Potential of botanicals for the management of forest insect pests of India, an overview

R. Sundararaj

ABSTRACT

This paper reviews the botanicals evaluated against forest insect pests of India and presents the impact of neem and other plant products against major forest insect pests. Various neem products were found effective in field condition against many forest insect pests like the rohida defoliator, *Patialus tecomella,* the babul defoliator, *Taragama siva,* the desert locust *Schistocerca gregaria,* the babul whitefly *Acauldaleyrodes rachipora,* the spiralling whitefly, *Aleurodicus dispersus* and the teak defoliators *Hyblaea puera* and *Paliga machaeralis* etc. Neem oil and neem oil based formulations were used to contain the populations build up of *A. dispersus* on roadside plantations of *Bauhinia. variegata* and *Michelia champaca.* Neem cake, pongam cake and VAM were commonly applied in combination for the management of sucking pests on seedlings. Other than neem about 58 plant species were reported to have pest management properties on forest insect pests. In these plants, mostly crude extracts were reported to have different type of pest management properties in laboratory condition against defoliating pests. Not much work has been carried out on other group of insects like sap suckers, wood borers, gall inducers etc. Extractives of different parts of *Capparis decidua* were found to possess aphidicidal principles against three species of aphids *viz., Aphis gossypii, Lipaphis erysimi* and *Mysus persicae.* Plant products other than neem were not practically used much for pest control. It is recommended to have national, regional and international coordinated effort to exploit botanicals that are more potent as an integral component of pest management in different cropping systems including forestry.

Key words: Botanicals, forest insect pests, pest management

INTRODUCTION

The use of synthetic pesticides during the last half century has often been careless and indiscriminate which resulted in malicious effects on the environment and leads to "ecological backlash" (Sundararaj, 1997). Concern about this has led to a surge of research into alternative pest control technologies. One of the efforts is the development of botanical insecticides as a novel and safer alternative strategy. Botanical insecticides, which contain plant extracts as active components, are safer as well as environmentally friendlier than synthetic insecticides. Use of these chemicals of plant origin, commonly called 'botanicals' or 'phytochemicals' have attracted particular attention because of their specificity to insect pests, their biodegradable nature and their potential for commercial application (Bishop and Thronton, 1997;Shukla *et al.,* 2000). These materials have been, since time immemorial, reported to be devoid of the various disadvantages, which are associated with the use of synthetics. Bioactivity of plant-based compounds is well documented in literature and is a subject of increasing importance. Knowledge of the toxic plants, their toxic principles and their biological activity is of paramount importance not only to enable them to be utilized as natural pest control agents and replace the commercial synthetic pesticides but also to enable us to understand the nature of their toxicity to non-targeted animals. The efficient use of such renewable natural resources is becoming increasingly important worldwide. There is no doubt that many plant secondary metabolites affect insect behaviour, development and reproduction. Characterization and identification of these

substances is an important first step in understanding the effect of plants on insect life. The botanicals thus obtained offer better compatibility with other biological pest control agents than that of the synthetics and this has brought them to sudden prominence in pest management programme.

Neem- A potential source of biopesticide

Neem (*Azadirachta indica*) products are known in use in India from time immemorial against noxious insects. Because of its legendary insect repellant and medicinal properties, it being identified as "the most promising of all plants" and at the present moment it is the source of most promising pesticides. More than 100 protolimonoids, limonoids or tetranortriterpenoids and some nonterpenoid constituents have been isolated from various parts of neem (Koul *et al*., 1990). From the neem seed extract alone, over 57 components have been isolated and identified (Jacobson, 1988). It is now well established that azadirachtin, the most important phagorepellent of neem kernels protects plants against insect attack. Bernays and Chapman (1977) indicated azadirachtin as the most potent antifeedant against insects like *Locusta migratatoria migratorioides* and *Schistocerca gregaria*. It exhibits strong antifeedant activity against locusts as well as growth inhibiting properties (Rembold *et al*., 1980). Neem kernel extracts or their oil repel insects, act as antifeedant, cause growth disruption, deformities or mortality and impairing egg production (Sieber and Rembold, 1983). The review offer further evidence for the impact of neem products against the major forest insect pests of India. The control of forest pests like poplar defoliator, *Pygaera cupreata* (Bhandari *et al.,* 1988), babul defoliator, *Taragama siva* (Sundararaj *et al.,* 1995), the rohida defoliator, *Patialus tecomella* (Sundararaj and Murugesan, 1995), the babul whitefly, *Acaudaleyrodes rachipora* (Sundararaj *et al.,* 1995; 1996, Sundararaj, 1999a, b), the teak defoliators, *Eutectona machaeralis* and *Hyblaea puera* (Kulkarni *et al.,* 1996; Remadevi and Raja Muthukrishnan, 1988; Murugan *et al.,* 1999; Sree *et al.,* 2008) using different neem products have been tested and found useful. Dubey and Sundararaj (2004) demonstrated neem oil as effective like that of commercial neem formulations and Chlorpyriphos in containing the nymphal populations of *A. disperses* infesting trees of *Michelia champaca* and *B. variegata*.

Neem seed kernel suspension as effective repellent against the polyphagous desert locust *Schistocerca gregaria* was demonstrated (Pradhan and Jotwani, 1971; Singh, 1985; Sundararaj *et al*., 1985). Ramarethinam *et al*. (2002) repored insecticidal property of azadirachtin against *Eurema hecabe* on *Cassia fistula*, Ambika *et al*. (2007) recommended neem seed oil against *Pemplia morosalis* on Jatropha and Murugesan *et al*. (2008) recommended nimbicidin against *Carryedon serratus* infesting seeds of many forest trees. The application of neem cake alone or in combination with other seed cakes and VAM was recommended to control whiteflies in nurseries (Sundararaj, 2010). As the neem products proved its practical utility, they are recommended for large-scale application in forestry.

Other plant products

A perusal of literature revealed that other than neem about 58 plant species were reported to have pest management properties on forest insect pests (Table 1). Mostly crude extracts were found to have different type of pest management properties in laboratory condition against defoliating pests of teak, poplar, subabul, bamboo etc., without identifying the active principles in the plant products. Defoliating insects were mostly used as test insects except the report of Sharma *et al.* (1992) who reported insecticidal properties of 15 plant oils against the sap sucking psyllid *Heteropsylla cubana.* Similarly extractives of different parts of *Capparis decidua* were found to possess aphidicidal principles against three species of aphids viz., *Aphis gossypii* on marwar teak (*Tecomella undulata*), *Lipaphis erysimi* on mustard (*Brasicca compestris*) and *Mysus persicae* on cabbage (*Brassica oleracea*) (Table 2). The order of aphidicidal potential of extract is root > seed > stem bark > branch > wood. These plant products are probable sources of some biologically active agents for pest management for the future. Although the potential of various plant species in pest management has been demonstrated, the plants

Table 1. Plant products other than neem reported to have pest management properties against tree pests of India

Tree species	No. of plant species reported	Nature of plant products	Pest species and their nature	Effects	Reference
Acacia nilotica	1	Leaf powder: 1	**Seed feeders:** *Bruchidius* sp., and *Caryedon serratus*	Insecticidal	Murugesan *et al*., 2008
Ailanthes sp.	3	Leaf extract: 3	**Defoliator:** *Atteva fabriciella*	Antifeedant	Ahmed *et al*., 1991;
Bambusa balcooa	6	Leaf extract: 6 Flower extract: 2	**Defoliator:** *Crypsiptya coclesalis*	Antifeedant	Kulkarni and Joshi, 1998; Kulkarni and Joshi *et al.*, 1999; 2003
Bamboo spp			**Termites**	Resistant to degradation	Borthakur and Gogoi, 2009
Dalbergia sissoo	5	Leaf extract: 5	**Defoliator:** *Plecoptera reflexa*	Antifeedant	Kulkarni *et al.*, 1997b, Meshram, 2000
Feronia elephantum	1	Leaf extract: 1	**Defoliator:** *Papilio demolius*	Antifeedant	Meshram *et al*., 1996
Gmelina arborea	1	Plant oil: 1	**Defoliators:** *Calopepla leayana* *Eupterote geminata*	Antifeedant	Singh and Sushilkumar. 1998
Leucaena leucocephala	15	Plant oil: 15	**Sap sucker:** *Heteropsylla cubana*	Insecticidal	Sharma *et al*., 1992
Pongamia pinnata	2	Leaf extract: 2	**Defoliator:** *Lamprosema niphaelis*	Growth inhibition	Deepa and Remadevi, 2007a
Poplar spp.	3	Bark extract: 1 Leaf extract: 2 Root extract: 1	**Defoliator:** *Clostera cupreata*	Antifeedant	Ahmad *et al*., 1997
Tamarindus indica	1	Leaf powder: 1	**Seed feeder:** *Bruchidius* sp., and *Caryedon serratus*	Insecticidal	Murugesan *et al*., 2008
Tectona grandis	36	Bark extract: 5 Leaf extract: 27 Seed extract: 4 Seed oil: 1 Tuber extract: 1 Wood extract: 1	**Defoliators:** *Hyblaea puera*	Antifeedant Growth inhibition Insecticidal Larvicidal Ovicidal	Sundararaj *et al.*, 2004; Ramana *et al.*, 2004; Deepa and Remadevi, 2005; Senthil Nathan and Sehoon, 2006; Ramana and Himavathi, 2006; Ramana *et al*., 2007 Deepa and Remadevi, 2007b Krishnakumar *et al*., 2011 Javaregowda and Naik, 2006; Ramana, 2005
			Paliga machaerolis	Antifeedant Growth inhibition	Meshram, 1995; Kulkarni *et al.*, 1997a; Murugesan *et al*., 2003 ; Sundararaj *et al.*, 2004; Durairaj, 2009 Sree *et al.*, 2008

have not been exploited commercially (Srinivasan, 2012) and as of now except neem other botanicals are not practically used in pest control. Geden (2012) is of the view that further research on blends of essential oils with other botanicals and improved formulations and delivery systems could lead to substantial improvements in the performance of botanicals.

In conclusion synthetic insecticides have been used to contain insect populations since the inception of green revolution with the significant increase in crop production. However, the consequent pollution jeopardizes the agricultural as well as forestry business. In this context, plant products are preferred over synthetic chemicals as they are non-

Table 2. Efficacy of extracts of *Capparis decidua* on different species of aphids.

Aphid species	**Host Plant**	**Method of application**	**Mortality (%) over control with 1% extracts of different parts of *Capparis decidua* at 48 hrs**				
			Seed	Wood	Branch	Bark	Root
Aphis gossypii	*Tecomella undulata*	Dipping	94.85	91.20	70.28	97.24	100.00
		Spraying	90.00	80.00	60.00	84.66	100.00
Lipaphis erysimi	*Brasicca compestris*	Dipping	96.64	90.00	73.32	96.64	100.00
		Spraying	93.33	80.00	66.66	80.00	100.00
Mysus persicae	*Brassica oleracea*	Dipping	93.33	92.10	76.64	98.20	100.00
		Spraying	90.00	90.00	73.33	76.66	100.00
CD (P= 0.05%)			5.76	4.86	6.12	8.04	NS

persistent and are compatible. Over 2,000 plant species have been reported to possess pesticidal activity but only a handful of pest control products directly obtained from plants are in use. Botanicals used as insecticides presently constitute 1% of the world insecticide market and in Indian market it is less than 1%. To enjoy widespread use, plant based products must demonstrate efficacy that is competitive with existing chemicals and must remain within the reach of resource limited farmers in the developing countries. Besides, there is a need for promoting the use of plant products in the insect pest management programs. Undoubtedly, neem compared to other plant products can boost the biopesticide industry if ventures of its commercial production and village industry are set up so that its neem products are available to the reach of planting community all round the year. Besides with the recent spell of research on botanicals, it is recommended to have national, regional and international coordinated effort to exploit botanicals as an integral component of pest management in different cropping systems including forestry.

REFERENCES

Ahmad, M., Gupta, B. K. and Bhandari, R.S. 1991. Efficacy of some plant extracts against *Ailanthes* web worm *Atteva fabriciella*. *Indian Journal of forestry*, **14**(1): 5-7.

Ahmad, M., Dayal, R., Mishra, R. K. and Dobhal, P. C. 1997. Antifeedant potency of some plants produce against defoliating pest of poplar, *Clostera cupreata*. *Indian Forester*, **123**(9): 821-826**.**

Ambika, S., Manoharan, T., Stanley, J. and Preetha, G. 2007. Biology and management of *Jatropha* shoot webber. *Indian Journal of Entomology*, **69**(3): 265-270.

Bernays, E. A. and Chapman, R. F. 1977. Deter chemicals as basis of oligophagy in *Locusta migratoria*. *Ecological Entomology*, **2**: 1.

Bhandari, R. S. Lal, J., Ayyar, K. S. and Singh, P. 1988. Effect of neem seed extractives on Poplar defoliator, *Pygaera cupreata* Butler (Lepidoptera: Notodontidae) in laboratory. *Indian Forester*, **114**: 790-795.

Bishop, C. D. and Thornton, I. B. 1997. Evaluation of the antifungal activity of the essential oils of *Monardo citriodora* var. *critriodora* and *Melaleuca alternofloia* on post-harvest pathogens. *Journal of Essential Oil Research,* **9**: 77-82.

Borthakur, R. D., Gogoi, P. K. 2009. Studies on dimensional stability and termite resistance capacity of bamboo (*Bambusa balcooa*) after treatment with chemicals and plant extracts. *Indian Forester*, **135**(9): 1217-1231.

Crosby, D. G. 1971. Naturally occurring insecticides. Jacobson, M, Crosby, D. G. Marcel Dekker, New York, 177-242 **PP**.

Deepa, B. and Remadevi, O. K. 2005. Larvicidal activity of the wood extract of *Pterocarpus marsupium* on the 3rd instar larvae of *Hyblaea puera* (Hyblaeidae), the defoliator pest of the teak (*Tectona grandis*). *Advances in Indian Entomology: Productivity and Health*, **2**: 97-100.

Deepa, B. and Remadevi, O. K. 2007a. Efficacy of plant products against the teak defoliator *Hyblaea puera* Cramer (Lepidoptera:

Hyblaeidae). *Pest Management in Horticultural Ecosystem*, **13**(1):68-70.

Deepa, B. and Remadevi, O. K. 2007b. Growth-inhibiting efficacy of various plant extracts on *Lamprosema nephaelis* (Pyralidae: Lepidoptera). *Indian Journal of Plant Protection*, **35**(1):106-107.

Deepa, B. and Remadevi, O. K. 2008. Insecticidal activity of the leaf extract of *Dodonaea viscosa* Linn. (Sapindaceae) on teak defoliator, *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae). *Recent Trends in Insect Pest Management*, 228-230.

Dubey, A. K. and Sundararaj, R. 2004. Evaluation of some neem products against *Aleurodicus dispersus* Russell (Aleyrodidae: Homoptera) on *Bauhinia racemosa* and *Michelia champaca*.). *Indian Journal of Plant Protection*, **32**(2): 126-128.

Durairaj, S. 2009. Preliminary efficacy of *Parthenium* extract on the feeding pattern of *Eutectona machaeralis*. *Insect Environment*, **14**(4): 153-154.

Geden, C. J. 2012. Status of biopesticides for control of house flies. *Journal of Biopesticides*, **5** (Supplementary): 1-11.

Jacobson, M. 1988. The chemistry of neem tree. In: *Focus on Phytochemicals. Vol.1. The Neem Tree* (Jonus, P.S. et al.), 19-45 **PP.**

Javaregowda and Krishana Naik, L. 2006. Ovicidal properties of plant extracts against the eggs of teak defoliator, *Hyblaea puera* Cramer. *Karnataka Journal of Agricultural Sciences*, **20**(2): 291-293.

Koul, O., Isman, M. M. and Ketker, C. M. 1990, Properties and uses of neem, *Azadirachta indica. Canadian Journal of Botany.* **68**:1-11.

Krishnaiah, N. V. and Kalode, M. B. 1991. Efficacy of neem oil against rice insect pests under green house and field conditions. *Indian Journal of Plant Protection*, **19**: 11-16.

Krishnakumar, N., Murugesan, S, Senthilkumar, N., Rajeshkannan, C., Manicachakam, P. and Sumathi, R. 2011. Vilvekam- *Aegle marmelos* seed oil based biopesticide for the management of teak defoliator. *Pestology*, **35**(3): 8-9.

Kulkarni, N. and Joshi, K. C. 1998. Feeding inhibition property of a common weed, *Ipomoea carnea* (Jacq.) ssp. *Fistulosa* (Austin) against bamboo leaf roller, *Crypsiptya coclesalis* (Walk.) (Lepidoptera: Pyralidae). *Allelopathy Journal*, **5**(1):93-96.

Kulkarni, N., Joshi, K. C. and Gupta, B. N. 1997a. Antifeedant property of *Lantana camara* var. *Aculeate* and *Aloe vera* leaves against teak skeletonizer, *Eutectona machaeralis* Walk. (Lepidoptera: Pyralidae). *Entomon*, **22**(1):63-67.

Kulkarni, N., Joshi, K. C. and Kalia, S. 1997b. Feeding inhibition property of some botanical extracts against sissoo defoliator, *Plecoptera reflexa* (Lepidoptera: Noctuidae). *Indian Journal of Forestry*, **20**(4):390-394.

Kulkarni, N., Joshi, K. C. and Rama Rao, N. 1996. Screening of some plant extracts for feeding inhibition property against major forest insect pests. *My Forest*, **3** (32): 118-122.

Kulkarni, N., Joshi, K. C. and Shukla, P.K. 2003. Antifeedant activity of *Annona squamosa* Linn. against *Crypsiptya coclesalis* Walker (Lepidoptera: Pyralidae). *Entomon*, **28**(4): 389-392.

Kulkarni, N., Neelu Singh, Joshi, K. C. and Lal, R. B. 1999. Activity of *Lantana camara* var. *aculeate* extract against the larvae or Bamboo leaf roller, *Crypsiptya coclesalis* (Walker) (Lepidoptera:Pyralidae). **In:** *Biopesticides in insect pest management*. (Ignacimuthu, S.J. and Alok sen, eds.), Phoenix publishing House Pvt. Ltd. New Delhi. 118-123 **PP.**

Meshram, P. B. 1995. Evaluation of some medicinal and natural plant extracts against teak skeletonizer, *Eutectona machaeralis* Walk. *Indian Forester*, **121**(6): 528-532.

Meshram P. B. 2000. Antifeedant and insecticidal activity of some medicinal plant extracts against *Dalbergia sissoo* Defoliator *Plecoptera reflex*a (Lepidoptera:Noctuidae) *The Indian Forester*, **126**(9): 961-965.

Meshram, P. B., Kulkarni, N. and Joshi, K. C. 1996. Antifeedant activity of Neem and *Jatropha* against the larvae of *Papilio demoleus*. *Journal of Environmentl Biology*, **17**(4): 301-304.

Murugan, K., Senthil Kumar, N., Jeyabalan, D., Senthil Nathan, S. and Sivaramakrishnan, S. 1999. Neem as a effective Bio-pesticide to control teak defoliator *Hyblaea puera* (Cramer) (Lepidoptera: Hyblaeidae), *Journal of Non Timber Forest Products* **6**(1/2): 78-82.

Murugesan, S., Ramsewak, R. S., Mattson, W. J., Nair, M. G., Narayanan, C. and Mohan, V. 2003. Antifeedant and antifungal compounds from *Dirca palustris. The Indian Forester*, **129**(3): 364-370.

Murugesan, S., Sundararaj, R., Prasanth Jacob, J., Anitha, J., Karthick, S. 2008. Biopesticidal potential of neem against forest insect pests. *Hexapoda*, **15** (1): 56-60.

Singh, N. and Sushilkumar. 1998. Biopesticidal plants from Indian forests and their role in insect pest management. **In:** *Ecofriendly Pest Suppression* (Gautam, R. D. and Prasad, D., eds.), Westvill Publishing House, New Delhi, 73-123 **PP.**

Pradhan, S. and Jotwani, M. G. 1971. Neem kernels as antifeedant for locusts. *Sneha Sandesh,* **13:** 1-5.

Ramana, P. 2005. Ovicidal evaluation of *Chromolaena odorata* extracts on teak defoliator-*Hyblaea puera* Cramer. *My forest*, **41**(4): 519-524.

Ramana, P. 2006. Ovicidal evaluation of *Semecarpus kathalekanensis* extracts on teak defoliator, *Hyblaea puera* Cramer. *Journal of Non-Timber Forest Products*, **13**(4): 245-248.

Ramanna, P. and Himavathi Bhat. 2006. Antifeedant activity of some plant products against the larvae of teak defoliator, *Hyblaea puera* Cramer. *My Forest*, **42**(4):323-326.

Ramana, P., Patil, S. K. and Rao, K. S. 2004. Antifeedant activity of *Holigarna* against larvae of teak defoliator, *Hyblaea puera*. *Journal Non-Timber Forest Products*, **11**(2): 158-160.

Ramana, P., Patil, S. K. and Rao, K. S. 2007. Preliminary phytochemical screening and antifeedant evaluation of *Semecarpus kathalekanensis* Dasappa. *Indian Journal of Forestry*, **30**(2): 175-178.

Sree, D. S., Sankar, N. R. and Sreeramulu. 2008. Evaluation of *thirteen medicinal plant extracts against teak (Tectona grandis)* leaf skeletonizer *Eutectona machoeralis* Walk. *Biomed*, **3**(1): 33-35.

Srinivasan, R. 2012. Integrating biopesticides in pest management strategies for tropical vegetable production. *Journal of Biopesticides*, **5** (Supplementary): 36-45.

Ramarethinam, S., Loganathan, S., Marimuthu, S. and Murugesan, N.V. 2002. Potential of nimbicidine (0.03% Azadirachtin) in the control of *Eurema hecabe* (L.) infesting *Cassia fistula* L. (Caesalpiniaceae). *Pestology*, **26**(12): 5–10.

Rembold, H., Sharma, G. K., Czoppelt, Ch. and Schmutterer, H. 1980. Evidence of growth disruption in insects without feeding inhibition by neem seed fractions. *Z. PflKrankh. PflSchutz*, **87**: 290-297.

Senthilnathan, S. and Sehoon, K. 2006. Effects of *Melia azedarach* L. extract on the teak defoliator *Hyblaea puera* Cramer (Lepidoptera : Hyblaeidae). *Crop protection***, 25**: 287-291

Sharma, H. C., Leuschner, K., Sankaram, A. V. B., Gunasekhar, D., Marthanda-Murthi, M., Bhaskriah, K., Subramanyam, M. and Sultana, N. 1984. Insect antifeedants and growth inhibitors from *Azardiracta indica* and *Plumbago zeylanica*. **In:** *Natural pesticides from the Neem tree and other tropical plants* (Shmutterer, H. and Ascher, K.R.S., eds.), *Proc 2nd Int. Neem Conf.* (*Rausischholzhausen, Germany, 1983*), 291-320 **PP.**

Sharma, R. N., Tare, V., Pawar, P. and Vartak, P. H. 1992. Toxic effects of some plants oils and their common constituents on the psyllid pest, *Heteropsylela cubana* (Homoptera: Psyllidae) of social forestry tree *Leucaena leucocephala*. *Applied Entomology and Zoology*, **27**(2): 285-287.

Shukla, A. C., Shahi, S. K. and Dikshit, A. 2000. Epicarp of *Citrus sinensis*: a potential source of natural pesticide. *Indian Phytopathology*, **53,** 318-322.

Singh, B. 1985. Studies on the effect of neem kernel extract and certain less persistent insecticides on the oviposition behaviour and mortality of the desert locust *(Schistocerca gregaria* Forsk*.) Ph. D. Thesis*, Agra university. India, 162 **P**.

Sundararaj, R. 1997. Evaluation of neem seed oil and some insecticides against the babul whitefly *Acaudaleyrodes rachipora* (Singh) (Aleyrodidae: Homoptera) on *Acacia senegal* seedlings. *Pestology*, **21**(5): 34-37.7.

Sundararaj, R. 1999a. Potential of neem products for the control of the babul whitefly on *Acacia tortilis* in nursery. *My Forest*, **35**(1): 51-57.

Sundararaj, R. 1999b. Field evaluation of neem cake with biofertilizers and conventional fertilizer

against the incidence of the babul whitefly *Acaudaleyrodes rachipora* (Singh) (Aleyrodidae: Homoptera) on *Acacia nilotica* seedlings. *Pestology*, **22**(12): 9-12.

Sundararaj, R. 2010. Potential of neem for forest insect pests management: an overview. **In** : Non-Chemical Insect Pest Management (Ignacimuthu S. and David, B. V. eds.). Elite Publishing House Pvt. Ltd., New Delhi, 15-25 **PP.**

Sundararaj, R. and Murugesan, S. 1995. Evaluation of Neem, *Azardirachta indica* (A. Juss) seed kernel powder against the rohida defoliator weevil, *Patialus tecomella* Pajni. *Journal of Applied Zoological Researches,* **6**(2): 141-142.

Sundararaj, R., Murugesan, S. and Mishra, R. N. 1995. Biopesticidal potential of neem against insect pests of arid zone. *Neem Newsletter of International Neem Network.* **2**: 8-10.

Sundararaj. R., Murugesan, S. and Mishra R. N. 1996. Field evaluation of neem seed oil against babul whitefly *Acaudaleyrodes rachipora* (Singh) (Aleyrodidae: Homoptera) on *Acacia senegal* seedlings. *Annals of Arid Zone,* **35** (4): 369-372.

Sundararaj, R., Remadevi, O. K. and Rajamuthukrishnan, 2004. Some plant products as antifeedants against the teak defoliator, *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae) and teak skeletonizer *Paliga machaeralis* Walker (Lepidoptera: Pyralidae). *Annals of Forestry*, **12**(2): 273-277.

R. Sundararaj
Wood Biodegradation Division, Institute of Wood Science and Technology, 18th cross, Malleswaram, Bangalore-560 003, India.
Phone (O) +91-080-23465940;
Fax +91-080-233340529
Email: rsundariwst@gmail.com

Manuscript history

Received : 18.05.2012

Revised : 25.05.2012

Accepted : 30.05.2012