Status Report

NEEM AS AN EFFECTIVE BIOCONTROL AGENT FOR TEA PESTS

Ramarethinam, S., Marimuthu, S and Murugesan, N.V.[1]

ABSTRACT

Chemicalisation of agriculture in general and tea in particular results in chemical residues in the finished product. Due to stringent MRL values fixed for various pesticides in made tea, and the difficulties in marketing of such produce, chemicalisation of tea cultivation is now getting reduced. Diversification of tea-based produce as value added therapeutics and cosmetics is also paving way for organic tea farming. This situation necessitated introducing nature's friendly methods of tea cultivation with 'ecofriendly' products as a major input for plant protection and production. Neem with its multiple biological effects, like antifeedant, repellent, oviposition deterrent, growth regulation and its environment- friendly nature, is a handy tool to control insect pests in tea. The present article is focused on the positive role of neem and its derivatives in controlling tea pests in an ecofriendly way.

Keywords : India; neem; bipesticide; biocontrol

INTRODUCTION

Tea (*Camellia sinensis)*, growing as a natural under growth in the Asian rain forest, is native to Southern China and India and is the most popular drink on earth, next to water. The attempt to make 'tea beverage' from plants other than tea has not met with lasting success. Tea is known to be a good source of polyphenols that include flavonoids, flavanol glycosides, bio-flavonoids, proteins, amino acids, carbohydrates, lipids, vitamins and minerals. The remarkable health benefits of tea, coupled with generic campaign, has increased the Indian domestic consumption (per capita) to a higher level from 0.53 kg in 1981-83 to 0.66 kg in 1997-98. Though chemicalisation has significantly helped to increase tea productivity, the limitations involved in the use of pesticides due to risks of increasing cost and dosages, development of resistance, disruption of ecological balance, pollution of environment and more importantly the level of residue and stringent MRL level prescribed for the final product have made the usage of the synthetic insecticides an unprofitable input in the tea cultivation. This encouraged the planters to seek suitable alternatives with more discriminative, preventive and efficient pest management strategies.

The plant kingdom, which is considered to be a natural factory of phytochemicals, is now recognized to offer a viable and effective alternative strategy to manage pests and diseases. Over 2000 plant species have been reported to possess insecticidal activity. Among various known plant species, Meliaceae in general and the Neem tree (*Azadirachta indica A. Juss.*) in particular has been identified as one of the most promising, environmentally sound bio-rational tree possessing pest control properties.

BIOLOGICAL EFFECTS OF NEEM ON INSECT PESTS OF TEA

No other botanical or synthetic chemical insecticide is known to have such varied and diversified effects on insects as neem. The beneficial effects of Neem in the control of insect pests is an age old practice known to Indians for over 6000 years. However, the studies carried out on desert locust *Schistocerca gregaria* by Pradhan *et al.* (1962), and by Butterworth and Morgan (1968) are reported to be the first two authentic scientific papers that high

[1] Director - Projects T. Stanes and Company Limited 8/23-24, Race Course Road, Coimbatore – 641 018. Tamil Nadu
Phone : 0422 – 222 1514 Email: manoram@sancharnet.in

lighted the insect controlling properties of neem and also formed the basis for further research, both on the chemistry and biological activities of neem (Govindachari et al., 1997). The intense research conducted on neem over the last 30 years have enabled the neem pesticides to rise to the present status of commercial pest control components in the midst of burgeoning chemical pesticides.

The main constituents of neem are a combination of 3 or 4 azadirichtin related compounds in addition to over 20 minor constituents which are equally active in containing about 200 species of insects. Though volumes of data on the bio-effectiveness of neem on a diverse group of insect pests attacking various crops are available, extensive work on the effects of neem on tea pests is limited. However, it remains to be noted that the biological effects of neem applicable to the analogue pests in other crops can be taken as an indicator for the likely effectiveness of neem pesticides on tea pests as well. The most important biological activities of neem are repellency, feeding and oviposition deterrency, growth regulation and sterilant effects (Fig.1).

Repellency And Oviposition Deterrency

Repellency and oviposition deterrency are the two most important behavioral effects of neem on insects. Oviposition is the first step in pest infestation, and any attempt to reduce the deposition of eggs on the target crop prevents further establishment of pest population. Induction of abnormality in the behavioral sequence leading to deferment of egg laying until 2 or 3 days after treatment with neem, and the selective preference of moths to untreated leaves for oviposition are some of the behavioral characters commonly observed following treatment with neem products (Dethier, 1980; Saxena, 1989; Ramarethinam and Marimuthu, 2000). The chemoreceptors present at the ovipositor and appendages are responsible for this behavioral deviation in egg laying (Fig.2). Electro-physiological studies have also confirmed the significant action of neem on chemoreceptors, neurons and central nervous system (CNS) in the reception, perception and processing of signals leading to a deviation from the normal pattern of egg laying. Studies conducted on *Helopeltis sp.* at the Cashew Research Station with oil-based neem formulations have claimed reduction in adult populations in the treated plots. By spraying neem formulations either by themselves or in judicious, combination with chemical pesticides, it was possible to reduce, if not eliminate, oviposition of the *Helopeltis* sp. Similarly, trials conducted at UPASI using neem oil based EC formulations and solvent extracted formulations have also revealed a significant reduction in the population of pink mites 3-4 weeks following treatment. By preventing egg laying on plants with its oviposition deterrent character, neem can thus effectively contain pest population build-up through the succeeding generations.

Antifeedant Property

Feeding deterrency is yet another important property of neem. In general, insects take a test bite prior to commencing feeding on the host plant. In this process of host selection the biochemicals present in the plant play a very important role in final acceptance or rejection of potential food sources (Dethier, 1980; Schoonhoven, 1980). The antifeedant property of neem is brought about by the presence of deterrent chemicals like azadirachtin, salanin, meliantriol and the likes. These deterrent chemicals, by their action on the gustatory sensillae, alter the sensory inputs causing feeding inhibition (Fig.3). Electrophysiological studies proved azadirachtin to act on the chemo-receptors bringing about distortion in the normal sensory pattern leading to highly abnormal across-fibre bursting impulse pattern (Schoonhoven, 1980), ultimately resulting in an effective feeding inhibition or rejection of food source. Further antifeedant characters of neem on insects are also reported to be non-gustatory. Prolonged treatment with neem

Fig. 1. Mode of action of neem

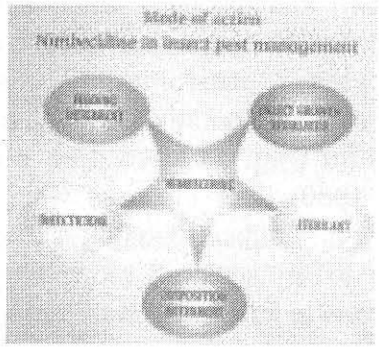


Fig. 2. Chemosensilla of insects

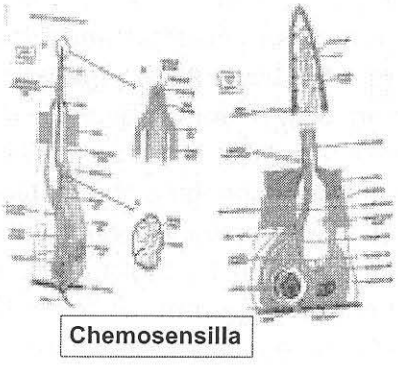


Fig 3. Antifeedant activity of insects

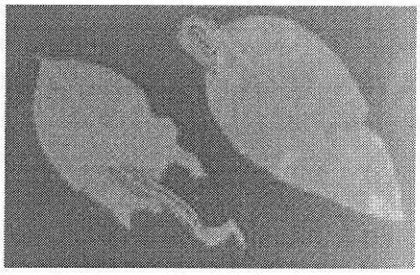


Fig. 4. Effect of neem on the histomorphology of insects

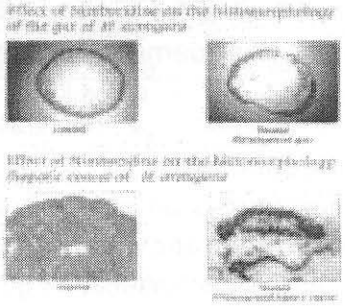


Fig. 5. Growth regulatory effect of neem

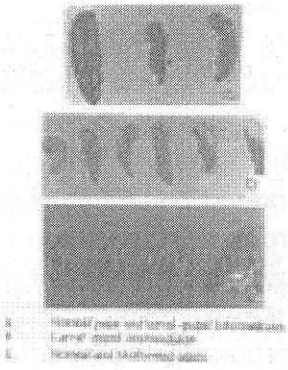


Fig. 6. Effect of neem on growth regulating hormones in insects

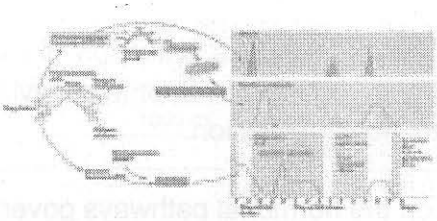
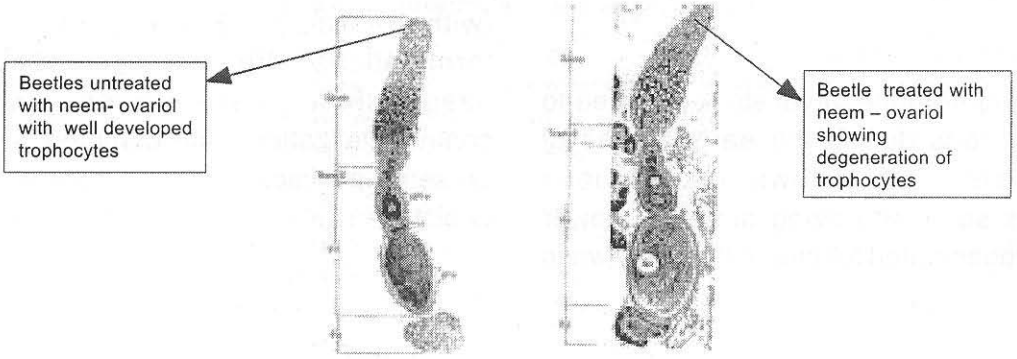


Fig. 7 Effect of neem on the ovary of insects



products known to bring about reduction in the mobility of the gut, resulting in a rapid decline in food consumption, conversion and utilization efficiency, as well as the degeneration and disorganization of gut epithelial cells (Fig.4)., Prolonged neem treatments are also reported to play a significant role in bringing about antifeedant activities of neem (Ramarethinam *et al.*, 2000). The in-house trial conducted by the authors in their contracted field, with neem oil formulations, revealed significant reduction in the damage to tea bushes affected by flush worm at 3-5 weeks from application. Thus the anti-feedant activity of neem formulation cumulatively offers greater protection to the tea bushes from damage by preventing feeding activity.

.

Insect Growth Regulation

Insect growth regulation is an unique property of neem besides antifeedancy, repellency and oviposition deterrency. Neem affects the growth and metamorphosis in insects at larvae, pupal and adult stages (Fig.5). Generally, the growth regulatory property of neem manifests in insects in two ways:

a. Antifeedants often induce starvation in insects and indirectly cause development deviation leading to growth inhibition.

b. It works on the hormonal pathways governing the growth and metamorphosis in insects and disrupts the systematic development of insects (Fig.6) leading to severe malformation at different stages of growth (Ramarethinam and Marimuthu, 1998; Ramarethinam et al., 2000).

Sterility

Adults emerging from the larval stock exposed to neem formulations during the early stages of metamorphosis have shown conspicuous abnormalities such as having smaller / fewer deformed or degenerated follicles in the ovary when compared to control (Schulz, 1980; Ramarethinam et al., 2000). In addition to the above abnormalities, destruction of epithelial sheath, terminal filaments, trophocytes, pre-follicular tissues and disorganization of nurse cells in the anterior part of germanium (Fig. 7) have also been reported (Schulz, 1980). Even the eggs, which survived the treatment and subsequently got oviposited, were observed to be discolored, brownish and very often found prone to infestation with fungi.

NEEM USAGE AND THE COST

Unlike chemicals, which exhibit 'knock-down' effect, treatment with neem does not bring about instantaneous death to insects. It is also significant to note that some of the insect pests that are resistant to chemical pesticides can be effectively controlled by neem. Though the cost involved in the adoption of biologicals as a major pest control input is high (Table 1), this is justifiable in comparison to the greater damage caused to the environment due to the depletion of natural enemies and the consequent ecological imbalance brought about by chemical pesticides.

NEEM PRODUCTS AVAILABLE IN INDIA

Presently there are several neem formulations (based both on kernel extracts and neem seed oil) which are marketed in India against insect pests of agricultural crops and plantation crops, including tea. Initially two standards of neem formulations were fixed and granted permission for commercialization; these included (a) neem-oil based formulation (with 300 ppm of azadirachtin) (b) kernel – based solvent extracted formulation (with 1500 ppm). Subsequently a number of formulations with varying concentrations of azadirachtin have been cleared for commercialization. The commercial formulation presently available for use in agriculture in India is depicted in Table 2.

Table 1. Common tea pests, their present and suggested control measuresand their economics*

S.No.	Pests	Chemical Method			Botanical/Biological Method			Cost Difference	
		Product	Dosage /ha	Cost /ha	Product	Dosage /ha	Cost /ha	Chemical	Biological
1.	Mites (Red spider mite, Pink mite and Purple mite)	Dicofol	1000 ml	Rs. 280	Neem oil**	1000 ml.	Rs. 208	Rs. 72	-
		Sulphur – 80%	1000 gm	Rs. 55	Neem oil + *Paecilomyces* sp.***	500 ml +2.5 kg	Rs. 104 +Rs. 302	-	Rs. 351
		Quinolphos 25EC	750 ml	Rs. 195	Neem oil	1000 ml	Rs. 208	-	Rs. 13
		Dicofol	1000 ml	Rs. 280	Neem oil + *Paecilomyces* sp.	500 ml +2.5kg	Rs. 104 +Rs. 302	-	Rs. 126
		Cost		**Rs. 810**			**Rs. 1228**		**Rs. 418**
2.	SHB	Quinolphos 25EC +Dichlorovos 76 EC	750 ml +250 ml	Rs. 195 +Rs. 95	Neem oil+ *Beauveria bassiana****	500 ml +1.5 kg	Rs. 104 +Rs. 105	-	-
		Lambdacy halothrin 5EC	120 ml	Rs. 130	Neem oil+ *Beauveria bassiana*	500 ml +1.5 kg	Rs. 104 +Rs. 105	-	Rs. 79
		Fenvalerate 20 EC	500 ml	Rs. 103	Neem oil + *Beauveria bassiana*	500 ml +1.5 kg	Rs. 104 +Rs. 105	-	Rs. 106
		Quinolphos +Dichlorovos	750 ml +250 ml	Rs. 195 +Rs. 95	Neem oil+ *Beauveria bassiana*	500 ml +1.5 kg	Rs. 104 +Rs. 105	Rs. 195	-
		Cost		**Rs. 813**			**Rs. 836**	-	**Rs. 23**
3.	TMB	Endosulfan 35EC	1000 ml	Rs. 210	Neem oil+ *Beauveria bassiana*	500 ml +2.5 kg	Rs. 104 +Rs. 362	-	Rs. 256
		Quinolphos 25EC	750 ml	Rs. 195	Beauveria bassiana	2.5 kg	Rs. 362	-	Rs. 167
		Endosulfan +Dichlorovos	1000 ml +250 ml	Rs. 105 +Rs. 95	Neem oil+ *Beauveria bassiana*	500 ml +2.5 kg	Rs. 104 +Rs. 362	- Rs.290	Rs. 266 -
		Endosulfan +Dichlorovos	750 ml +250 ml	Rs. 195 +Rs. 95	-	-	-	-	-
		Cost		**Rs. 895**			**Rs. 1294**	-	**Rs. 399**
4.	Flush worm	Endosulfan	1000 ml	Rs. 211	Neem oil	1000 ml	Rs. 208	Rs. 3	-
		Quinolphos 25EC	750 ml	Rs. 195	Neem oil+ *Beauveria bassiana*	500 ml +1.5 kg	Rs. 104 +Rs. 105	-	Rs. 14
		Fenvalerate	500 ml	Rs. 103	Neem oil	1000 ml	Rs. 208	Rs. 103	-
		Cost		**Rs. 509**			**Rs. 625**	-	**Rs. 116**

** = The number of sprays as given in the table for the control of various pests is only approximate and it will vary depending upon the prevailing abiotic and biotic conditions in a given area.*

*** = Cost given here is based on a neem oil product namely Nimbecidine.*

**** = Cost given here is based on a Paecilomyces sp. product.*

***** = Cost given here is based on a Beauveria bassiana product namely Bio-Power (certified for use in organic agriculture)*

Table 2. Neem formulations available in India.

Azadirachtin contents	Type of formulation	Commercial formulations	Dosage recommendation	No. of formulations available	Products certified for use in organic farming
300 ppm	Oil based	Nimbecidine and others	5ml/lit	13	Nimbecidine
1500 ppm	Kernel based solvent extracted	Neem gold, Fortune Aza and other	3-6 ml/lit	30	Fortune Aza
3000 ppm	-do-	Eco-Neem and others	2-4 ml/lit	5	Eco-Neem
10000 ppm	-do-	Neem Azal, Eco-Neem and others	1-2 ml/lit	3	Neem Azal and Eco-Neem
50000 ppm	-do-	Neem Azal	0.5-1.0 ml/lit.	1	Neem Azal

STEP FORWARD

The synthetic chemical inputs such as fertilizers and pesticides, coupled with appropriate harvesting technology, were extensively used in the past to improve the yield of tea. However, the ever-increasing production cost and stock accumulation of tea, through import from Kenya, Sri Lanka and Indonesia, poor market off take and the resulting falling prices are now creating an alarming situation in tea industry. Such awareness of chemical residues and the difficulty in export of the produce are now inducing the industry to turn away from synthetic agriculture to natural farming. In view of this, alternate systems of agriculture like pure organic farming, integrated farming systems, nature farming, integrated intensive farming (IIFS), low external input supply agriculture (LEISA), bio-dynamic agriculture and permaculture are being adopted in tea cultivation. This will not only help to reduce the level of chemical residue to the permissible MRL, but also enhance the profitability through improved export value of tea.

CONCLUSION

The productivity of tea plantations depends on the interaction of tea bushes with several abiotic, biotic and managerial factors. Pests of tea are important among the biological components of the ecosystem, which are responsible for considerable crop loss (Muraleedharan, 1991). Use of chemical insecticides is quite indispensable in any agricultural system, for which tea is no exception. But the ecological dangers owing to the willful excessive application of insecticides should be seriously viewed. Further several countries and international organizations like EPA, FAO and Codex Alimentarius Commission have established more stringent 'Maximum Residue Limits (MRL) and Tolerance Limit' for a number of pesticides in tea. Therefore, to elevate the vibrant image of this beverage, it is imperative to grow tea without the use of hazardous chemicals. Neem with its multifaceted biological activity coupled with its discriminative, preventive, efficient and ecofriendly nature offers a viable alternative to chemical pesticides. The usage of neem-based pesticides can thus help greatly in containing the pests successfully and coverting the major pests of today into minor pests of tomorrow, besides rejuvenating tea industry through value addition of tea – as a pesticide free health beverage.

REFERENCES

Butterworth, J.H. and Morgan, E.D. (1968). Isolation of substance that suppresses feeding in locust. J. Chem. Soc. Chem. Com., 23-24.

Dethier, V.G. (1980). Evolution of receptor sensitivity to secondary plant substances with special reference to deterrents. Am.Nat. 115:45-66.

Govindachari, T. R., Suresh, G and Geetha G. (1997). Neem kernel triterpinoids for insect control. In "Organic Tea- A successful approach in low energy input agriculture". Proc 2nd Int. IFOAM Conf., Calcutta, pp. 78-83.

Muraleedharan, N. (1991). In. "Pest Management in Tea". (ed. Muraleedharan). UPASI Tea Research Institute Publication. pp.1-130.

Pradhan, S., Jotwani, M.G and Roy, V.K. (1962). The neem seed deterrent to locust. Indian Farming 12: 7-11.

Ramarethinam, S and Marimuthu, S. (1998). Effect of neem extracts on the morphogenesis of caterpillars of *Pericallia ricini* (F). (Arctidae : Lepidoptera). Pestology 22(11): 15-18.

Ramarethinam, S and Marimuthu, S. (2000). Bioactivity of a neem formulation, pongamia oil and sesame oil: their compatibility and synergism against some lepidopteran pests. Int. Conf. on Spray Oils Beyond 2000: Sustainable Pest and Disease Management, Sydney, Australia.

Ramarethinam, S., Marimuthu, S. and Murugesan, N.V. (2000). Effect of a neem oil formulation on the growth, development and histomorphology of some lepidopteran pest (*Helicoverpa armigera* H.; *Spodoptera litura* F. and *Gangara thyrsis*). Pestology 24 (10): 1-8.

Saxena, RC. (1989). Insecticides from Neem. In "Insecticides of Plant Origin", (ed. Arnason et al), ACS Symp. Sere. 387, American Chemical Society, Washington DC, pp 110-135.

Schoonhoven, L.M. (1980). Chemical mediators between plant and phytophagous insects. In "Semiochemcials: Their role in pest management", (ed. Nordlund, D.A.). J.Wiley, New York, NY. pp. 31-50.

Schulz, W. D. (1980). Pathological alterations in the ovaries of *Epilachna varivestis* induced by an extract from neem kernels. In "Natural pesticides from the neem tree", (eds. Schmutterrer, H.; Ascher, K.R.S and Rambold, H.). Proc. 1st Int. Neem Conf., Rottchegern, Federal republic of Germany, 16-18, pp. 81-96.