Caspian J. Env. Sci. 2005, Vol. 3, No.1, pp. 1~8

CJES
Caspian Journal of Environmental Sciences

[Review]

The Development of Botanical Products with Special Reference to Seri-Ecosystem

R. N. Singh* and B. Saratchandra
Central Silk Board, B. T. M. Layout, Madiwala, Bangalore 560 068, India.
**Corresponding Author's E-mail: spilorns@yahoo.com*

ABSTRACT

The search for alternative ways of controlling sericultural pests has led to the investigation of plant sources for naturally occurring compounds which may have Insect growth regulatory, feeding deterrency, repellency and confusantcy characteristics. More than 2000 species of the families Asteraceae, Fabaceae and Euphorbiaceae are known that possess some insecticidal activity. Plants with insecticidal properties found in India are reported. But to use them it is necessary to conduct an analysis of the risks to the environment and to human health. Various parts of rotenone, pyrethrum, sabadilla, ryania and neem are often used to minimize pest population. Recently several other plants viz. Pongamia, Indian privet, Adathoda, Chrysanthemum, Turmeric, Onion, Garlic, Tobacco, Basili, Custard apple, Ginger and some other plants have been screened and their efficacy has been tested. The efficacy of leaf extracts of basil (*Ocimum basilicum*), bitter leaf (*Vernonia amygdalina*), lemon grass (*Cymbopogen citratus*), and *Chenopodium ambroissoides* was investigated for its insecticidal and ovicidal activity against coleopteran bruchids. Several citrus limonoids and limonin derivatives have been found to be insect antifeedants. Among all the plant originated insecticides, neem (*Azadirachta indica*, *A. juss*) is known to contain diverse array of biologically active principles of which azadirachtin (a tetranortriterpenoid) is the best known derivatives which is used in sericulture to control various pests. Botanical insecticides are prepared in the form of the crude plant material, extracts or resins. This paper includes the plants that have been reported to be insecticidal against the pests, which visit seri-ecosystem and damage the silkworm and its host plants.

Keywords: Botanical insecticides, Pest control, feeding deterrent and repellent

INTRODUCTION

Increasing reliance on conventional pesticides to combat intricate pest problems in sericulture and human health during the past four decades paid rich dividends in terms of enhanced productivity and suppersion of diseases but proved extremely risky to environment and mankind. Repeated application of synthetic organic insecticides resulted into pest resistance and out break. Most insecticidal compound falls within four main classes, the organochlorines, organophosphates, the carbamates and pyrethroids. Out of these the major classes in use today are organophosphates and carbamates. There are problems of pesticides resistance and negative impacts on non-target organisms including man and the environment (Singh *et al*. 2000, 2004). Many environmental problems such as development of resistance in pests to pesticides, resurgence of target and non-target pests, destruction of beneficial organisms and pesticides residue in host plants may be reduced after proper use of the active ingredients present in the plants (Singh and Saratchandra, 2002). The use of organochlorine insecticides has been banned in developed countries and the alternative methods of insect pest control are being investigated (Klein and Dunkel, 2003). Botanicals are the most promising source and under extensive trails for their biological activity against various sericultural pests. Therefore, this vast wealth of plants that are rich sources of bioactive compounds need to be documented in detail.

WHY BOTANICALS

Public awareness and resulting environmental protection agencies (EPA) rulings have led to the removal of some chlorinated, organophosphorus and carbamate insecticides from the market. It is because of growing concern for clear environmental and insect populations that are resistant to conventional chemicals. During the last 15 years interest in botanical insecticides has increased to look for substitutions for synthetic insecticides with those based on naturally occurring substances. Safer products are being used in sericulture to control the pest population because the application of insecticides to silkworm host plant may be harmful to the rearing of silkworm. Sericultural techniques such as maintenance of phytosanitary and cover crops, trap crop systems, irrigation and soil amendments and biological control is alternative to banned insecticides (Singh and Saratchandra, 2004a), Such practices are the result of an emphasis on integrated pest management (IPM) rather than insect control. Etebari *et al.*, (2004) reported that proper planning an accurate IPM and utilizing all management method of pest control is very important to control pest population in sericulture. Alternative Pest Management Practices have focused on the balance of natural and sericultural ecosystems (Carmona and Landis, 1999). Structure and function of plant communities, habitat fragmentation, herbivore, parasitoid interactions, and other natural regulating factors of arthropods in crop communities focus on maintaining stable ecosystem. (Jaiswal *et al.*, 2004). Among the oldest means of controlling insects are cultural practices for managing *Bemisia tabaci* (Gennadius) (sweet potato whitefly) in tropical and subtropical countries. An array of strategies has been used successfully, such as crop free periods, crop residue disposal, barrier, and weed removal (Douressamy *et al*. 1997). The use of botanicals in pest management is not only useful for suppression of pest population but also helps to maintain the sound ecological balance.

METHODS AND MODE OF ACTION

Botanical insecticides are prepared in the form of the crude plant material, extracts or resins. The crude plant material is usually ground into a powder and marketed full strength or diluted with a carrier. Rotenone, pyrethrum flowers, sabadilla seeds, ryania stems and neem seeds are often ground into powdered form. Simple methods of preservation by drying and heat-treating the seeds were the most common practices to reduce the pest population (Singh *et al*. 2004). During early days, plants were used in various forms to keep the pests away from the agricultural field. Similar approach has been made in sericulture to ward off the pest of silk host plants and silkworms (Singh and Saratchandra 2004b).

Most plant species used for plant protection exhibit an insect deterrent rather than insecticidal effect. It indicates that in some way those compounds inhibit normal development in insects. It acts in different ways viz. Insect growth regulators (IGR), feeding deterrents, repellents and confusants. Antifeedant and repellant activity have been evaluated for some of the plants. A true antifeedant gives insect the opportunity to feed on the plants, but the food intake is reduced until the insect die from starvation (Saxena, 1987). The growth regulator causes abnormality in metamorphosis and the insects suffer malformations may become sterile or even die.

Feeding deterrence is perhaps the most studied mode of action for plant derivatives used for insect pest management. Feeding deterrent is a compound that once probed by the insect, causes it to stop feeding and starved to death. Many compounds showing this activity are terpenes and most have been isolated from medicinal plants native to Africa and India. The extracts of the plants greatly reduced feeding regardless of the method of treatment. This indicates that the extract contained chemicals, which deter feeding. In all plants tested, more feeding was observed on air-dried leaves than on wet leaves. Probably the components of the extract, which deter feeding, were volatilized during drying. The reduced feeding on wet leaves could be either due to direct toxic action of the extract on the larvae and or to the presence of feeding deterrent as exhibited by the *L. camara* leaf extract, which is both toxic and antifeedant. Antifeedant activity of *Myllocerus viridanus* on *Terminalia arjuna* leaves was reported by Sharma *et al.* (2003). More than 75% mortality was exhibited at 24 h when the leaf squares were sprayed after introduction of the larvae. Singh and Thangavelu (1996) reported influence of neem compound on the growth and development of immature forms of the uzifly an important parasite of tasar silkworm. It acts on insects by repelling them, by inhibiting feeding, and by disrupting their growth, metamorphosis and reproduction.

Repellents, on the other hand drive the insects away after exposure to the plant without necessarily feeding. The use of plants as repellents is very old but has not received the necessary attention for proper development. The compounds having bad odor or irritant effects are used. Garlic and peppers are most common plants under this group. Garlic powder has been used to shoo away rodents. Further, the use of fennel (*Foniculum vulgare*), rue (*Ruta graveolens*) and eucalyptus (*Eucaliptus globolus*) among other aromatic plants to repel cloth moths are very common. Isman (1997) reported that the odor of the essential oils prevents the larvae from

Table 1. Inventory of plants with insecticidal properties found in India (Baskaran and Narayanasamy, 1995)

Scientific Name	Part(s)with Insecticidal property	Nature of action
Acacia arabica Lam.	Gum	General
Acacia concinna	Pods	Repellent
Acacia nilotica L.	Flowers, stem	Contact, Antifeedant
Acorus calamus L.	Rhizome	Antifeedant, Repellent, Contact inhibitor
Adhatoda vasica Nees	Leaves	Antifeedant, Repellent
Aegle marmelos L.	Leaves	Repellant
Agave americana L.	Leaves	Contact
Ageratum conyzoides L.	Leaves	Contact
Allium cepa L.	Bulbs	Repellent
Allium sativum L.	Bulbs	Repellent
Aloe vera L.	Leaves	Repellent
Amorphophallus sp.	Rhizome	Repellent
Anabasis aphylla	Leaves	Contact
Anamirta cocculus L.	Leaves	Contact
Annona squamosa L.	Leaves	Contact
Annona reticulata L.	Seed	Contact
Anacardium accidentale	Bark, Stem	Growth inhibitor
Arachis hypagaea L.	Leaves, seeds	Used in poison baits
Areca catechu	Flower	Contact
Argemane mexicana	Flowers	Contact
Aristalochia sp.	Leaves	Repellent
Artemeisia absinthim	Leaves	Antifeedant
Artocarpus heterophyllus Lam	Leaves/Latex	General
Azadirachta indica	Whole	Contact, repellent
Bassia lalifolia Roxb.	Oil	Synergist
Brassica nigra Rosc.	Seeds	Attractant
Butea monosperma Lam.	Flowers	Contact
Caesalpinia pulcherrima	Flowers	Contact
Callistephus chinensis	Flowers	Contact
Calophyllum inophyllum	Oil	Contact
Calotropis gigantean	Leaves	Stomach
Canna indica	Flowers	Contact action
Canna orientalis Rose	Petals, Flowers	Fumigant
Cannabis sativa L.	Leaves	Contact
Capsicum frulescens L.	Fruits	Insecticide
Capparis decidua	Twigs	Repellent
Carica papaya L.	Fruits. Latex	Repellent
Carthamus tinctorius	Oil	Contact action
Cassia fistula L.	Flowers	Repellent
Callosabruchus chinensis	Leaves	Repellent
Cassia occidentalis	Leaves	Antifeedant
Crocidolomia binotalis	Leaves	Repellent
Casuarina spp.	Leaves	Contact
Chrysanthemum sp.	Fruits	Contact
Cinnamomum sp.	Twigs	Attractant
Cinnamomum camphora	Fruits, Latex	Repellent
Cissus quadrangularis L.	Oil	Contact
Citrus aurantium L.	Leaves	Contact
Clerodendron Infortunatum	Leaves	Contact action
Clerodendron multiflorum	Whole plant	Contact
Cocos nucifera	Oil	Contact
Combretum ovalifolium	Leaves	Repellent
Carchorus capsularis	Seeds	Repellent
Crotalaria juncea Buch.	Leaves, flowers	Repellent
Cuminum cyminum L.	Seeds	Contact
Curcuma domestica	Rhizome	Contact
Cycas revoluta Thumb.	Male cone	Contact
Datura strumarium L.	Leaves	Contact
Delonix regia	Flowers	Contact
Derris elliplica Roxb.	Roots	Contact
Callosobnlchus	Flowers	Repellent
Echinochloa frumentacea	Whole plant	Antifeedant
Eleusine coracana L.	Leaves	Contact
Eucalyptus globulus L	Leaves	Contact

wandering away from the food plant. Confusants are used to attract the insects in the trap set up in the field. Watery extracts of the plant is kept in the trap so that insects will land in the traps and not on the crop. All those known compounds have insect deterrents and have preventive rather than curative effects.

Table 1. Continued

Scientific Name	Part(s)with Insecticidal property	Nature of action
Euphorbia sp	Whole plant	Contact
Ficus benghalensls L.	Latex	Contact
Ganoderma lucidum	Flowers	Contact
Glyricidia sepium KW	Leaves	Contact
Gossypium indicum L.	Seed oil	Contact
Cymbopogon citrates	Leaves	Antifeedant
Helianthus annuus L.	Seed oil	Contact
Hibiscus rosa chinensis	Flowers	Contact
Jasminum spp.	Flowers	Contact
Jatropha curcus L.	Whole plant	Repellent
Justicia adhatoda	Leaves, kernels	Repellent
Kaempfera galanga	Whole plant	Contact
Lantana aculeata L.	Leaves	General
Lantana camara L.	Leaves, stem	General
Lobelia nicotionifolia	Leaves	General
LujJa acutangula	Flowers	Contact
Madhuca longifolia.	Oil	Contact
Mangifera indica L.	Leaves (dried)	Fumigant, contact
Maranta arundinacea	Rhizome	Contact poison
Melia azedarach L.	Bark	Attractant
Melilotus indica	Capsule	Repellent
Mentha spicata L.	Leaves	Antifeedant
Michelia champaca	Flowers	Repellent
Mundulea sericae Willd.	Leaves	Contact poison
Nerium indicum Mill.	Fruits, seeds	Stomach poison
Nicotiana tabacum L.	Leaves, whole	Stomach poison
Nigella sativa	Seed	Contact action
Ocimun basillum	Leaves, Oil	Repellent
Ocimum sanctum L.	Leaves, Oil	Repellent
Opuntia spp.	Leaves	Contact action
Parthenium fruiticosum L.	Leaves	Contact action
Piper betel L.	Leaves	Contact action
Piper nigrum L.	Seeds	Stomach poison
Pogostemon heyneanus	Oil	Contact action
Pogostemon patcholi	Leaves	Contact
Poinsettia pulcherrima	Flowers	Contact
Pongamia pinnata L.	Oil cake	Antifeedant
Prosopis juliflora SW.	Leaf	Contact
Ricinus communis L.	Seed oil	Synergist
Ryania speciosa Vahl.	Roots	Contact
Sapindus emarginatus V.	Fruit, leaves	Contact
Sansurrea lappa	Roots	Repellent
Sesamum orientale L.	Seeds	Synergist
Shoenocaulon officinale	Seeds	Contact
Sigesbeckiia orientalis	Leaves	Antifeedant
Sorghum bicolor L.	Stems	Contact
Strychnos nuxvomica L.	Seeds, leaf	Contact
Tabebuia rosea	Flowers	Contact
Tagetes patula L.	Leaf	Contact
Tamarindus indica L.	Seed wood ash	Contact
Tecoma indica	Flowers	Contact
Tephrosia candida	Seeds	Contact
Tephrosia purpuria	Leaves	Contact
Tinospora crispa L.	Vines	Contact
Tridax procumbens	Flowers	Contact
Trigonella foenum-graecum	Seed	Antifeedant
Tripterygium iifordii	Roots	Stomach poison
Vitex negundo	Leaf extract	Contact
Xeronlphis spinosa	Fruits	Antifeedant
Zingiber officinale Rose.	Rhizome	Repellent
Zizyphus mauritiana Lam.	Leaf folder	Contact

BOTANICALS IN USE

The pool of the plants possessing insecticidal substances is enormous. More than 2000 species of the plants are known that possess some insecticidal activity (Jacobson, 1975). In the middle of the 17th century, pyrethrum, nicotine and rotenone were recognized as effective insect control agents. The most economically important of the natural plant compounds used in commercial insect control are the pyrethrins from the flower heads of pyrethrum *Chrysanthemum cinerariaefolium.* Despite the relative safety of the well-known botanical insecticides, most of these substances have their drawback hindering large-scale application. Pyrethrins are unstable in the light and are rapidly metabolized thus limiting their potency and application (Casida, 1983). These limitations gave impetus for synthesis of active analogues, termed pyrethroids. Nicontine isolated from number of species of *Nicotiana* is insecticidal, but its use in insect control has dropped steadily because of the high cost of production, disagreeable odour, extreme mammalian toxicity, instability in the environment and limited insecticidal activity. Rotenone is unstable and very toxic to fish. Further, several insects have exhibited resistance to pyrethroids. For these reasons, the search for new safer and more effective insecticides from the plants is justified. Indeed the research in this area has led to the discovery of substances with increasing activities on insects. The substances include insect growth regulators/inhibitors and antifeedants.

It was estimated that nearly 2400 species of plants in India possess insecticidal properties (Baskaran and Narayanswamy, 1995). Botanical insecticides break down readily in soil and are not stored in animal and plant tissue. Often their effects are not as long lasting as those of synthetic insecticides and some of these products may be very difficult to find. The plant parts used for extraction or assay were the leaves, roots, tubers, fruits, seeds, flowers, the whole plant, bark, sap, pods and wood. The most commonly utilized parts were the leaf (62 species) followed by roots (16 species) and tuber (12 species). The plant families Asteraceae, Fabaceae and Euphorbiaceae contain most of the insecticidal plant species reported.

Recently several other plants viz. Neem, Pongamia, Indian privet, Adathoda, Chrysanthemum, Turmeric, Onion, Garlic, Tobacco, Ocimum, Custard apple, Ginger and some other plants have been reported as insecticidal plants which can be used in insecticide preparation (Table 1). Apart from this Cinerin I (Flowers 0.7-3 %) and Cinerin II, Jasmolin I and Jasmolin II are also used as insecticides. Garlic acts as a repellent against various pests and is grown as border/ intercrop to prevent pests from going near the main crop. Extract and powder preparations of garlic and onion bulbs are used to check pests in the field and grainage. Similarly plants like Nochi (*Vitex negundo*), Pongamia (*Pongamia glabra*), Adathoda (*Adathoda vasica*) and Sweet flag (*Acorus calamus*) are found to be effective against various pests of field crops and in storage. Extracts of *Pomoea cornea fistulosa*, *Calotropis gigantea* and *Datura strumarium* contain principles toxic to many crop pests. The extract of flowers of champak (*Michelia champaca*) is potent against mosquito larvae. The leaf extracts of lantana (*Lantana camara*), Citrous oil, tulsi (*Ocimum basilicum, O. sanctum*) and vetiver (*Vetivera zizanoides*) are useful in controlling leaf miners in potato, beans, brinjal, tomato, chillies, etc. Crushed roots of marigold (*Tagetus erecta*) provide good control of root-knot nematode when applied to soil in mulberry garden. The seed extract of custard apple (*Annona squamosa*) and citrus fruit (*Citrus paradisi*) are effective against diamond back moth and colarado potato beetle respectively. Bark extract of *Melia azadarach* acts as potential antifeedant against tobacco caterpillar (*Spodoptera litura*) and gram pod borer (*Heliothis armigera*). Leaf extracts of lemon grass (*Cymbopagon citratus*), argemone (*Argemone mexicana*), cassia (*Cassia occidentalis*). artemesia (*Artemesia absinthium*) and sigesbekia (*Sieges beckiia orientalis*) are strong antifeedants of caterpillar pests like *Crocidolomia binotalis*. Root extract of drumstick (*Moringa oleifera*) inhibits growth of bacteria. The leaf and fruit extracts of bel (*Aegle marmelos*) and leaf extracts of Opuntia, Nochi and Jatropha are potential against various pests. Some of the plants having herbal insecticide principles are presented on Table (2).

These plants in harmonious integration with other safe methods of pest control like biological control, trap crops and cultural practices etc. can provide eco-friendly and economically viable solutions for pest problems in near future. Among all the important insecticidal plants, Neem (*Azadirachta indica*) is the most promising

Table 2. Source of herbal insecticide procured from different plants.

Chemical Group	Principal Chemical	Source of plant	Plant organ and content
Azadirachtin	Alkaloid	*Azadirachta indica*	
Nicotine	Alkaloid	*Nicotiana tabacum, N. rustica*	Leaves 5-14%
Anabasine	Alkaloid	*Anabasis aphylla*	Leaves 1-26%
Piperine	Alkaloid	*Piper nigrum*	Seeds
Veratine	Alkaloid	*Schoenocaulon officinale*	Seeds 2-4% (effective as cevadine & veratridine)
		Veratrum album, V. viridae	Root
Ryanodine	Alkaloid	*Ryania speciosa*	Wood 0.16-0.2%
Wilfordine	Alkaloid	*Tripteryglum wilfordii*	Root (a mixture of 5 alkaloids)
Quassin, Neoquassin, Picrasmin	Diterpenoids	*Quassia amara, Lactones excelsa*	Wood
Sesamin	The crystalline	*Sesamum indicum*	Seed- fraction of sesame oil (0.25%)
Rotenone (ellipton)	Rotenoids Derris	*Deguella elliptica*	Root- sumatrol, malaccol (deguelin a-toxicarol)
Pyrethrin I	Pyrethrins	*Chrysanthemum cinerari*	
Pyrethrin II	Pyrethrins	*C. roseum* *C. carreum*	

source of biopesticide and its various formulations are extensively used for pest control (Schmutterer, 1990). Neem leaves, stems, seeds and oil have been used for pest control in sericulture (Singh, 1999). The limonoids present in it and its products have made it a harmless to mankind while functioning as insecticide, bactericide, fungicide, pesticide etc. It is likely to provide a solution to many of pest and disease problem in sericulture (Singh and Sinha, 1993). Generally, extracts of plant leaves or seed are prepared and sprayed; otherwise, seeds are dried under sunshade, powdered finely and applied as dust. Neem cake has the value of fertilizer to plants besides acting against beetles and nematode infestation in mulberry. More than 20 neem based biopesticides are available in the market (Table 3). Because neem products are used for human consumption and medication, exposure to neem in the process of treating plants with neem oil poses no threat to humans or other higher animals. Moreover, neem is not harmful to beneficial insects, affecting only those insects feeding on plants treated with neem. Since most predator insects do not also feed on plants, they are not harmed by the presence of neem. Neem biodegrades in a matter of weeks when exposed to sunlight or in soil. Neem products are highly photodegradable and normally degrade within a week. No problem of development of pest resistance and resurgence has been reported from neem products. Hence they have characteristics suitable for IPM strategy.

Much of the information's are available on insecticidal properties of plants having some sort of toxic property against insects. But to use them it is not enough that the plant be considered as promising or even with proven insecticidal properties. It is also necessary to conduct an analysis of the risks to the environment and to human health. The plants that are on the verge of extinction, that are difficult to find, or if their use results in important alterations to their population density in natural conditions may not be recommended for use. An ideal insecticidal plant should be perennial and have a wide distribution and be present in large numbers in nature. The plant parts to be used should be removable: leaves, flowers or fruit and harvesting should not mean destruction of the plant. The plants should require small space, reduced management and little water and fertilization and should not have a high economic value. The active ingredient should be effective at low rates.

ADVANTAGES

Plants producing the compounds having insect growth regulators (IGR), feeding deterrents, repellents and confusants activities are known by the farmer because most of the time they grow in the same general area. Often these plants also have other uses like household insect repellents or are plants with medicinal applications. The rapid degradation of the active product may be convenient as it reduces the risk of residues on food. Some of these products may be used shortly before harvesting. Many of these products act very quickly inhibiting insect feeding even though long term they do not cause insect death. Since most of these products have a stomach action and are rapidly decomposed they may be more selective to insect pests and less aggressive with natural enemies. Most of these compounds are not phytotoxic and have rapid action and low toxicity to mammals and plants. Resistance to these compounds is not developed as quickly as with synthetic insecticides.

Table 3. Commercial Neem insecticides available in the market.

Trade name	Name of Compound
Bioneem	Azadirachtin 0.3%
Econeem	Azadirachtin 0.3%
Gillmore	Azadirachtin 0.3%
Godrej Achook	Azadirachtin 0.3%
Margocide CK20	Azadirachtin 0.15%
Margocide OK80	Azadirachtin 0.3%
Neemark	Azadirachtin 0.3%
Neemazal F	Azadirachtin 5%
NeemazolT/S	Azadirachtin 1 %
Neembecidine	Azadirachtin 0.3%
Neem Gold	Azadirachtin 0.15%
Nimbasol	Azadirachtin 0.15%
Rakshak	Azadirachtin 0.15%
RD-9 Ropellin	Azadirachtin 0.3%
Sukrina	Azadirachtin 0.15%
Neemax	Neem kernel Ecomax

DISADVANTAGES

Most of these products are not truly insecticides since many are merely insect deterrents and their effect is slow. They are rapidly degraded by UV light so that their residual action is short and breakdown is rapid, requiring more precise timing of and/or more frequent application. Not all plant insecticides are less toxic to other animals than the synthetic ones. They are not necessarily available and sometimes cost is more. Most of them have no established residue tolerances and there is lack of test data and sometimes lack of state registration of some materials. There are no legal registrations establishing their use. Not all recommendations followed by growers have been scientifically verified.

FUTURE RESEARCH

From the evidence available to date the most promising candidate materials for consideration as future silkworm and its plant protestants are Azadirachta, Eucalyptus, Ocimum, Piper and Tetradentia together with oils from various sources. However, in order for plant materials to be seriously considered further information is required. Standardized laboratory tests need to be under taken, examining the residual effects of these materials over six to twelve months duration against key insect species. These include gall insect (*Trioza fletcheri minor*), stem borer (*Psiloptera fastuosa*), vapourer tussock moth (*Notophus atiqua*), weevils (*Myllocerus undosulauts*) on vanya silk host plants, mealy bug (*Macconelloccoccus hirsutus*), bag worms (*Diaphania pulventris*) on mulberry and uzi fly on silkworm. The residual effects of the materials on the silkworm could be critically evaluated and compared for both repellant/antifeedant. Thus we, have a vast wealth of plants which are rich sources of bioactive compounds and several more might still be lying unexplained. The plants, in harmonious integration with other safe methods of pest control like biological control, trap crops and cultural practices etc. can provide eco-friendly and economically viable means for pest control in near future.

REFERENCES

Baskaran, V. and Narayanasamy, P. (1995) Traditional Pest Control. Caterpillar Publications, Mariyappa Nagar, Tamil Nadu, India.

Carmona, D. M. and. Landis, D. A. (1999) Influence of refuge habitats and cover crops on arsenal activity density of ground beetles (Coleoptera: Carabidae) in field crops. *Eviron. and Entomol.* **28,** 1145 – 1153.

Casida, J. E. (1983) Development of synthetic insecticides from natural products: case history of pyrethroids from pyrethrins. In: Natural Products from innovative pest measurement (Ed. Whitehead, D. L. and W. S Bowers.) PP. 109 – 125. Pergamon press, New York.

Douressamy, S., Chandramohan, N., Sivaprakasam, N., Subramanian, A. and Sundra babu, P. C. (1997) Management of spiralling whitefly. Indian Silk, **36**, 15 – 16.

Etebari, K., Matindoost, L. and Singh, R. N. (2004) Decision tools for mulberry thrips *Pseudodendrothrips mori* (Niwa, 1908) management in sericultural regions; An overview. *Entomologia Sinica*. **11**, 243-258.

Isman, M. B. (1997) Leads and prospects for the development of new botanical insecticides. *Rev. Pesticide Toxicol.* **3**, 1 –20.

Jacobson, M. (1975) Insecticides from plants: A review of the literature, 1954-1971.

Agriculture Hand Book 461, U.S.D.A., Washington, D. C. pp. 138.

Jaiswal, K., Upadhyay,S., Dhami, S. S. and Gangwar, S. K. (2004) Application of different neem (Azadirachtin) formulations for the control of insect pest (*Ergolis meriona* C.) population infesting castor. Proc. National workshop on Potential and Strategies for sustainable development of Vanya silks in Himalayan states. pp. 93-95.

Klein, A. R. and Dunkel, F. V. (2003) New Pest management frontiers: Linking plant medicine to traditional knowledge. *American Entomologist*. **49,** 7 –73

Saxena, R. C. (1987) Antifeedants in tropical pest management. *Insect Sci. Applic*. **8,** 731 –736.

Schmutterer, H. (1990) Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. *Ann. Rev. Entomol*. **35,** 271 – 297.

Sharma, S. P., Kishore, R. and Thangavelu, K. (2002) Evaluation of azadirachtin against *Notolophus antiqua* Linn. (Lepidoptera: Lymantriidae) a major pest of primary tasar food plants. *Sericologia*. **42,** 265 – 269.

Singh, R. N. (1999) Use of neem against pest of tasar food plants. *Indian Silk*. **38,** 20-22

Singh, R. N. and Sinha, S. S. (1993) Neem to control pests of tasar. Indian Silk. **32,** *42- 44.*

Singh, R. N. and Thangavelu, K. (1996) Influence of neem compound on the growth and development of immature forms of the uzifly *Blepharipa zebina*. *Pestology*. **20,** 16-21

Singh, R. N., Samson, M. V. and Datta, R. K. (2000) Pest Management in Sericulture. Indian Publisher Distributor, Delhi, India.

Singh, R. N. and Saratchandra, B. (2002) An Integrated Approach in the Pest Management in Sericulture. *Int. J. Indust.* Entomol. **5,** 141-151.

Singh, R. N. and Saratchandra, B. (2004a) Properties and potential of natural pesticides against sericultural pests. New Horizon of Animal Science (eds. B. N. Pandey, N. Armugam, P. Natraj, S. Pranjith) *Publ. Zool. Soc. India*. pp. 200–206.

Singh, R. N. and Saratchandra, B. (2004b) Use of neem in plant protection in Vanya silk. Proc. National workshop on Potential and Strategies for sustainable development of Vanya silks in Himalayan states. pp. 125 – 130**.**

Singh, G. B., Sahay, A., Roy, D. K., Sahay, D. N., Kulshrestha, V., Roy, G. C. and Sinha, B. R. R. P. (2004) Efficacy of Botanicals against virosis in tasar silkworm, *Antheraea mylitta* Drury. Proc. National workshop on Potential and Strategies for sustainable development of Vanya silks in Himalayan states. pp. 260-263

Singh, R. N., Maheshwari M. and Saratchandra, B. (2004) Sampling, Surveillance and Forecasting of insect population for Integrated Pest Manage-ment in Sericulture. *Int. J. Indust. Entomol*. **8**, 17 –26.

(Received: Mar. 16, Accepted May. 11, 2005)