Neem for sustainable pest management in agriculture -Indian experience

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Introduction

Neem (Indian Lilac, *Azadirachta indica* A. Juss., synonymous *Melia azadirachta* L., *M. indica* (A. Juss) Brandis; Family Meliaceae), is a highly esteemed tree for the people in the region. For centuries its derivatives have found use in agriculture, public health, medicine, toiletries, cosmetics, and livestock production and health. Neem is believed to be a native of upper Burma and possibly to the Siwalik Deccan and other parts of south India. Indian settlers have introduced neem in the African countries. It is now abundant in the tropical belt from Somalia in the east to Mauritiana in the west. It was taken to Fiji Islands and has spread from there to other Islands in the South Pacific. Neem is reported to occur in Trinidad and other West Indian Islands and also in some countries of central and South America. Large scale plantations of neem have come up in Malaysia and the Philippines.

1. Neem in Indian Tradition

The Neem tree has been held in high esteem because of it is medicinal and insecticidal value since time immemorial. One who plants three neem trees lives after death in the sun world and for three epochs never goes to hell. Neem is one of the trees which should be planted near ones house, according to Varaha mithira's Brihat Samhita (Vijayalakshmi *et al.,* 1995)

1.1. Neem as Food

Neem leaves are taken in the form of chutney (paste) and rasam (soup) to enhance health and resistance to disease. This is particularly taken on occasions such as shradaha karma (ceremony for ancestors). The neem chutney will be served in ugadhi, the Telugu new year, to put in a mind set that life is both sweet and bitter.

1.2. Neem in mythologies

Indira, the kind of celestials, while returning to his abode Devaloka (Heaven), riding Airavata (white elephant) after retrieving Amruth (Ambrosia) from their arch rivals Asuras (Demons), in golden pot dropped on the neem tree making it a tree blessed with virtuous qualities which could remove all diseases. The another mythological story is that, fearing awesome power of the Demons, many of Devas (Good) sought refuge on tree tops; Shiva on the vilva (*Aegle marmelos*), Vishnu on the banyans, Indira on the Sirsia (*Albizzia lebbeck*) and surya the sun god on the neem tree.

1.3. The shade tree

Neem is a very good shade tree. In arid region neem is planted for its shade. Neem is one of few trees that can come up in any type of land.

1.4. Neem the religion

There exists a ritual among the people of India especially in southern state like Tamil Nadu, Andhra Pradesh, Karnataka and Maharastra. Couples desirous of having a child perform (Ashwatta Narayana Puja) marriage of neem with banyan and go round these trees seven times every morning. The deities of Lord Jagannath, Subadhra and Balabhadra of the Jagannath temple at Puri (Orissa) are made of neem wood. They are replaced every 12 or 13 years.

2. Preparation of Neem Products

Though neem product is marketed commercially at present after standardization, various neem constituents had been used for a variety of applications earlier. Even now some of the marginal farmers use the following preparations utilizing the neem trees grown in their home and farm.

2.1. Neem Seed Kernel Extract (NSKE)

Fifty gram of neem kernel is required for use in 1 liter of water. The neem kernel is pound gently. It should be pound in such away that no oil comes out. The outer seed coat is removed before pounding. If seed s without removing coat are used, one and

half times the quantity of neem seeds are required. The seeds collected within 3 months are preferred and should not be used after 8 to 10 months. In the seeds afte 3 months the azadirachtin quantity is quite low. The pound neem kernel is taken in a muslin pouch and this is soaked overnight in the water. The pouch is squeezed with the hand in the water. Before use this is filtered and emulsifier/soap is to be added. The kernel extract should be milky white in colour and not brownish.

2.2. Neem Cake Extract (NCE)

One hundred gram of neem cake is required for 1 litre of water. The neem cake taken in a muslin pouch is soaked in water overnight before use in the morning. It is then filtered and emulsifier is added at the rate of 1 ml for 1 litre of water. It is now ready for spraying.

2.3. Neem Oil Spray

For preparation of neem oil spray 30 ml neem oil is required for 1 litre of water. 30 ml neem oil is added to water and stirred well. To this emulsifier is added @ 1 ml/l and mixed properly. It should be used straightway.

2.4. Neem Leaf Extract (NLE)

For 5 liters of water, 1 kilo gram of green neem leaf is required. The leaves are soaked overnight in water. The next day the leaves are ground and the extract is filtered. To the filtrate an emulsifier like Tween 80, sandovit, soap oil, Nirma or soap cake powder can be used. One ml of emulsifier is added to one liter of water. There is no need to boil the extract. Boiling reduces the azadirachtin content. Hence the cold extract is more effective. Some farmers prefer to soak the leaves for about one week. However this creates foul smell.

Note: Since the quantity of leaves required for preparation of this extract is quite high this was used for nursery and kitchen gardens in earlier days. But the product from leaf source is discouraged in preference to fruiting parts (renewable source) to avoid large scale defoliation of neem trees.

2.5. Preparation of Neem Cake Coated Urea (20%)

For 100 gm of urea, 20 gm of neem cake is required. Both urea and neem cake are dry substances a sticky substance is required. Gum arabic, tar solution or neem oil is used as a sticker. The sticky substance is added to the urea and to this very fine powder of neem cake is added and mixed. For treating 100 kg urea, one kg coal tar and 1.5 lit. of kerosene are needed. Melt coaltar over a low flame and dissolve it in kerosene. Mix urea with the solution thoroughly in a plastic container, using a stick. Allow it to dry in shade on a polythene sheet. This can be stored for a month and applied basally (Crop Production Guide, 1999).

2.6. Proprietary Products

Having understood the various effects of neem extracts and neem oil, different organization throughout the world ventured in the development of commercial formulations that are ready to use just like any other chemical insecticides by the farmers. Thus in 1985 the first neem based formulation called Margorsan-0 was developed by Vikwood Limited, Wiscosinj U.S.A. which was approved by U.S., Environmental Protection Agency (EPA) for use on nonfood crops. Later in 1986 the company introduced two additional products namely Margosan that contained no oil but with quicker and more effective systemic action and Margosan-D, and dust made with saw dust and the residual neem based cake for use on food crops (Larson, 1986). In India the neem based commercial formulation was introduced in 1988 by West Coast Herbochem Ltd; Bombay with three trade name Neemark, an azadirachtin-rich granular formulation recommended for use (at a rate of 18.75Kg/ha) on cotton, paddy, tobacco, groundnut, sugarcane, chilli, eggplant, other common vegetables, horticultural crops, legumes and food grains. Researchers at the National Chemical Laboratory, Pune produced a standardized extra of "Neem rich II" and "Neem rich III" for use.

The Indian Tobacco Company (ITC) started marketing two neem based formulations- Replin and Wellgro for spraying in tobacco growing areas to check damage by cutworms, other insect pests, and tobacco mosaic virus in tobacco nurseries (Saxena, 1989).

Parmar and Srivatava (1986) developed a 25 per cent water dispersible powder (WDP) and a 10 per cent dust preparation both based on crushed neem kernel and a 25 per cent emulsifiable concentrate (EC) based on neem kernel oil, all satisfying various physico-chemical, phyto compatibility and self-life (based on bioassay of the pre- and post-accelerated-storage treated samples) requirements. All these formulations were found effective against *Spilosoma obliqua* (Wlk) and *Euchrysops cnejus* on green gram *Vigna radiata* (L).

Tamilnadu Agricultural University developed EC formulation with solvent(TNAU 0.03EC) and without solvent viz. NO 60 EC (A), NO 60 EC (C), NO PO 60 EC (A) and NO PO 60 EC (C) (Abdul Karem *et al.,* 1999) and dust formulations (Section 2.6.1 and 2)

2.6.1. Emulsion Concentrates

Tamil Nadu Agricultural University has developedg eco-friendly commercial neem and other plant product-based formulations (Regupathy *et al.,* 1999a; Ayyasamy *et al.,* 2002). One of the commercially successful neem-based formulations is TNAU 0.03 EC. This is an emulsifiable concentrate containing 300ppm azadirachtin and not less than 80 per cent neem oil. Over the past 5 years this has been tested extensively under field conditions. Results have been obtained from field trials on rice (3), cotton (3), field bean (3), tobacco (4), tea (12) and coffee (18). The pests involved were brown plant hopper *Nilaparvata lugens* (Stal.), thrips *Stencheatothrips biformis* (Bagnal), whorl maggot *Hydrellia sasaki* Yuasa and Isitani, stem borer *Scirpophaga incertulus* (Wlk), leaf folders *Cnaphalocrosis medinalis* (Guen.), *Leptocorisa acuta* (Thumb), gall midge *Orseolia oryzae* (Wood-Manson), white backed plant hopper *Sogatella furcifera* (Horv.), aphid *Aphis craccivora* Koch., spotted pod borer *Maruca testulalis* (Geyer), blue butterflies *Euchrysops cnejus* (F.) and *Lampides boeticus* (L.), cotton aphid *Aphis gossypii* G., cotton leaf hopper *Amrasca biguttula biguttula* Ishida, tobacco cutworm *Spodoptera litura* (F.), green peach aphid *Myzus persicae* Sulz., whitefly *Bemisia tabaci* (Genndius), tea flush worm *Cydia leucostoma* (Meyr.), tea purple mite *Calacarus carinatus* (Green),

tea pink mite *Acaphylla theae* (Watt), coffee green bug *Coccus viridis* (Gr) and coffee brown bug *Saissetia coffeae* (Walk.). Good crop protection was achieved through reduced pest incidence (Regupathy *et al.,* 1999a).

Apart from this several commercial neem oil formulations *viz.,* Godrej Achook, Biosol, Kemissal, Margocide EC 1K OK, Margosal, Neemplus, Neemguard, Neem pure, Neem Azal, Neem Gold, Nimbecidine, Phytowin has been developed by several private agencies. Also, different neem kernel based formulations like Ecomak, Margocide-OK, Neemax, Neemactin, Neemicide are available in the market (Regupathy *et al.,* 1997).

2.6.2. Dust Formulations

The following dusts were prepared by TNAU using the talc powder as a carrier material *viz.,*neem seed kernel (NSK) 20D, neem cake (NC) 20D and neem oil (NO) 10D.

The talc and plant derivative concerned were mixed by grinding and blending in the mixie, thoroughly until uniform structure was obtained. At frequent intervals, dusts prepared were observed for caking. There was no such aggregation problem (Abdul Kareem *et al.,* 1999).

2.6.3. Granules

Neem Azal 0.1% G has been developed by E.I.D.Parry Co, Chennai and is in the process of evaluation (Personal Communication)

3. Biological effects of neem on Insect

3.1. Repellency

Neem had repelling properties and reduce the settling response (Table 1).Settling response of *Aphis craccivora* Koch and *Myzus persicae* (Sulzer) with neem was below 50% (Regupathy and Ayyasamy, 1999; Rajamohan, 1997; Annie Bright,1997; Murali Ragini, 1998; Gomathi,1998).

3.2. Feeding deterrence

Insects show varying degree of sensitivity for antifeedant activity to various extracts and pure compounds irrespective of the order or the family of the insect. Neem seed kernel suspension (NSKS) caused absolute feeding deterrency against the desert locust at 0.001% while 0.05% needed for the migratory locust *Locusta migratoria* (Singh 1996). *Euproctis lunata, Spodoptera litura, Utethesia pulchella and Acrida exaltata, E. lunata* were found to be highly sensitive (Mane 1968) (Table 2)

3.3. Ovipositon deterrence

Oviposition deterrency is an important behavioural effect of neem on insects and is very useful in protecting crop especially in IPM and IRM. Both neem oil and NSKE had been reported to deter oviposition in several insects (Table 3)

3.4. Insect Growth Regulation

The seed kernel extracts or azadirachtin when feed or applied at juvenile stages arrest their growth. Depending on dose, the insects are either killed before reaching adult stage or produce malformed and miniature adults. The other physiological effects include prolongation of larval period, production of larval-pupal and pupal adult- intermediates.

The first report on the growth the disruptions was by Mcmillan *et al.* (1969), the chloroform extract of the leaves of *Melia azadirach* on *Spodoptera frugiperda* and *Heliothis zea.* Later Gil and Lewis (1971) reported that *Pieris brassicae* larvae fed on NSKE treated foliage failed to develop to maturity. Malformation of pupae and prolongation of pupal period was observed (Table 4).

3.5. Effect on fertility and reproduction

Azadirachtin is found to affect vitellogenesis. *Locusta migratoria* when treated with azadirachtin had smaller ovaries weighing half that of control and contained less number of mature oocyles (Rembold and Sieber, 1981). The azadirachtin treated moths laid only 705 eggs when compared to 7923 eggs laid by 5 pairs of *Spodoptera litura*

amounting to 90% reduction. The egg hatchability was reduced by 67% (Gujar and Mehrotra, 1984). Topical application severely impaired embryogenesis. The trophocytes got damaged in *Dysdercus koenigii* (Koul, 1984). Neem oil vapour reduced egg laying and hatchability in rice moth *Cocyra cephalonica* and *Earias fabia* (Pathak and Krishna, 1986).

4. Conjunctive use of neem with other IPM components like trap crop

The principle of trap cropping is known for many centuries and is effectively exploited in India; marigold and pigeon pea in cotton, marigold in tomato for *Helicoverpa armigera* (Hub.), bhendi in cotton for *Earias* spp. and *Amrasca biggutula biggutula* ishida,castor in tobacco, cotton and castor in groundnut for *Spodoptera litura* (F.), mustard in cabbage for *Plutella xylostella* (L), cowpea in groundnut for *Amsacta albistriga* (Wlk). Repellent, feeding and oviposition deterrency of neem products had been used for diverting pests to trap crop by selective application (Regupathy and Ayyasamy, 1999).

4.1. Groundnut: The preference of *E. kerri* was towards the trap crops, cowpea and soybean compared to groundnut. The population ratio on groundnut: cowpea and groundnut: soybean was 0.81 to 1.4 and 0.80 to 0.94. Groundnut and trap crops (cowpea and soybean) were raised at the ratio of 6:1. Spraying of plant based oil formulations Neem oil (NO), Pungam Oil (PO) and Madhuca Oil (MO) 80 EC @ 3 ml/ lit on main crop groundnut leaving trap crop diverted population to groundnut; the population ratio on groundnut: cowpea and groundnut; soybean was 1.38 to 2.41 and 1.13 to 1.60 respectively. (Ayyasamy *et al.,* 2002).

4.2. Cotton: The preference of *A. devastans, B. tabaci and, A. gossypii* was towards bhendi as a trap crop compared to cotton. The preference of semilooper was towards cotton 1: 0.7. The population ratio on cotton: bhendi was 1: 1.5, 1: 1.4, 1: 1.2, respectively. By the application of neem kernel based formulations on cotton leaving bhendi untreated ions diversification of pests to bhendi was increased; the population

ratio on cotton: bhendi was 1 : 3.4, 1: 3.6, 1: 1.9 and 1 : 1.9 respectively (Saminathan, 2000).

4.3. Rice: Application of neem on CO47 leaving susceptible TN1(S) as a trap variety enhanced the diversion of leaf folder *Cnaphalocrocis medinalis* to TN1(S) for egg laying. The preference ratio increased from 1.18 - 1.43 in both untreated to 1.47 - 1.77 in both treated and 1.99 - 2.84 in TN1(S) untreated - CO47 treated under controlled conditions. In field NSKE (5%) and TNAU neem 0.03 EC were more efficient in repelling the leaf folder population from treated CO 47 to untreated TN1(S) as indicated from the increasing preference ratio from 1.48 - 1.55 (prior to treatment) to 2.36 - 2.48, 3.98 - 4.17 and 3.81 - 3.92 after first, second and third applications respectively (Anbalagan and Regupathy, 2002).

5. Effect on non- target species

5.1. Parasitoids

Spraying of neem oil on aphid mummies containing larvae or pupae of braconids, viz. *Dieraetiella rapae* (M'Intosh) and *Aphidius cerasicola* did not prevent the normal emergence of the parasitoids (Schauer, 1984). Azadirachtin 10 ppm, azadirachtin free fraction (200 ppm) and enriched products AZT-VR-K were slightly harmful to the gregarious larval parasitoid *Apanteles glomeratus* (Linnaeus) when they were applied against fifth instar larvae of *Pieris brassicae.* Azadirachtin 10 ppm was relatively non-toxic but slightly toxic at 20 ppm to the whitefly parasitoid, *Encarsia formosa* Gahan (Feldhege and Schmutterer, 1993).

Jayaraj *et al.* (1993) reported that neem products such as NSKE (5%) neem oil 50 EC (3%) were safe to *Trichogramma japonicum* Ashmead. Srinivasa babu *et al.* (1993) found that Repelin and Neem Gold on *Trichogramma australicum* Girault were relatively safe at lower concentration. According to Klemm and Schmutterer (1993), neem treated host eggs were less parasitized and adults of *Trichogramma pretiosum* (Riley) did not emerge in the laboratory. However, in the field, parasitization of *P. xylostella* (L) by *T. pretiosum* was not affected due to neem seed kernel extract spray.

Aqueous, ethanolic and hexane extracts of neem seed kernel were found to deter oviposition and feeding of *Trichogramma chilonis* Ishii but no physiological and IGR effects were noticed (Raguraman and Singh, 1995). Azatin, Neem EC and Azadirachtin at 50 g/ha, had no significant effect on *T. minutum* Riley (Lyons *et al.*, 1996). Endoparasitic solitary or gregarious hymenopterous larvae were much less endangered as they were at least protected by their hosts from botanical sprays.

Neem products are thought to be relatively benign to beneficial insects such as pollinators, predators and parasitoids (Naumann *et al.*, 1994; Saxena 1987)

In multiple choice test the preference of adult *T.chilonis* to neem treated host eggs was reduced by 22.2%.However in single choice test there was not significant difference.No deleterious effect of Neem oil 50 EC and NSKE were observed on the development and fecundity of *T.chilonis(*Balasubramanian and Regupathy, 1994)
Raguraman and Singh (1999) reported that neem seed oil 0.3 to 5 per cent had no adverse effect on the development, fertility, oviposition, egg hatchability and pupal emergence of *T. chilonis* and on *Bracon hebetor* Say. Muthukrishnan *et al.* (1999) observed that neem seed oil 0.3 per cent and NSKE 5 per cent resulted minimum reduction in the beneficial capacity of *T. chilonis* on cotton. Jayaraj and Regupathy (1999) observed no deleterious effect of neem oil on the development and fecundity of *T. chilonis.* Abdul Kareem *et al.,* (1999b) observed that TNAU Neem formulations viz., NO 60 EC (A), NO 60 EC(C), NOPO 60 EC (C) are safer to the egg parasitoid, *T. chilonis*

5.2. Predators:

Neem oil when effectively controlled the sorghum aphid *Melanaphis sacchari* (Zehntner) it did not affect the survival of predaceous coccinellids (Srivastava and Parmar, 1985). Schmutterer (1987) reported that azadirachtin had low toxicity to natural enemies. Neem oil caused no harm to *Chrysoperla carnea* (Stephens) (Natarajan, 1990). Although Margosan-O reduced the survival of coccinellid larvae under laboratory conditions it was non toxic to these predators in green house trials (Hoelmer *et al.*, 1990). Salem and Matter (1991) stated that neem seed oil had no detrimental effects on predators and acting only as temporary repellent. Neem extracts with or without oils were harmless

to the eggs, larvae or adults of *C. carnea* and *Coccinella septempunctata* Linnaeus (Kaethner, 1991).

Ineffectiveness of neem extracts against mirid bug *Cyrtorhinus lividipennis* (Reuter) was reported by several workers (Chellaiah and Rajendran, 1984; Saxena *et al.*, 1987, Saxena, 1989 and Mohan, 1989). The predatory spider, *Lycosa pseudoannulata* (Bosenberg and Strand) was not affected even by 50mg of NO / individual (Saxena *et al.*, 1984; Shukla *et al.*, 1988) and by NO combined with NSKE (Mariappan *et al.*, 1993; Nanda *et al.*, 1993). Sontakke (1993) found that NO was as safe as untreated check to all the predators such as carabid beetle, rove beetle and spiders.

Neem oil did not affect the survival and behaviour of the larvae of *Coccinella undecimpunctata* Linnaeus (Matter *et al.*, 1993). Margosan OTM and RD-9 (Mansour *et al.*, 1993) were non-toxic to the predatory *Chiracanthium mildei* Linnaeus Neem Azal T/S (1% aza – A, 51% plant oils) showed no negative effective on *C. carnea* and predatory mites (Schutz *et al.*, 1997). Neem Azal T/S gave very good control of the aphid *Dysaphis plantaginea* Passerini and it was harmless to *C. carnea* (Vogt *et al.*, 1997). Schulz *et al.*, (1997) reported that the side effects of Neem Azal on arthropods and non-target organisms was generally scarce or tolerable.

Saminathan (1997) reported that direct spraying of neem oil 1.5 to 4.5 per cent on egg, grub and adults of *C. carnea* was less toxic. Neem products did not affect fecundity and adult and egg hatchability of an aphid predator *Aphidoletes aphidimyza* (Rondani) (Kevin and Murray, 1996). Neem oil 3 per cent was safe to the predatory coccinellid, *Menochilus sexmaculatus* Fabricious (Jayasree, 1984).

Dhaliwal *et al.*, (1999) reported that neem formulations were comparatively safer to the predator *Coccinella septempunctata* Linnaeus. Jayaraj and Regupathy (1999) observed no adverse effect on larval and pupal duration and development and feeding potential of *C. carnea.* According to Jazzar *et al.*, (1999), only 11.4 per cent mortality on the mirid predator of *B. tabaci* was resulted by applying the leaf extract of *Melia azadirach* Linnaeus. Abdul Kareem *et al.*, (1999b) observed that TNAU Neem

formulations viz., NO 60 EC (A), NO 60 EC(C), NOPO 60 EC (C) did not affect the development of predators *C. carnea, Tetragnatha javana, L. pseudoannulata*

5.3. Honey bees

Direct topical application of neem products on larvae reduced larval weight gain and development process (Sharma *et al.,* 1980; Schmutterer and Holst, 1987a) but neem was safe to bees in doses applied at field conditions. Similarly Neem Gold 0.15EC and TNAU Neem 0.03EC were found to be safe to honey bees (Subaharan, 1998).

5.4. Fish and Frog

Two weeks old fingerlings of *Tilapia mossambica* showed complete moratlity at 5.0, 2.5, 0.6, 0.3% NSKE and 0.1 and 0.05% NO within 24 h or exposure. NSKE 0.15% effected 48% mortality at 24 h and 100% at 48h. NSKE 0075% resulted in 24 and 72% mortality at 48 and 72 h of exposure (Bhuvaneshwari *et al.,* 1994). The observed mortality was 20% in 0025% NSKE during the observation period of three days 0025 and 001% NO 50 EC caused complete mortality 72 h after exposure and 0005% NO 50 EC treatment showed 40% mortality of fingerlings at 48 and 72 h of exposure. The observed mortality might be due to the oil that acted as physical poison. Zebitz (1987) reported the toxicity of Margosan - O formulation to rainbow trout and bluegill sunfish might be due to its oil content (15%) or some other compound used for formulation. NO and NSKE did not affect the young adults of the frog *Phyllobates bicolor.*

6. Residue Studies

The results of supervised trials conducted on the residues of neem showed that there were no such residual effects of azadirachtin due to application neem formulations to different crops (Table 5) (Regupathy *et al.,* 1999a).

7. Registration requirements

Initially, the neem products were not registered under the Insecticides Act, 1968, as it was argued that these were not pesticides in the true sense of the term and that neem materials have been in extensive use in India for various purposes, since time immemorial, without any known deleterious effect. It is now considered essential that each product which is marketed commercially is standardized with respect to physical as well as chemical parameters In late 1991, the Central Insecticides Board decided to bring

these under its net and the Registration Committee constituted under Section 5 of the Insecticides Act has approved the guidelines and data requirements for their registration for domestic use and export purposes.

The Indian Standard for neem based EC containing azadirachtin was adopted by the Bureau of Indian Standards, after the draft finalized by the pesticides sectional committee, had been approved by the food and Agriculture Division council (IS 14300-BIS, 1995).

The Indian Standard specifies the requirements under the following heads.

1. The material should consist of neem based azadirachtin
2. Physical characteristics

a. Cold test

b. Flash point

c. Emulsion stability

d. Heat stability

3. Chemical

a. Azadirachtin content

b. Acidity/Alkalinity

c. Aflatoxin content

4. Packing
5. Marking
6. Sampling

Conclusion

The importance of neem in integrated pest management (IPM) is being increasingly experienced by the Indian farmers in over last few years. The country is making the challenging switch from predominance dependence on chemical pesticides to rational use of chemicals and adoption of IPM. Available indications are that Indian farmers will adopt biorational, of which neem will constitute a major part, in a big way. But a lot of concerted effort is needed on the part of plant protection scientists and extension functionaries in reaching the millions of still unreached.

Table 1. Repellent Property of different neem formulations

Component	Pest	Reference
NSKE	*Tribolium castaneum* (Herbst)	Quadri, 1973
NSKE	*Bemesia tabaci* (Genn.)	Coudriet *et al.*, 1985
Methanolic Extract of NSK	*Spodoptera litura* Fab.	Ayyangar and Rao, 1989a
Aqueous NSKE	*Henosephilachna elaterii*	Dreyer, 1984
Alcoholic extracts of neem cake	*Schistocerca gregaria* Forsk, *Locusta migratoria*	Sinha and Gulati, 1963
Petroleum ether extract	*T. castaneum*	Jilani and Su, 1993
Aqueous extract of powdered neem seed	*Cosmopolites sordidus* Germar	Musabyimana and Saxena, 1999
Air dried neem leaf	*Ephestia cautella* (Wlk.)	Fry and Sons, 1938
Neem leaf	*Trogoderma granarium* Everts, *Sitophillus oryzae* L, *Sitotraga cerealella* Oliv.	Singh, 1980
Margosan-O	*T. castaneum*	Jilani *et al.*, 1987
RD – Repelin	*Aphis craccivora* Koch	Hunter and Ullman, 1992
Neem Azal – F	*A. craccivora*	Dimetry and El-Hawary, 1995

Neem gold 0.15 EC, TNAU neem 0.03 EC, NSKE	*Myzus persicae* Sulzer	Rajamohan, 1997
Neem Gold 0.15EC, TNAU Neem 0.03 EC, Neem oil, NSKE	*Acaphylla thea* (Watt), *Calacarus carinatus* (Green), *Toxoptera aurantii* Boyer	Subharan, 1998; Subharan and Reguapthy, 1999
Neem Gold 0.15EC, TNAU Neem 0.03 EC	*S. litura, M. persicae*	Murali Raghini and Regupathy, 1999a
Nimbecidine 0.03 EC and TNAU Neem 0.03 EC	*A. craccivora*	Annie Bright and Regupathy, 1998; Regupathy *et al.*, 1999b

Table 2. Feeding Deterrence by various neem formulations

Component	Pest	Reference
NSKE	*Amsacta moorei* B.	Patel *et al.*, 1968
	*Euproctis lunata*W.	Babu and Beri, 1969
	S. litura	Pradhan and Jotwani, 1971
	S. litura	Joshi and Ramaprasad, 1975; Joshi *et al.*, 1978
	Nephantis serinopa Meyr	Abdul Kareem *et al.*, 1974
	Pieris brassicae (L.)	Sandhu and Singh, 1975
	Helicoverpa armigera (Hubn.)	Kumar and Sengappa, 1984
	Spomopteryx subsecivella Zell	Chandramohan and Sivasubramanian, 1987
	Spilosoma maculates Wlk.	Umesh, 1988
Methanolic extract of NSKE	*S. litura*	Murugan *et al.*, 1999; Ayyasamy *et al.*, 1999
NSKE + Sesame oil	*S. litura*	Rajasekaran and Kumarasami, 1985
NSKE , NO	*S. litura*	Abdul Kareem, 1981; Koul, 1987; Jeyarajan *etal.*, 1990
Alcoholic extract of NSK	*S. gregaria*	Mishra, 1983

Water extract of deoiled NSK	*S. gregaria*	Jhansi Rani, 1984
Methanolic extract of NSK	*S. litura*	Ayyangar and Rao, 1989a
Neem seed extract	*Planococcus citri* (Risso)	Bouhelier, 1937; Jacobson *et al.*, 1978; Ketkar and Ketkar, 1985
Neem oil	*Cnaphalocrocis medinalis* (Guen.)	Saxena *et al.*, 1980
	A. moorei	Verma and Singh, 1985
	Nephotettix virescens (Distant)	Saxena and Khan, 1985
	C. binotalis (Zell)	Panda, 1987
Neem leaf powder	*S. gregaria*	Chopra, 1928
Aqueous neem kernel suspension	*S. gregaria*	Pradhan *et al.*, 1962
Neem extracts, Crude oil emulsion, Alcohol soluble fractions	*A. gossypii* Glover, *A. craccivora, M. persicae*	Roy Choudhry nad Bhatt, 1999
NO 60 EC, NSKD	*C. medinalis*	Saikia and Parameswaran, 1999
Vepicidin, Nemidin and Vemidin	*S. litura*	Chitra and Kandasamy, 1987

Neem azal – F	*S. litura*	Jeyarajan *et al.*, 1990; Durairaj and Venugopal, 1994
Vepacide I and II, SPIC Neem formulation	*S. litura*	Anon, 1992
Neem Gold 0.15 EC and TNAU Neem 0.03EC	*M. persicae*	Raja Mohan and Regupathy, 1999
Nimbecidine 0.03 EC and TNAU Neem 0.03 EC	*N. lugens* Stal, *C. medinalis*	Regupathy *et al.*, 1999b
Neem Gold 0.15 EC and TNAU Neem 0.03EC	*S. litura*	Murali Ragini and Regupathy, 1999a

Table 3. Oviposition Deterrence by different neem formulations

Component	*Pest*	Reference
NSKE	*S. litura*	Joshi and Sitaramaiah, 1979; Chari and Ramprasad, 1993
	Sucking pests of cotton	Ahmed *et al.,* 1995
	B. tabaci (Genn)	Coudriet *et al.,* 1985
	Leptinotarsa decemlineata (Say)	Schmutterer, 1987
	N. virescens (Dist.)	Abdul Kareem *et al.,* 1987; 1988; 1989
	E. vitella (Biosduval)	Sojitra and Patel, 1992
NSKE and NLE	*H. armigera*	Gawi Gowda *et al.,* 1996
Neem oil	*C. maculates* (F.)	Yadav, 1985
	Earias sp.	Pathak and Krishna, 1986
	N. virescens	Velusamy *et al.,* 1987
	N. lugens	Raguraman, 1987
	Xylotrechus quadripes Chevrolat	Anonymus, 1988
	H. armigera	Saminathan *et al.,* 2000
Neem oil and Pungam oil	*Cofana spectra* (Dist)	Abdul Kareem, 1995

Ground neem seeds	*S. littoralis* (Biosd)	El-sayed, 1985
Methyl tertiary butyl ether extract	*Lucilia sericata* E.	Rice *et al.*, 1985
Methanolic extracts	*S. litura*	Ayyangar and Rao, 1989a
Fortified emulsifiable formulations of NEOs and SKEs	*S. litura, H. armigera*	Saminathan, 2000
Neemark	*B. tabaci*	Sundarababu and Rajasekaran, 1980
Neemolin	*S. litura*	Singh, 1996
Neem Gold 0.15EC and TNAU Neem 0.03EC, NSKE	*M. persicae*	Raja Mohan, 1997
Neem Gold 0.15EC and TNAU Neem 0.03EC	*S. litura*	Murali Ragini and Regupathy, 1999a

Table 4. Insect Growth Regulation by different neem formulations

Component	Pest	Reference
NSKE	*Plutella xylostella* F.	Mong Ting Tan and Sudderuddin, 1978
	Dysdercus cingulatus Fab.	Abraham and Ambika, 1979
	H. armigera	Jotwani and Srivastava, 1981; 1984
	Maduca sexta (Joh.)	Heasler, 1984
	B. tabaci	Coudriet *et al.*, 1985
Aqueous and alcoholic NSKE	*Ceratitis capitata* Wied	Steffens and Schmutterer, 1982
Alcoholic NSKE	Mosquito	Singh, 1984
Crystalline NSB from NSK and leaves	*N. lugens*	Abdul Kareem *et al.*, 1989; Krishnaiah and Kalode, 1991
NSK based WDP	*H. armigera*	Sathyanarayana Rao and Srivastava, 1985
Neem cake	*N. lugens*	Abdul Kareem *et al.*, 1987a
NO 10D, NSK 20D	*S. litura*	Regupathy, 1995
Azadirachtin	*S. litura*	Koul, 1983;1987, Chari *et al.*, 1990; 1993, Prabu and Singh, 1993, Natarajan and Sundaramurthy, 1990
	H. armigera	Barnby and Klocke, 1987

	S. litura	Ramachandran *et al.*, 1989
	S. litura	Ramachandran *et al.*, 1989; Ayyangar and Rao, 1989b
	M. persicae	Nisbet *et al.*, 1994
Neem oil	*N. lugens*	Krishnaiah *et al.*, 1990, Meenakshi Sundaram, 1991 and Sontakke, 1993
NSKE, NO, NCE, NSB, TNAU Neem 0.03EC, NO 60 EC(C), NO 60EC(A) and NOPO 60 EC(C)	*N. lugens, N. virecscens, C. medinalis*	Mohan, 1986; Mariappan and Saxena, 1984; Saikia, 1996
Neemark	*Adisura atkinsoni* (Moorai)	Mallikarjunappa, 1989
Neemolin	*S. litura*	Singh, 1996
Neem Gold 0.15EC and TNAU Neem 0.03EC	*M. persicae*	Raja Mohan, 1997
Neem Gold 0.15EC and TNAU Neem 0.03EC	*Cydia leucostoma* (Meyrick)	Subaharan and Regupathy, 2000
	S. litura, M. persicae	Murali Ragini and Regupathy, 1999b

Table 5. Residues of TNAU Neem formulations in different crops

Crop	Formulation	Residues	Reference
Rice - Grain, husk, bran, straw	Nimbecidine 0.03% EC TNAU neem 0.03% EC (200ml-1000ml/ha	BDL	Selvam and Regupathy, 1999; Gomathi, 1998
Field bean – green pods	Nimbecidine 0.03% EC TNAU neem 0.03% EC	BDL	Gomathi, 1998; Annie Bright and Regupathy, 1998
Tea and coffee	Neem Gold 0.15% EC, TNAU neem 0.03% EC (250-2500 ml/ha	BDL	Subaharan, 1998
Tobacco (sun cured)	Neem Gold 0.15% EC TNAU neem 0.03% EC (625-2500 lm/ha)	BDL	Rajamohan, 1997; Murali Ragini, 1998

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