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New Group of Insecticides

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Indiscriminate use of insecticides, leads to resistance development by insect and ill effect posed on environment opened the new modern era of chemicals having novel mode of action with higher bioefficacy on insect control and safer to environment. These new group of insect control insecticides includes neonicotinoids, spinosyns, avermectins, oxadiazines, IGR's, fiproles, pyrroles, pyridine azomethine, ketoenols and benzenedicarboxamides. Most of these groups of pesticides play an important role in managing many arthropod pests with good bioefficacy, high selectivity and low mammalian toxicity, which make them attractive replacement for synthetic organic pesticides. These novel groups of pesticides are likely to play an important role in IPM programme in future.

Introduction

Mankind has a history of using crop protection products from non-selective, naturally occurring compounds to highly specific synthetic and biological materials for assured food production and protection of environment since long time. Researchers are going on to develop safer molecules which could undergo photo-degradation, microbial degradation as well as chemical degradation leaving very less amount of residues in the environment. Accordingly, many conventional pesticides have been replaced by newer insecticides which are more selective than conventional insecticides. The prime motto for these developments is to give protection to the crops along with safety to the natural enemies of different pests as a whole safety to environment.

Neo-Nicotinoids

They are synthetic analogues of nicotine. These neo-nicotinoids are further classified into three groups namely:

a) **Chloronicotinyl compounds:** Examples are Imidacloprid and Acetamiprid

Imidacloprid: It is the first commercial insecticide of this group which inhibits nicotinic acetylcholine by binding with nicotinic acetylcholine receptor (nAChR). Imidacloprid has good xylem mobility and formulated for use as seed treatment, soil and foliar application and it is found effective against sucking pests (aphids, leaf hoppers, plant hoppers, white flies and thrips). In India many

formulations of Imidacloprid are registered viz., Imidacloprid 17.8% SL (**Confidor**), and 70% WS (**Gaucho**) as seed treatment.

Acetamiprid: The mode of action is same as imidacloprid and it is a broad-spectrum insecticide used for control of pests of vegetables, fruit trees, tea etc. It is found effective against sucking insect pests of cotton and formulated as Acetamiprid 20% SP and available in Indian market as **Pride**®,

Thiacloprid: It affects transmission of nerve impulse. Thiacloprid is also available with trade name **Calypso.**

b) Thionicotinyl group compounds e.g. Thiomethoxam

Thiamethoxam is a broad spectrum insecticide acting against stem borers, hoppers, jassids, whiteflies, aphids, mosquito bug, psyllids and used in crops viz., rice, cotton, wheat, mustard, okra, mango, potato, tea and citrus etc. It can be used both for seed and foliar treatment. The formulations developed are 25% WG (foliar spray), 70% WS (Seed treatment). It is commercially available in market as **Actara**®, **Cruiser**® etc.

c) Furanicotinyl group compounds e.g. Dinotefuran

Dinotefuran is third generation nicotinyl group of insecticides acting against sucking pests like hoppers, jassids and aphids of different crops. It is highly systemic compound. Commercially available formulation is Dinotefuran 20% SG in the name of **Osheen** and **Token.**

d) Pyridincarboxamides e.g Flonicamid

Flonicamid has systemic as well as translaminar activity which gives long term control. Flonicamid rapidly inhabits the feeding behavior of aphids. Excellent activity against major species of aphids. It offers good persistence gives long time protection from the pest. It is also moderately effective against whiteflies, plant hoppers, plant bugs and mealy bugs of cotton, potato vegetables and fruit crops. It is available with the brand name **Ulala** with flonicamid 50% WG in the market.

Phenyl Pyrazoles

The insecticide of this group is Fipronil. It is having systemic compound with contact and stomach activity. Fipronil blocks the gamma-aminobutyric acid (GABA) regulated chloride channel in neurons,thus antagonizing the “calming” effect of GABA. It is found effective against stem borer, gall midge, DBM, thrips, shoe borers, root borer and can be used in crops viz., sugarcane, cruciferous crops cotton and rice. In India the formulations registered are 5% SC and 0.3% GR. It is popular with the farmers under the brand name as **Regent**®

Pyridine azomethines

The insecticide of this group is **"Pymetrozine"** and it has no direct toxicity against insects but it blocks stylet penetration of sucking insects which may cause immediate cessation of feeding after exposure to this insecticide. It found to effective against sucking pests (whiteflies, hoppers and aphids) and can be applied both

as foliar and soil application. The commercial products of pymetrozine available in USA market are Chess®, Fulfill®.

Oxadiazine Group

The insecticide of this group is **"Indoxacarb"** which inhibits the flow of sodium ions into nerve cell in insects that cause paralysis and death and enters into the insect body in two ways like through ingestion of treated foliage and also penetrates through insect cuticle used to control for variety of lepidoptera pests, specially against american boll worm, *Helicoverpa armigera* and diamond back moth (DBM), *Plutellla xylostella.* The formulation available is 14.5% SC and recently indoxacarb 15.8% EC is registered with different isomers and found to be more effective against cotton bollworms, DBM, & pod borer complex. It is sold under trade name as Avaunt® and Avanut EC.

Halogenated Pyrroles

The insecticide of this group is **Chlorfenapyr**. It is first and only member of this unique chemical group, acts by disrupting the proton gradient across mitochondrial membrane and prevent mitochondria from producing ATPs. It is found effective against DBM in cabbage and cauliflower and also against mites in *chilli* and commercially available as Intrepid® (Chlorfenapyr 10% SC)

Thiazolidine Group

The insecticide of this group is **Hexythiazox**. Hexythiazox is an acaricide of this group. It affects growth and development of mites and used for control of red spider and yellow mites in tea and chilli, and available as hexythiazox 5.45% EC in the market with trade name as **Maiden**.

Thiourea Derivatives

The insecticide of this group is Diafenthiuron. The mode of action of this insecticide is inhibition of oxidative phosphorylation i.e specifically they inhibit ATP synthase. They are found to be effective against sucking insects (whiteflies, aphids, jassids, thrips), mites and capsule borer. It is available in Indian market as Diafenthiuron 50% WP as Pegasus or Polo.

Sulfite Ester Group

Propargite an acaricide belongs to this group. It kills mites through inhibition of oxidative phosphorylation i.e this compound act as disruptors of ATP formation. It is highly effective against phytophagous mites viz., red spider mite, pink mite, purple mite, scarlet mite in tea, yellow mite in chilli and European red mite & two spotted mite in apple and available in liquid formulation as 57% EC in market as **Omite**.

Diamide Group

Flubendiamide and Chlorantraniliprole are two insecticides of this group. Flubendiamide a novel class of insecticide having a unique chemical structure used against broad spectrum of lepidopterous insects. Ryanodine receptors are intracellular Ca^{2+} channels specialized for the rapid and massive release of Ca^{2+} from intra cellular stores, which is an essential step in the muscle contraction process. It has been recently registered in India under different

formulations such as **20**% WG registered trade name as Takumi® & 39.35% SC with registered trade name as Fame® which act on insect pests of rice (stem borer, leaf folder) and cotton *(H. armigera* and spotted bollworm) (Ebbinghaus-Kintscher et al., 2006; Lümmen et al., 2007)

The other new class of chemistry of this group is Chlorantraniliprole, to be specific it belongs to anthranilidin diamides controlling almost all economically important Lepidoptera and other species. It has high larvicial potency and long lasting activity with new mode of action and safe to non target insects (parasitoids, predators and pollinators). It is also used to control insects which are found resistant to other insecticides and fits into IPM programs. It binds to insect ryanodine receptors in muscle cells causing the channel to open and release Ca^{2+} ions from internal stores into cytoplasm and because of depletion of calcium it causes paralysis and death. It is registered in India in 2009 and available in different formulations as 18.5% SC and 0.4% GR and targets stem borer, leaf folder (Rice), DBM (Cabbage), *H. armigera, S. litura, Earias* spp (Cotton), Termites, early shoot bore, top borer in sugarcane and yellow stem borer, leaf folder in rice, respectively. It is marketed as Coragen and Ferterra.

Ouinazoline Group

Acaricide, Fenazaquin belongs to quinazoline group. It inhibits mitochondrial electron transport chain by binding with complex I at co-enzymes site Q. In India, it is registered as Fenazaquin 10% EC and sold as Magister which proved to be effective against mites in tea and chilli.

Tetronic Acid Derivatives

Spiromesifen: This acarcide cum insecticide belongs to tetronic acid derivatives. It blocks the fat synthesis which ultimately causes the target pest to dry out and die i.e. the active ingredient is a lipid biosynthesis inhibitor that prevents insects from maintaining a necessary water balance.

Insect Growth Regulators

A. Benzoyl Urea

The insecticides of this group are Novaluron and Lufenuron. Novaluron is new Insect Growth Regulator. It is powerful toxicant for controlling lepidopteran larvae. It acts by both ingestion as well as contact. It has got translaminar effect. It is quiet safe for beneficial insects and natural parasites and predators. It is available with the name of **Rimon** and **Signa** in the market**.**

B. Thiadiazines

This is Chitin synthesis inhibitor. It prevents proper formation of exoskeleton after molting. It is effective against homoperean insects such as hoppers, Jassids and white fly. In the market Buprofezin active ingredient available with trade name **Applaud.**

Carbazate Acaricide

It is selective acaricide that controls spider mite. These compounds are neuroactive but it's exact mode of action is unclear. It paralyses the mites suggesting that it may act on nervous system of mites. In the market it is available by trade name Bifenazate with Trade name **Floramite**.

Pyridazinones Acaricide

This class of acaricide is very effective against red spider mites and two spotted mites. It inhabits mitochondrial electron transport. It affects respiratory chain also. In the market it is available with active in gradient Fenpyroximate with trade name **Mitigate**.

New Insecticides from Microorganisms

Avermectins

These are 16 members macrocyclic lactones natural product isolated from soil microorganism mycelia of *Streptomyces avermitilis.* These compound are closely related to milbemycins. Series of closely related macro cyclic lacton derivatives produced as fermentation metabolites of *Streptomyces avermitilis* . It inhibits signal transmission at the neuromuscular junction. Upon stimulation releases the inhibitory neurotransmitter Gamma-Amino Butyric Acid (GABA) from the pre-synaptic nerve terminals and by potentiating its binding at the post-synaptic receptors. Abamectin **(Vertimec®, Avid®, Agrimec®)** is commercially used against sucking pests, dipterans, psyllidae, leaf miners and phytophagous mites. Ivermectin, a semi synthetic derivative of abamectin used to control parasites of cattle.

Emamectin benzoate is also a semi synthetic derivative of avermectin which is highly effective against lepidopteran pests with the trade name of **Proclaim.**

Spinosyns

Spinosad is the first active ingredient proposed for a new class of insect control products, the Naturalytes. Spinosad is derived from the metabolites of the naturally occurring bacteria, *Saccharopolyspora spinosa.*. This formulation contained a mixture of two of the most active metabolites, Spinosyns A and Spinosyn D. The name spinosad is derived by combining the species name spinosa, with the two metabolites, available in formulations as 45% SC and targets stem borer, leaf folder (Rice), DBM (Cabbage), *H. armigera, S. litura, Earias* spp (Cotton), Termites, early shoot borer, top borer in sugarcane and yellow stem borer, leaf folder in rice, respectively. It is marketed as Tracer.

Future Challenges

1. To develop more and more new molecules having
   - Low dose compounds
   - High efficacy and quick knock down against target pest
   - Low mammalian toxicity
   - Relatively safer formulations such as SC, WG, contains Water Soluble Pouches
   - Less soluble in water
   - Less or no leaching potential
   - New chemistry
   - Less harmful to beneficial insects such as honey bees and natural enemies
   - Less residual effect.
   - High persistence in the plant.
2. More discoveries in macromolecular pesticides.
3. More innovations required for new neo-nicotinoids.
4. More biotechnological innovations to be directed in transgenic plants etc.
5. More innovative technology to be developed in application of pesticides, a special care shall be given on the nozzles, sprayer or applicator with an intention to minimize the loss of applied pesticide or target organisms.

6. Minimization of residue load in ecosystem.
7. More emphasis shall be given in bio-control agents.
8. Due concern of the safety for environment and reducing health hazards.

Conclusion

Scientific community has been involved in approaches towards the developments of newer molecules which could be easily biodegradable, target-specific with very low mammalian toxicity. A distinct division in scientific opinion was made to decide whether to go for bio-based products or for using synthetic chemicals for protecting the crops. Therefore, a new horizon of analytical chemistry was evolved as pesticide residue analysis to judge the residue level of these harmful chemicals in food grains. Researches were carried out to develop safer molecules which could undergo photodegradation, microbial degradation as well as chemical degradation leaving very less amount of residues in the environment. The prime motto for this development is to give protection to the crops along with safety to the natural enemies of different pests as a whole safety to environment.

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