ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

BOTANICALS AS BIOPESTICIDES: A REVIEW.

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Manuscript Info

Manuscript History:

Received: 14 January 2016
Final Accepted: 15 February 2016
Published Online: March 2016

Key words:
Biopesticides. Phytochemicals. botanicals

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Abstract

The uncontrolled use of synthetic pesticides has severely impacted ecosystem function and dynamics. The plant kingdom is treasure trove of natural secondary metabolites from plants. Research on pesticides of botanical origin are progressing in top gear globally as these are eco-friendly, non-pollutive, renewable, inexhaustible, indigenously available, easily approachable, readily biodegradable and relatively cost effective. Hence new biorational and specific trends to pest control are the need of the hour to cop up with emerging challenges.

Introduction:-

Pesticides are chemicals or mixture of chemicals upon application will prevent, destroy, repel, attract, sterilize, or mitigate pests. However, the unabated application and uncontrolled consumption of pesticides has resulted in a myriad of ecological and public health consequences across the world (Michael and Alavanja, 2009). Several studies have shown that the use of synthetic chemical pesticides has gravely impacted drastically not only abiotic but also biotic elements of the environment (Al-Zaidi et al., 2011). The entry of chemical pesticides into the food chain and subsequent bioaccumulation inductions has resulted in a deluge of unanticipated consequences. Pesticides which are widely used such as the DDT (dichloro-diphenyl-trichloroethane) was promiscuously used which led to the contamination and pollution of water and food sources, intoxication of non-target beneficial insects and development of pesticide resistance among target insects (Kumar et al., 2008). As chemically based pesticides has severely affected ecosystem functioning, extensive research were progressing with biopesticides so as to reduce pressure on ecology and environment. Majority of the currently using synthetic pesticides have biomagnifications potential with catastrophic effects on food chain (Linde, 1994; Gavrilescu, 2005) (Table 1).

Biopesticides:-

Biopesticides or biological pesticides are preparations or formulations made from naturally occurring substances that controls pests by non toxic mechanisms in an ecofriendly manner. Generally biopesticides are educed from botanicals, animals or microorganisms for pest management (Mazid et al., 2011). Biopesticides pose less threat to the environment and human health when compared with synthetic pesticides. Moreover, biopesticides have little or no residual effects and bioaccumulation threats and has wider acceptance in organic farming. In short the term biopesticide encompasses a wide spectrum of applications which includes multivariate pest control strategies such as microbial (viral, bacterial or fungal), entomophagous nematodes, plant-deduced pesticides (botanicals), secondary metabolites from microbes (antibiotics), insect pheromones employed for mating disruption and genetical modification to express resistances to various pest attacks (Copping & Menn, 2000).

The benefits of using biopesticides are of paramount importance in the current era, as the entire world is struggling hard with depleting environmental qualities and sources. Application of biopesticides is broadly based on their inherently less harmful and less environmental load, specificity in target pests, often effective in small concentrations and quick decomposition which avoids pollution issues and has an admirable role in Integrated Pest Management (IPM) programs.

Types of biopesticides:-
Biopesticides are categorized into plant-incorporated protectants (PIPs), biochemical, and microbial pesticides. Microbial pesticides contain a microorganism (bacteria, fungi, virus, protozoan or alga) as the active constituent which is effective to control biologically the pestiferous insects, plant pathogens and weeds. The most popular and commonly used microbial pesticide is Bacillus thuringiensis (Bt). The bacterium produces crystalline proteins which specifically kills one or a few related insect species by binding the crystalline protein to insect gut receptor. However the microbial pesticides must be incessantly monitored so as to ensure target organisms and specificity. Microbial pesticides include biofungicides (Trichoderma), bioherbicides (Phytopthora) and bioinsecticides (Bacillus thuringiensis and Baculovirus).

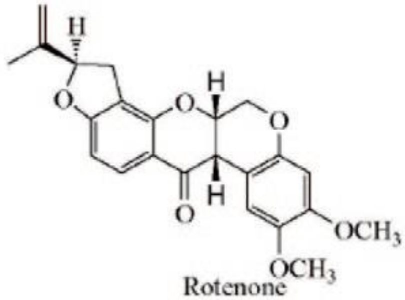
Biochemical pesticides are natural substances such as plant extracts, fatty acids or pheromones which control pests by non-toxic mechanisms. Plants produce an array of secondary metabolites for self defense and some of these have biopesticide potential like the pyrethrins, produced by Chrysanthemum cinerariaefolium (Silverio et al., 2009). Neem oil has also large scale applications as insecticidal chemical extracted from Azadirachta indica (Schmutterer, 1990). Generally, many plants contain a wide spectrum of secondary metabolites such as phenols, flavonoids, terpenoids, quinones, tannins, alkaloids, saponins, coumarins and sterols which show much variation in their efficaciousnesses against different pest species.

Plant- Incorporated-Protectants (PIP) are pesticidal substances that plants produce from genetic material like the insertion of gene for the Bt pesticidal protein, protease inhibitor, lectines, chitinase into the plant genome so that the transgenic plant synthesizes it its own. Here, the transgenic plant produces biodegradable protein with no calumnious effect on animals and humans, and thus restricts the use of hazardous pesticides.

Botanicals as biopesticides: a sustainable, safe and traditional option:-
Phytochemicals are relegated as either primary or secondary metabolites and majority of the plant species still remaining unexploited and untapped for pesticidally active principles. Among the plants studied for pesticidal properties only a negligible have achieved the commercial status. Currently whole world is before the development and promotion of eco-friendly bio-pesticides which only attack the target pest and harmless to beneficial biota. Plants has inbuilt genetical mechanisms like repellency and insecticidal action to protect from pest attacks. Likewise, botanicals are considered as an effective substitute for chemical pesticides as these botanicals or their derivatives have good potentiality to regulate and control harmful pests.

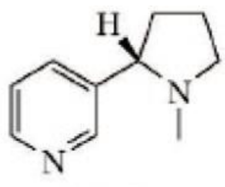
Plants are able to synthesize a fulgurant array of structural variety which exhibits an almost equally fulgurant array of anti-insect biological activenesses. It should be noted that the use of Neem seeds and Tobacco extract for grain protection is in practice for more than 300 year in both India and Europe. The Egyptians and Indians used to mix the stored grains with fire ashes to control pest infestations Since ancient times (Rajashekar et al., 2012). The antediluvian Romans used false hellebore (Veratrum album) as rodenticide while the Chinese is accounted with discovering the insecticidal properties of Derris species, whereas pyrethrum was used as an insecticide in Persia and China (Ahmed and Grainge, 1986). The pesticidal products of plant origins have been found outstandingly efficient in the form of antifeedant, repellent, protectants and growth disrupting hormones and as other biocides. Among the currently available biopesticides, the major ones include pyrethrins, rotenone, nicotine, ryanodine, sabadilla, neem based products and toosendanin with differences in mode of action.

Rotenone ($C_{23}H_{22}O_6$)**:-**



Rotenone is one of several isoflavonoids produced in the roots or rhizomes of the tropical legumes Derris, Lonchocarpus, and Tephrosia. Rotenone is a mitochondrial poison, which disrupts the electron transport chain (Hollingworth et al., 1994). It is a potent inhibitor of cellular respiration. It exerts its toxic effects in insects primarily on nerve and muscle cells, causing rapid cessation of feeding.

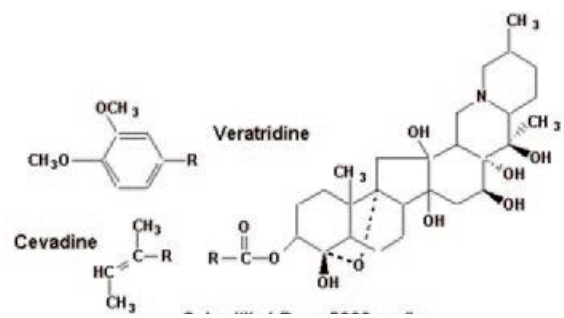
Nicotine ($C_{10}H_{14}N_2$**):-**
Nicotine is an alkaloid from tobacco plants (Nicotiana tabacum) and related species, has a very long history as an insecticide. Nicotine are synaptic poisons that mimic the neurotransmitter acetylcholine. Nicotine is neuro-toxic which competes with acetylcholine, the major neurotransmitter, by bonding to acetylcholine receptors at nerve synapses and causing uncontrolled nerve firing which results in rapid failure of body systems that depend on nervous input for sound functioning.



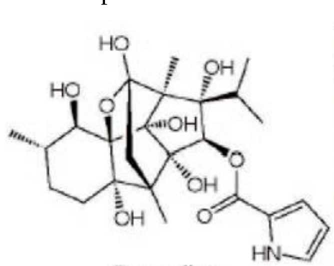
Nicotine

Sabadilla (Veratrine alkaloids)
Cevadine: $C_{32}H_{49}NO_9$
Veratridine: $C_{36}H_{51}NO_{11}$

Sabadilla is obtained from the seeds of the South American lily Schoenocaulon officinale. In insects, it affects nerve cell membrane action, causing loss of nerve cell membrane action, causing loss of nerve function, paralysis and death. Sabadilla kills insects of some species immediately, while others may survive in a state of paralysis for several days before dying.

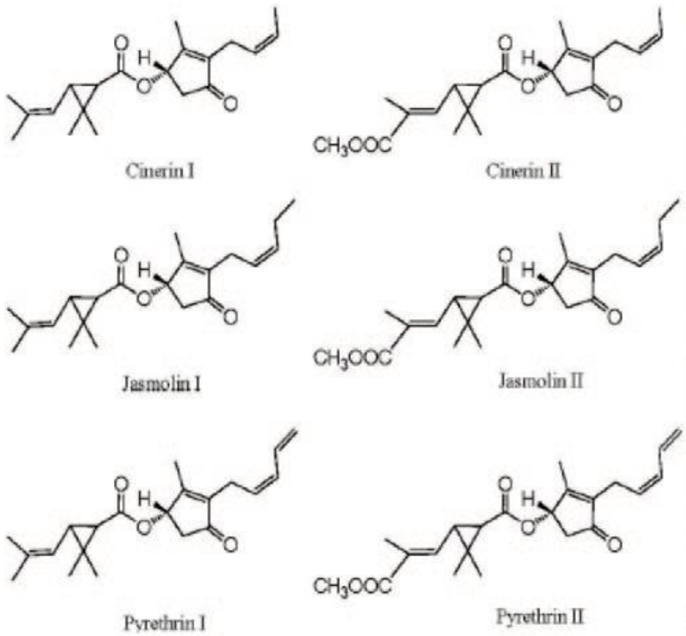


Ryania:-
Ryania is obtained by grinding the wood of the Caribbean shrub Ryania speciosa (Flacourtiaceae). It interferes with calcium release in muscle tissue. It causes insects to stop feeding soon after ingesting it. Ryania is a slow-acting stomach poison.



Ryanodine

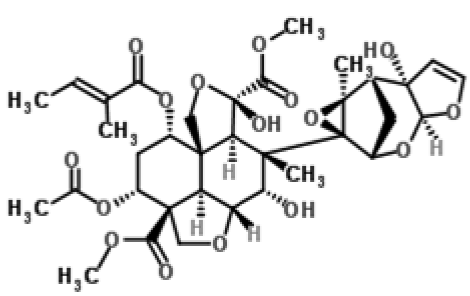
Pyrethrum and Pyrethrins:-



Cinerin I	$C_{20}H_{28}O_3$
Cinerin II	$C_{21}H_{28}O_5$
Cinerin III	$C_{21}H_{30}O_3$
Jasmolin I	$C_{21}H_{30}O_3$
Jasmolin II	$C_{22}H_{30}O_5$
Pyrethrin I	$C_{21}H_{28}O_3$
Pyrethrin II	$C_{22}H_{28}O_5$

]Pyrethrum is obtained from Chrysanthemum cinerariaefolium. The term “pyrethrum” is the name for the crude flower dust itself, and the term “pyrethrins” refers to the six related insecticidal compounds that occur naturally in the crude material, the pyrethrum flowers. They are extracted from crude pyrethrum dust as a resin that is used in the manufacture of various insecticidal products. Pyrethrins exert their toxic effects by disrupting the sodium and potassium ion exchange process in insect nerve fibers and interrupting the normal transmission of nerve impulses. Pyrethrins insecticides are extremely fast acting and cause an immediate “knockdown” paralysis in insects.

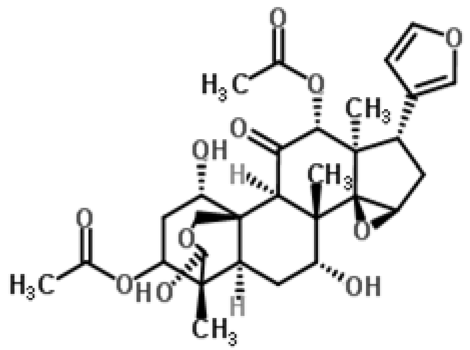
Neem ($C_{35}H_{44}O_{16}$)**:-**



Neem products are derived from Azadirachta indica, with the principle active compound as azadirachtin, a bitter, complex chemical that is both a feeding deterrent and a growth regulator.

Neem is a complex mixture of biologically active materials, and it is difficult to pinpoint the exact modes of action of various extracts or preparations. In insects, neem is most active as a feeding deterrent, but in various forms it also serves as a repellent, growth regulator, oviposition (egg deposition) suppressant, sterilant, or toxin.

Toosendanin ($C_{30}H_{38}O_{11}$)**:-**



Toosendanin was extracted from the genus Melia in particular Melia azedarach, M. toosendan and M. dubia. Toosendanin can block the nerve central conduction of insect, destroying its midgut tissues with a variety of detoxifying enzymes and respiratory metabolism, affect the digestion and absorption of food and loss of taste function.

Plant essential oils:-

Steam distillation of aromatic plants yields essential oils with complex mixtures of monoterpenes, biogenetically related phenols, and sesquiterpenes. Examples include 1,8-Cineole, the major constituent of oils from Rosemary (Rosmarinus officinale) and Eucalyptus (Eucalyptus globus); Eugenol from clove oil (Syzygium aromaticum); Thymol from Garden Thyme (Thymus vulgaris); and Menthol from various species of Mint (Mentha species) (Isman, 1999; Isman, 2000). Majority of researches are progressing in this regard too for developing plant oil based pesticides.

Botanical pesticides cause no adverse effects on non-target biota with biodegradability. It should be noted that most of the crops sprayed with botanical pesticides are quite safe for consumption after a short period after spraying. Moreover, resistance development was also rather meager with biopesticides.

Table 1: Pesticide groups and effects.

Sl. No.	Class	Examples	Effects
1.	Organochlorines (insecticide, acaricide, HCB & PCP are fungicides)	Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Lindane, Methoxychlor, Toxaphene, Hexachlorobenzene (HCB), Pentachlorophenol (PCP), DDT	Persistent, bioaccumulative, affect the ability to reproduce, develop, and to withstand environmental stress by depressing the nervous, endocrine and immune systems
2.	Organophosphates (insecticide, acaricide)	Schradan, Parathion, Malathion	Non-persistent, systemic (cholinesterase-inhibiting), broad spectrum, toxic to humans
3.	Carbamates (Fungicide, insecticide, acaricide)	Carbaryl, Methomyl, Propoxur, Aldicarb	Non-persistent, cholinesterase inhibiting, narrow spectrum, toxic to birds and fish
4.	Phenoxy (Herbicide)	2,4-D 2,4,5-T	2,4-D: potential to cause cancer in laboratory animals 2,4,5-T: is the source of a toxic contaminant dioxin
5.	Pyrethroids (insecticide)	Fenpropanthrin, Deltamethrin, Cypermethrin	Target-specific: more selective than the organophosphates or carbamates, generally not acutely toxic to birds or mammals but particularly toxic to aquatic species.

Conclusion:-

Employment of botanical pesticides in agriculture is overwhelmingly emerging as it save the environment from pesticidal pollution. The plant based pesticides have low mammalian toxicity and is less hazardous to environment and health. However the demand of food for ever-growing population is essential and the use of pesticides seems to be unavoidable. The realm of botanicals of tropical and subtropical countries must be evaluated for developing more effective biopesticides.

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