available germplasm: Available germplasm collections are sown at a time in a single row in a location where there is a moderate to heavy incidence and evaluated by comparing with susceptible and resistant check varieties. Selective Screening under Natural Infestation: Select promising lines from general screening and screen under natural condition in a single row or 2-3 rows in replicated trials. Selecting Screening under Artificial Condition: To test true resistance, the selected varieties are screened under artificial condition in which insects are bomborded over the plant. Results are compared with a resistant and susceptible check.

Breeders start screening of lines or cultivars from F2 to F6 stages for yield and resistance. If found suitable they will be forwarded to multilocation trial (MLT) and for Adaptive Research Trials (ART). If a line or cultivar is succeeding in all stages, it will be released as a variety. Resistant Varieties: Some examples of resistant varieties are given below: Rice — Yellow stem borer: Vikas, Ratna, Brown plant hopper: IR 64, IR 36 Sugarcane — Early stem borer: CO 421, CO 661 Top shoot borer: CO 745, CO 6515 Cotton — Bollworm: Abhadita Spotted bollworm: Hopi, Deltapine Compatibility of HPR with other Pest Management Practices: HPR easily combines with other tactics of pest management, due to following reasons.

Resistant host will make the pests weak, or will suppress the population, so that less quantity of chemicals or botanicals or lesser rounds of chemicals or botanicals will control the pest. Resistant host will make the pests weak or will suppress the population, so that efficiency of predators, parasitoids or microbes (biological agents) on these population is increased, e. g.., i.

American root stocks of Grape vine resistant to aphid Phylloxera vitifolia. ii. Rice varieties IR 60, IR 36 are multiple resistance sources, PY3, IR 26 are BPH resistant and MDU3 gall midge resistant. Merits: i. Specificity ii. Cumulative effect iii.

Ecofriendly iv. Easily adoptable v. Effectiveness vi. Compatibility Demerits: i. Time consuming ii. Genetic limitations iii.

High initial cost

Pheromones:

Semiochemicals are chemical substances that mediate communication between organisms. Semiochemicals may be classified into Pheromones (interspecific semiochemicals) and Allelochemicals (intraspecific semiochemicals). Pheromones are chemicals secreted into the external environmental by an animal which has a specific reaction in a receiving individual of the same species. Pheromones are volatile in nature and they aid in communication among insects.

Based on the responses elicited pheromone can be classified into 2 groups. Primer Pheromones: They trigger off a chain of physiological changes in the recipient without any immediate change in the behaviour. They act through gustatory (taste) sensilla.

(e. g.) reproduction in social insects like ants, bees, wasps and termites are mediated by primer pheromones. These pheromones are not of much practical value in IPM. Releaser Pheromones: These pheromones produce an immediate change in the behaviour of the recipient. Releaser phermones may be further subdivided based on their biological activity into 1. Sex pheromones 2.

Aggregation pheromones 3. Alarm pheromones Releaser pheromones act through (smell) sensilla and directly act on the central nervous system of the recipient and modify their behaviour. They can be successfully used in pest management programs. 1. Sex Pheromones: Sex pheromones are released by one sex only and trigger behaviour patterns in the other sex that facilitate in mating.

They are most commonly released by females but may be released by males also. In over 150 species of insects, females have been found to release sex pheromones and about 50 species males produce. Aphrodisiacs are substances that aid in courtship of the insects after the two sexes are brought together. In many cases males produce aphrodisiacs. Pheromone producing glands: In Lepidoptera they are produced by reversible glands at the tip of the abdomen of the females.

The posture shown during pheromone release is called ‘’calling position. Aphrodisiac glands of male insects are present as scent brushes or hair pencils at the tip of the abdomen (e. g.. Male butterfly of Danaus sp.).

Pheromone reception: Female sex pheromones are usually received by olfactory sensilla on male antennae and males search upwind, following the odour corridor of the females. In pheromone perceiving insects, the antennae of male moths are larger and greatly branched than female moths to accommodate numerous olfactory sensilla. Chemical nature of sex pheromones: In general pheromones have a large number of carbon atoms 10 to 20 and high molecular weight 180 to 300 Dalton. Narrow specificity and high potency are two attributes which depend on long chain carbon atoms and high molecular weight. But since pheromones are volatile their molecular weights cannot be very high as they cannot be carried by wind. 2. Aggregation Pheromones: Pheromones which induce aggregation or congregation of insects for protection, reproduction and feeding or combinations of these are called aggregation pheromones. They are released by either male or female which attract both male and female of the same species.

Aggregation pheromones are known mostly in Coleoptera and Dictyoptera. Females of bark beetle Dendroctonus frontalis produce aggregation pheromone which attract both sexes. Similarly males of Phloem beetle Ips confusus incorporate their pheromone in faecal matter which attract both male and female to the infested tree. Some common names of aggregation pheromones are: Pheromone Insect Frontalin – Dendroctonus frontalis Ipsenol – Ips confusus Periplanone – Periplanata americana Aggregation pheromones of following insects are used for monitoring or mass trapping the pests in India. Coconut Rhinoceros beetle: Oryctes rhinoceros Red palm weevil: Rhynchophorus ferrugenius 3. Alarm pheromones: Alarm pheromones are chemical substances released by insects to warn members of the same species about the presence of or attack by an enemy. This warning elicits different behaviour in different insects as listed below: Dispersion or escape in aphids and bugs Aggression in ants and soldier termites Attraction in wasps and worker bees Alarm pheromones have been reported in Hemiptera, lsoptera and Hymenoptera. Organs producing alarm pheromones in various insects are listed below.

Aphids – Cornicles Termites – Cephalic glands Worker bees – Sting glands Ants – Anal, mandibular and Dufours’s gland The chemical nature of alarm pheromones are terpenese (aphids), aldehydes (hemipteran) and formic acid (ants). Alarm pheromones can be used in IPM for controlling aphids. When alarm pheromone of aphids is sprayed on plants, the aphids try to escape, fall down from the plants and get killed.

Allelochemicals:

Allelochemicals are intraspecific semiochemicals.

They mediate the communication between two different species of organisms or insects. Allelochemicals may be classified into : 1. Allomones 2. Synamones 3. Kairomones Allomones: Allomone is a chemical or mixture of chemicals released by one organism that induces a response in another organism which is advantageous to the releaser.

For example the defensive secretions of insects and plants that are poisonous or repugnant to attacking predators. Ants release a defensive allomone called citral from its mandibular glands. Kairomones: Kairomone is a chemical or mixture of chemicals released by one organism that induces a response in another organism which is advantageous to the recipient. The releaser turns out to be lower and the recipient (parasite or predator) a gainer. Synamones: Synamone is a chemical or mixture of chemicals released by one organism that induces a response in another organism which is advantageous to both the releaser and the recipient.

It encourages mutualistic relation between organisms, e. g.. Termites and protozoans.

Insect Growth Regulators:

Insect Growth Regulators (IGRs) are compounds which interfere with the growth, development and metamorphosis of insects. IGRs include synthetic analogues of insect hormones such as acdysoids and juvenoids and non-hormonal compounds such as precocenes (Anti JH) and chitin synthesis inhibitors. IGRs used in Pest Management: Ecdysoids: These compounds are synthetic analogues of natural ecdysone. When applied on insects, kill them by formation of defective cuticle.

The development processes are accelerated by passing several normal events resulting in integument lacking scales or wax layer. Juvenoids: They are synthetic analogues of Juvenile Hormone (JH). They are most promising as hormonal insecticides. Juvenoids have anti-metamorphic effect on immature stages of insect.

They retain status quo in insects (larva remains larva) and extra mouldings take place producing super larva, larval- pupal and pupal-adult intermediates which cause death of insects Juvenoids are larvicidal and ovicidal in action and they disrupt diapause and inhibit embryogenesis in insects. Anti JH: They act by destroying corpora allata and preventing JH synthesis. When treated on immature stages of insect, they skip one or two larval instars and turn into tiny precocious adults. They can neither mate, nor oviposit and die soon. e. g., EMD, and PB (Piperonyl Butoxide).

Chitin synthesis inhibitors: Benzoyl phenyl ureas have the ability of inhibiting chitin synthesis in vivo by blocking the activity of the enzyme chitin synthetase. Two important compounds in this category are diflubenzuron (Dimilin) and Penfluron. The effects they produce on insects include. i. Displacement of mandibles and labrum ii. Adult fails to emerge from pupal skin leading to death iii. Ovicidal effect. IGRs from Neem: Leaf and seed extracts of neem which contains azadirachtin as the active ingredient, when applied topically causes growth inhibition, malformation and mortality in insects.

Hormone mimics from other living organisms: Ecdysoids from plants have been reported from plants like mulberry, ferns and conifers. Juvenoids have been reported from yeast, fungi, bacteria, protozoans, higher animals and plants. Advantages of using IGRs i. Effective in minute quantities and so are economical. ii.

Target specific and so safe to natural enemies iii. Bio-degradable, non-persistent and nonpolluting iv. Non-toxic to humans, animals and plants Disadvantages: i.

Kills only certain stages of pest ii. Slow mode of action iii. Since they are chemicals, possibility of build-up of resistance iv. Unstable in the environment.

Antifeedants:

Antifeedants are chemicals that inhibit feeding in insects when applied on the foliage without impairing their appetite and gustatory receptors or driving them away from the food. They are also called gustatory repellents, feeding deterrents and rejectants. Since insects do not feed on treated surface they die due to starvation. Groups of Antifeedants: Organotins: They are compounds containing tin. Triphenyl tin acetate is an important antifeedants effective against cotton leaf worm, Colarado potato beetle, caterpillars and grass hoppers. Carbamates: At sublethal doses thiocarbamates and phenyl carbamates act as antifeedants of leaf feeding insects like caterpillars and Colarado potato beetle.

Baygon is a systemic antifeedant against cotton boll weevil. Botanicals: Antifeedants from non-host plants of the pest can be used for their control. The following antifeedants are produced from plants.

(a) Pyrethrum: Extracted from non-host plants of the pest can be used for their control. The following antifeedants are produced from plants. (b) Neem: Extracted from leaves and fruits of neem Azadiracta indica is an antifeedant against many chewing pests and desert locust in particular. (c) Solanum alkaloids: Leptine, tomatine and solanine are alkaloids extracted from Solanum plants and are antifeedants to leaf hoppers. Miscellaneous compounds: Compounds like copper stearate, copper resinate, mercuric chloride and phosphon are good antifeedants. Mode of action: Antifeedants inhibit the gustatory (taste) receptors of the mouth region. Lacking the right gustatory stimulus the insect fails to recognize the treated leaf as food.

The insect slowly dies due to starvation. Advantages: i. Affect plant feeders, but safe to natural enemies ii. Pest not immediately killed, so natural enemies can feed on them iii. No phytotoxicity or pollution Disadvantages iv.

Only chewing insects killed and not sucking insects v. Not effective as sole control measure, can be included in IPM

Insect Attractants:

Chemicals that cause insects to make oriented movements towards their source are called insect attractants. They influence both gustatory (taste) and olfactory (smell) receptors. Types of Attractants: Pheromones: Pheromones are chemical secreted into the external environment by an animal which elicit a specific reaction in a receiving individual of the same species.

Food lures: Chemical present in plants that attract insect for feeding. They stimulate olfactory receptors. Use of Attractants in IPM: Insect attractants are used in three ways in pest management. (a) Sampling and monitoring pest population (b) Luring pests to insecticide coated traps or poison baits (c) In distracting insects from normal mating, aggregation, feeding or oviposition.

The female insects if lured to wrong plants for egg laying, the emerging larva will starve to death.

Examples of Poison Baits: i. For biting insects: Moistened Bran + Molasses + insecticides ii. For sucking insects: Sugar solution + insecticide iii. For fruitflies: ` Trimedlure/Cuelure/ Methyl eugenol + insecticides iv.

For cockroaches: Sweet syrup + white or yellow phosphorus v. For sweet loving ants: Thallous sulphate + sugar + honey + glycerine + water Advantage: They are specific to target insects. Natural enemies not affected. But they cannot be relied as the sole method of control and can only be included in IPM as a component.

Insect Repellents:

Chemicals that induce oriented movements in insects away from their source are called repellents.

They prevent insect damage to plants or animals by rendering them unattractive, unpalatable or offensive. Types of Repellents: 1. Physical repellents: Produce repellent by physical means. Contact stimuli repellents: Substances like wax or oil when applied on leaf surface changes physical texture of leaf which are disagreeable to insects. Auditory repellents: Amplified sound is helpful in repelling mosquitoes. Barrier repellents: Tar bands on trees and mosquito nets are examples. Visual repellents: Yellow light acts as visual repellents to some insects. Feeding repellents: Antifeedants are feeding repellents.

They inhibit feeding. 2. Chemical repellents: Repellents of plant origin: Essentials oils of Citronella, Camphor and cedarwood act as repellents. Commercial mosquito repellent ‘ Odomos’ uses citronella oil extracted from lemongrass. Pyrethrum extracted from Chrysanthemum is a good repellent and has been used against tsetse fly. Synthetic repellents: Repellents synthetically produced Important synthetic repellents are listed below: InsectsRepellentsMosquito, blood suckersDimethyl pthalateMites (chigges)Benzyl benzoatePhytophagous insectsBordeaux mixtureWood feedersPentachlorophenolFabric eatersNaphthalene or mothballsBeesSmokeUses of Repellents: i. Applied on body toward off insects ii. Used as fumigants in enclosed area.

iii. Used as sprays on domestic animals iv. Used to drive away insects from their breeding place.

Biotechnology in Pest Management:

Molecular biology techniques are used for the management of insect pests. The following are some of the strategies. Wide hybridization: This technique involves transfer of genes from one species to other by conventional breeding. The genes for resistance are transferred from a different species, e. g.

WBPH resistant gene has been transferred to Oryzae saliva from O. officinalis. Somaclonal variability: This variation is observed in tissue culture derived progeny, e. g. Somaclonal variants of sorghum resistant to Spodoptera litura has been evolved. Transgenic plants: Transgenic plants are plants which possess one or more additional genes. This is achieved by cloning additional genes into the plant genome by genetic engineering techniques. Transgenic plants have been produced by addition of one or more following genes.

i. Bt endotoxin from Bacillus thuringiensis ii. Protease inhibitors iii.

? -Amylase inhibitors iv. Lectins v. Enzymes Bt endotoxin Gene: The gram positive bacteria Bacillus thuringiensis produces a crystal toxin called ? (delta) endotoxin. The 8 endotoxin is a stomach poison and kills the lepidopteran insects if consumed. The gene (DNA fragment) responsible for producing ? endotoxin is isolated from Bt and cloned into plants like cotton, potato, maize, etc. to produce Transgenic cotton, etc. Transgenic Bt plantsTarget insect pests 1.

CottonBollworms, S. litura2. MaizeEuropean com borer3. RiceLeaf folder, stem borer4. Tobacco, TomatoCut worms5. Potato, Egg plantColarado potato beetleProtease Inhibitors (PI) Gene: Insects have proteases in their gut which are enzymes helping in digestion of protein. Protease inhibitors are substances inhibit the proteases and affect digestion in insects.

The protease inhibitor gene are isolated from one plant and cloned into another to produce transgenic plants. Transgenic apple, rice, tobacco contains PI. gene.

Cowpea trypsin inhibitor (Cp TI) is a PI isolated from cowpea and cloned into tobacco. This transgenic tobacco is resistant to Heliothis virescens. ?-Amylase inhibitors gene: ?-Amylase is a digestive enzyme present in insects for digestion of carbohydrate. ? -Amylase inhibitor, affect digestion in insects. Transgenic tobacco and tomato expressing ? -amylase inhibitor have been produced which are resistant to Lepidopteran pests. Lectins genes: Lectins are proteins that bind to carbohydrates. When insect feed on lectins, it binds to chitin in peritrophic membrane of midgut and prevents uptake of nutrients.

E. g. Transgenic tobacco containing pea lectin gene is resistant to H. virescens. Enzymes genes: Chitinase enzyme gene, and cholesterol oxidase gene have been cloned into plants and these show insecticidal properties.

Pyramiding genes: Engineering transgenic crops with more than one gene to get multi-mechanistic resistance is called pyramiding of genes, e. g. The Cp Ti gene and pea lectin gene were cloned to produce a transgenic tobacco. Potential Advantages of Biotechnology in IPM: i. Slow Development of resistance against transgenic Bt, PI, lectins ii. All plant parts express toxin and so no need for insecticide spray iii. No need for continuous monitoring iv.

No environmental pollution, safe to natural enemies, non-target organism.