Insecticide & Insecticide Resistance

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- Recent Advances In Monitoring & Prevention Of Resistances
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INSECTICIDES

Insecticides

- Insecticides are the substance which are use to kill the insects.

- Insecticides have not only controlled malaria , plague & other diseases transmitted by insects but also brought vast economy & social benefits through better health & increase food production.

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- *<u>Insecticides are classified into three groups:</u>*
  1) *Contact poison*
  2) *Stomach poison*
  3) *Fumigants*

Continued….

Contact Poison	*Stomach Poison*	Fumigants
• Pyrethium • DDT • HCH • Dieldrin	• *Paris Green* • *Sodium fluoride*	• Hydrogen Cyanide • Methyl bromide • Sulphur Bromide • Carbon disulphate

Continued….

Group-I	Group-II	Group-III
Organochlorine Compounds	***Organophospherous Compounds***	***Carbamates***
DDT	Malathion	Propoxur
HCH	Fenthion	Carbaryl
Dieldrin	Chlorpyrifos	
Chlordane	Abate	
Methoxychlor		

DDT

(Dichloro- Diphhenyl- Trichloroethane)

- Was 1st synthesized in 1874, by German chemist , Zielder.
- Paul Muller found out the insecticidal properties in 1939.

- However that year also saw the 1st report of DDT among resistance , in Anopheles sacharovi in Greece.

The Way It Was

DDT was hailed as “the miracle insecticide” and “almost perfect control product for this pest”

Resistance was observed after only 5 years of use.

Continued….

- Presently different formulations of synthetic chemical insecticides are in the use for vector control.
- Wettable powder (WP) formulations are used for indoor residual spray IRS insecticides are used for larval control.
- For IRS insecticides in use are DDT 50% WP, malathion 25% WP & other synthetic insecticides.

HCH (BHC)

- Benzene Hexachloride or Hexachloro hexane was synthesized by Michel Faraday in 1825.
- Insecticidal prperties were discovered in 1933.

Properties:

1) *HCH is white or chocolate colour powder with musty smell.*
2) *It is irritating to eyes nose & skin.*

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Action:

- It kills insect by direct contact, but its residual action is of short duration.

Application:

- It is used like DDT.
- A dose of 25 to 50 mg of gamma HCH per sq. ft. is recommended for residual treatment.

Malathion

Properties:

- *It is yellow or clear brown liquid with an unpleasant smell .*
- *Available as water dispersible powder form.*

Action

- *Due to its low toxicity t is recommended for an alternative to DDT.*

Application

- *It is used in the dosage of 100 to 200 mg./sq.ft.every 3 months*

Abate (Temphos)

- It is an organophospherous compound.
- It is brown viscous liquid.
- Soluble in petroleum solvents.
- Low toxic in nature.
- Can be used in well & in domestic water.
- Dosage should not exceed more than 1.0 ppm.
- It is not very strong & effective as adulticide.

Diazinon

- It is a volatile liquid with a property of contact poison which has fumigant action too.
- It is effective in control of DDT resistant insects.
- It can satisfactory control flies & mosquitoes with the dosage of 60 to 100 mg / sq. foot.

Fenthion
(Baytex)

- It is a brown colour liquid with the smell of garlic.
- It is insoluble in water.
- Water dispersible powders are available containing 20to 40 percent Fenthion .
- Fenthion is found to be as effective as DDT.
- Dosage for residual sprays is 100 mg/sq. foot.
- It is mainly a powerful larvicide.

Dichlorovos (DDVP)

- It is very highly volatile liquid insecticide, which kills insects by fumigant action.
- It is used for the disinfection of aircraft.

Advantage:

- It can be combined with solid substances such as wax, which can be fashioned into tablets or bricks from which can it slowly evaporates.

Propoxur

- It is a new carbamate insecticide, recommended as substitute for DDT.
- It is used mainly in areas where anophelines have developed resistance to both DDT & dieldrin.

Pyrethrum

- It is of vegetable origin.
- It is extracted from flowers of Chrysanthemum cinerariafolium, a plant which is cultivated in Kashmir, Simla & Nilgiris In India.
- It is a nerve as well as contact poison.

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- The ready to spray solution contains up to 0.1 per cent of Pyrethrins.
- It is mainly used as a space spray to kill adult mosquitoes & other insects.
- It is sprayed at the rate of ½ to 1 oz. of the spray solution per 1000 cu.foot of space.

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- On space spraying fine atomization of spray solution is necessary & the doors & windows should be kept closed for ½ hour after spraying.

<u>Disadvantage:</u>

- *It dose not posses the residual action of DDT & other synthetic insecticides.*

Pyrethrum & DDT

- It is a synthetic insecticide.
- Pyrethrum & DDT are combined for space spraying for the synergistic action.

Dosage recommended by WHO:

1) *Pyrethrum extract (25%)- 1.6 %*
2) *DDT Technical- 3 %*

(to be dispersed at the rate of 10 gm per 1000 cu. Foot of space in treatment of aircraft) .

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- About 1/3 of this dosage, 3.3 gm per 1000 cu. foot can be used for treatment of dwellings.

Synthetic Pyrethroids

- They are now being developed to replace Pyrethrins.
- Newly developed pyrethroids have been found to be 10 times more effective than the naturally occurring Pyrethrins.
- Among the most developed prethriods the most promising once are;

a) Tetramethrin
b) Resthrin
c) Prothrin
d) Proparthrin

Rotenone

- It is obtained from the pant roots of *Derris Elliptica.*
- It is dried powdered & blended & used as insecticidal dust.
- An extract of rotenone may be made in organic solvent such as chloroform.

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- It was widely in use of control of lice, fleas & ticks.

Mineral Oils

- Kerosene, crude oil, malariol have been used to kill mosquito larva & pupae.
- Oil suffocate & poison the aquatic stage of mosquito.
- If added with DDT, HCH & other chemicals, oils killing power can be increased.

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- Oils are injurious to vegetation & fish when improperly used.

Paris Green
(Copper aceto-arsenite)

- It is a emerald green microcrystal powder which is not soluble in water yet it can be dissolved with ammonia & concentrated acids.
- A good sample of Paris Green contains 50% of arsenious oxide.
- It is a stomach poison.

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- Till the advent of DDT, Paris green was used in control of anopheline larvae, by spraying as a 2% dust over the breeding places once a week.

Insecticide Resistance

INSECTICIDE RESISTANCE

- *Insecticide resistnace:-*

The development of an ability in strain of insects to tolerate doses of toxicants which would prove lethal to majority of individual in normal population of the same species.

- The magnitude of the problem can be appreciated as the fact that , in 1946 resistance to insecticides was reported in only 2 species of insects of public health importance, in 1962 the number rose to 81 species & in 1980 to 134.

Why Does Resistance Develop?

- Resistance is quick to develop to compounds with high effective kill, long residual and are highly selective at a single biochemical target site.
- The toxicant is converted into a non toxicant form in the body of insect by various enzymes.
- All this enzymatic changes are carried forward & transmitted through genes, single or multiple.

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- A knowledge of insecticide resistnace is is important from the point of view of proper selection of insecticides.

Organochlorine resistance is divided into 2 groups :-

- Resistance to DDT & its analogue
- HCH-dieldrin group of insecticides.

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- *Single resistance:-* Resistance to DDT amounts to resistance to a number of DDT analogues such as methoxychlor, but not to HCH amounts to HCH- dieldrin group. Similarly resistance to HCH amonts to resistance to dieldrin but not to DDT.

- *Double resistance:- Resistance to two groups of organochlorine insecticides.*

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- *The only option here left to avoid more resistance is to change over to organophospherous & carbamate insecticides.*

- ***Cross resistance:-*** when there is resistance in the carbamates& organophospherous compound is seen.

How Can We Slow Down Resistance?

- Resistance is slow to develop with inefficient, short residual compounds because selection pressure is low!
- Select compounds that interfere with multiple biochemical or physiological systems.
- Mixtures like Botanical Insecticides & Synergists.
- Refugia – A source of susceptible individuals (genetic) within a population – Don’t Kill ‘em All!
- Integrated Pest Management – Ecology in Action!

Insecticide Resistance

- Insecticide Resistance can be:
  - Physiological
  - Behavioral
- Due to Behavioral Resistance:
  - Endophilic, endophagic mosquitoes have become exophilic& exophagus
  - *E.g. An. funestus* now bites late in the evening rather than at midnight

TIME UNTIL DEVELOPMENT OF RESISTANCE

- Organophosphates – 14 years
- Organochlorines (DDT) – 7 years
- Carbamates – 5 years
- Pyrethroids – 4 years
- Bacterial Insecticides, Avermectins
- New Compounds?
- Formulations – Cockroach Gel Baits, Ear Tags

Physiological Insecticide Resistance

- At present there are 40 malaria- endemic countries reporting physiological resistance to insecticides, most to pyrethroids.
- In India also, Quadrupled resistance has been detected
- *E.g.* A single gene mutation (knock down resistance gene or kdr) has mutated the Na-K Pump of *A. gambiae.*
- Multiple gene mutations provide a graded degree of resistance
- Mutations in Sand-fly has also been recently reported in India, thus providing resistance against DDT.

RESISTANCE MANAGEMENT

Resistance Management

Rotation of effective insecticides with different modes of action are used to provide insect control as well as rotation reduces the risk of developing the insecticide resistance from developing.

Continued….

- ***Following should be consider when designing an insecticide control program:-***

1) *Plan ahead:-* Determine when in a typical season insecticides applications are likely to be needed and plan for the rotation of insecticides with different modes of action, avoiding the consecutive use of products belonging to the same mode of action group. Plan for contingencies in case extra applications are needed due untypical pest infestations.

Continued….

- Determine which insecticides are most effective for controlling each insect/pest during each application timing.
- Evaluate the current insecticide resistance situation in the area.
- Avoid using insecticides already affected by resistance where possible.

Continued….

- Consider the impact of the insecticides on non-target insects and natural predators, especially during early season applications, where maintaining natural predators can reduce the need for later sprays.

Continued….

- Consider the use of insect-resistant biological control agents.

- Always follow insecticide label instructions for application timings, volumes and concentrations.

RECENT ADVANCES IN PREVENTION OF RESISTANCES

Figure 1: Five pillars of the Global Plan for Insecticide Resistance Management in malaria vectors

Five pillars of strategy

I. Plan and implement insecticide resistance management strategies in malaria-endemic countries.

II. Ensure proper, timely entomological and resistance monitoring and effective data management.

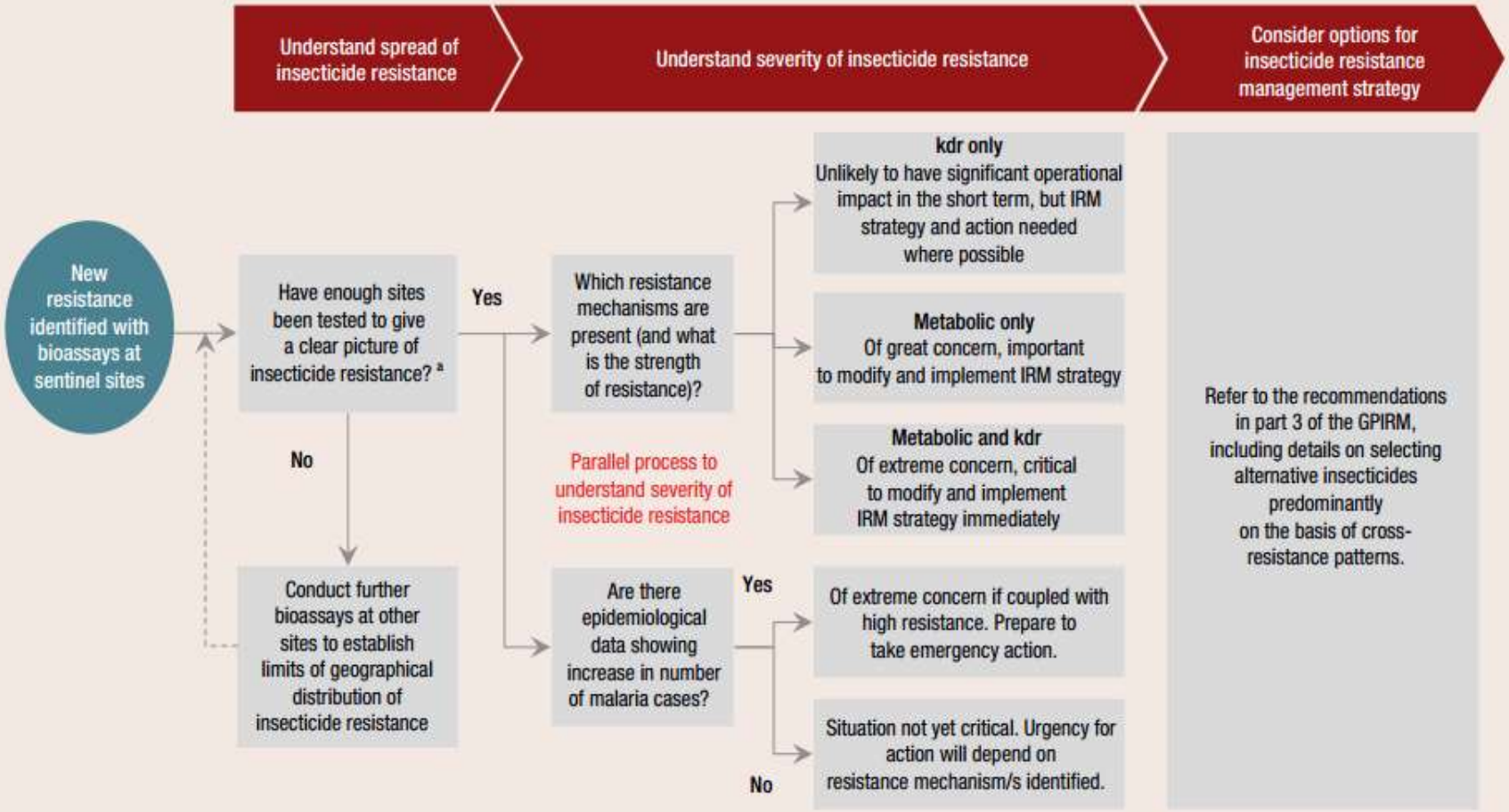
III. Develop new, innovative vector control tools.

IV. Fill gaps in knowledge on mechanisms of insecticide resistance and the impact of current insecticide resistance management strategies.

V. Ensure that enabling mechanisms (advocacy, human and financial resources) are in place.

IR, insecticide resistance

Figure 30: Three factors to be assessed when a new focus of insecticide resistance is identified



a Adequately tested means at least enough sentinel sites to cover a minimum of 200 000 houses or 500 000 nets. Resistance ratios (strength of resistance) should be investigated with WHO resistance tests kits or CDC bottle bioassays.

GENETICALLY MODIFIED MOSQUITO

- Transposon- based mechanism
- Aims either at :
  - Population Suppression Techniques
  - Population Replacement Techniques

Population Suppression Techniques

- Sterile Insect Technique (SIT):
  - The sterile males compete with the wild males for female insects.
  - If a female mates with a sterile male then it will have no offspring, thus reducing the next generation's population.
  - Genetics rather than radiation: Wild female mosquitoes mate released engineered sterile male, progeny will inherit the lethal gene and die.
  - Furthermore, the sterile males actively seek out wild females to mate.

Population Replacement Techniques

- This includes 2 steps:
  - Develop a modified strain of vector mosquito that is unable to transmit the pathogen of interest (or with greatly reduced ability to transmit relative to wild mosquitoes)
  - Introgress (i.e. spread) this 'refractoriness gene' or genetic system into the target population
- A 'gene drive system' or 'gene driver' is needed in the environment

INTEGRATED PEST MANAGEMENT

INTEGRATED PEST MANAGEMENT

- IPM – An ecology-based control system which combines many techniques in an organized program to keep pest populations below levels of economic damage or nuisance.

- Control techniques are selected and applied to minimize risk to human health, beneficial and non-target organisms, and the environment.

COMPONENTS OF AN IPM PROGRAM

- Natural Control – Use or Enhance What's There, Biological Control – Parasites, Predators and Pathogens

- Cultural Control – Modify Existing Practices such as Temperature, Watering, Fertilizing

- Mechanical/Physical Control – Specialized Equipment or Practices Such as Mowing and Tilling
- Chemical Control – Many Choices – Least Toxic Approach!

ELEMENTS OF AN IPM PROGRAM

Knowledge – Pest Biology and Ecology

Integrated System of Strategies – A Plan With Depth

Surveillance and Monitoring – Visual, Traps, Data Recorders

Continuous Evaluation and Updates – Is the Plan Working?

Education – New Information, Update the Plan

Resistance Management - Bioassays

NEW INSECT CONTROL STRATEGIES

NEW INSECT RESISTANCE STARTEGIES

- Reduce reproductive Potential.
- Extend generation time.
- Early season treatment
- Season long control
- Breaking the life cycle
- Target most vulnerable life stage

Continued….

- Planned & integrated control methods
- Education, Knowledge & surveillance
- Least toxic approach- Chemical, Mechanical, Cultural Control Techniques

Conclusion

- The widespread use of the synthetic insecticides has given rise to the serious problem of insecticide resistance all over the world.
- The problem of insecticide resistance is growing in magnitude is no doubt steadily diminishing the choice of effective insecticides for vector control.
- The frequent change in insecticides involves substantial increase in cost.

Continued….

- Pesticides must be used judiciously in an IPM program so as to preserve cost effective pesticides & maintain susceptible individuals in a pest population.

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THANK YOU