POTENTIAL OF NEEM CONSTITUENTS IN PEST MANAGEMENT

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With the advent of scientific and technical inputs, the humble Neem tree, well known for its healing effects and biocidal activities in folk traditions has been rediscovered as a potential source of eco-friendly phytopesticide. Highlight of research efforts on evaluation of various biocidal activities of neem as well as its pure individual active constituents are presented in this paper.

Neem, the most promising of all plants has received world wide attention in recent years. It is a versatile hardy tree with many potential applications and is considered as miracle tree for many of its effects in folk traditions. The utility of various parts of neem for curing human ailments have found place in legends of Ayurvedic literature. Since early centuries, neem products have been used by Indian villagers as a handy remedy for the treatment of diseases and to protect and nourish agricultural crops. Use of Neem to ward off damage by pest is well known to Indian masses. Ancient Indian folk mixed dried neem leaves with storage grains and with woollen clothe to protect them from ravage of insects. The most interesting fact is that many of the folklore medicinal as well as biocidal properties of neem have been reconfirmed by modern science. Apart from its folklore medicinal and biocidal properties, the tree has immence potential to protect environment through rehabilitation of degraded ecosystem and waste land, reduction in the use of synthetic pesticides and fertilizers and population control. Adaptability to a wide range of soil and climate as well as capability to perform better than many fast growing species in arid and semi arid regions, even in nutrient deficient soil establish the tree as the most preferred species for road side plantations with a long life upto 200 years.

Recent awareness about the hazards of persistent synthetic pesticides to the environment and their high cost have generated fresh interest and intensified research on pesticides of plant origin, free from these limitations to a large extent. Neem has been receiving global attention for the last two decades as a wonder tree of Indian origin for its tremendous pesticidal action. Following the discovery of neem kernel as a locust feeding deterrent, chemical investigation on neem has grown enormously that establish the treee a store house of several chemical constituents exhibiting a wide range of biological activity. As regard to pesticidal action, the chemical constituents of neem act in different ways under different circumtances. They produce their various biocidal action by deterring migrating locust from feeding, repelling larvae and adults, disrupting mating and sexual communications, deterring females from laying eggs, disrupting/inhibiting the development of eggs, larvae and/or pupae, poisoning larvae and adults, blocking the molting of larvae or nymphs, inhibiting the formation of chitin, inhibiting the degradation of pesticide in soil by micro-organism and through phagodeterrency. The multilateral mode of action of neem constituents makes practically impossible for insects to develop immunity to its pesticidal products.

Neem and its products have been tested for their pesticidal properties against more than

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300 species of insects belonging to different orders throughout the world. In India neem has been evaluated against 105 species of insects belonging to ten different orders viz. *Orthoptera, Dictyoptera, Lepidoptera, Hemiptera, Diptera, Coleoptera, Hymenoptera, Isoptera, Thysanoptera* and *Siphnoptera.* Indeed, neem is reported to be antifeedant, attractant, repellent, insecticidal, nematicidal, growth disrupter and antimicrobial.

Chopra (1928) first reported the repellant action of neem on desert locust by applying 0.001% of aqueous suspension of neem kernels[10]. The antifeedant Property of neem was demonstrated to desert locust *Shistocera gregaria* and migratory locust *Locusta migratoria* by applying a 0.1% aqueous suspension of neem seed powder[33]. Protection of stored grains viz., wheat, maize jowar, paddy and pulses from several species of insects viz, *Stiophilus oryzae, Rhizopertha dominica, Tribolium castaneum* and *Callosobruchus chinensis* over a period of one year has been achieved successfully by mixing 1-2% of neem kernel powder in grains[15,20,21,52]. Extract of neem seed have also been reported to inhibit feeding in some field pests like *Pieris brassicae* and *Chrotogonus trachypterous*[40,41]. It has been observed that white ants (*Microtemes sp.*) and some species of ant don't like odour of neem and move away from the treated vicinity. Neem oil has been found to be a strong deterrent to egg laying by potato tuber moth. It was observed that 2% kernel suspension in water was effective as a repellent and ovipositional deterrent for moth of tobacco caterpiller, *Spodoptera litura*[19]. Neem products do have low to moderate toxicity particularly to soft bodies insects. It was reported that the toxicity of water suspension of neem seed kernel to *Aphis gossypii, Urentius echinus* and *Saisetia nigra*[9]. Non-fatty alcohol of neem seed cake was found to possess considerable aphicidal activity (LD_{50} value being 0.202%) when tested against *Rhopalosiphum nymphae L*[16].

Nematodes have been considered as the limiting factor in raising agricultural crops during last two decades. Application of neem seed cake @ 1800 kg/hac. resulted in significant reduction in the root galls of okra and tomato caused by *Melodiogyne javonica*[49]. When N, P and K are applied as fertilizer to soil, marked increase of plant parasite nematodes were observed, but when they applied in combination with neem, the population decreased slowly and steadily[13].

The growth disrupting activity of neem was first demonstrated by Gill (1971) who reported that *Pieris* larvae feed for 48 hours on foliage treated with neem products and subsequently reared on clean food, failed to develop maturity and most of them died while mounting[14]. It has also been shown that *Culex* and *Anopheles* the vectors of malaria and *Musca,* the vector of Cholera failed to reach maturity in the food media containing neem extract. The effect of neem seed suspension of various concentration on a large number of insects and high mortility was studied, significant reduction in weight, morphological deformities of pupae, inhibition of pupating, death of larvae were noticed during the experiment[50]. Quadri (1978) also observed that application of neem seed extract prolonged the development and caused loss of body weight of *Sitophilus oryzae* (L)[35]. Mosquito larvae (*Culex fatigots*) when reared on medium containing 0.01-0.005% neem oil extractive failed to emerge as adults[2].

Synergistic action of Neem extract in combination with custard apple against pulse beetle (*Callosbruchus chinensis Fab.*) was investigated[35]. The product was found half toxic against lesser grain borer and equitoxic as DDT to the housefly.

Degradation of pesticides in soil is largely triggered by soil micro-organism which is a bottleneck in geting desired residual effectiveness of systemic soil insecticides. Alcoholic extract of fresh neem seed cake has been reported to inhibit the degradation of Carbofuran, a popular soil insecticide particularly for paddy pest[36].

The diversified biocidal activities of neem highly influenced the chemical investigation of neem and its products. A number of chemical compounds have been isolated from different parts of neem and tested for their bioactivity. Indian pharmacological chemists in 1919 isolated margosic acid from neem oil. However thorough chemical investigations were undertaken in the middle of the twentieth century. Mitra (1963) first extensively examined the chemistry of active principles of neem[26]. Besides the chemical constituents viz., protein, carbohydrates, amino acids[11,27], fatty acids[45], essential oils[4], flavonoids[3,31], glycosides and minerals, a number of chemically diversed and structurally complexed tetranortriterpenoids (limonoids) have been isolated and characterised from different parts of neem. Bioefficaeies of pure individual principles have been examined by various workers.

Nimbin, being the first limonoid isolated from neem leaves was found effective against various fungi like *Tinea rubrum*[21], ringworm fungus, *Tricyhophyton interdigitale, Coccidiodes immitis* and other species of *Trichophyton* at comparatively very low concentration. Nimocinolide and Isonimocinolide, also isolated from fresh uncrused leaves were found to affect fecundity in housefly (*Musca domestica*) at a dose ranging between 100 and 500 ppm and also showed mutagenic properties in mosquitoes (*Aedes aegypti*) producing intermediates[44]. Insonimbocinolide isolated from the acidic fraction of the alcoholic extract of fresh neem leaves showed insect growth regulating properties against mosquitoes[47]. Nimbidine and thionimone isolated from bark[4] were found to be effective in killing the nematodes and inhibiting the larwal growth[23].

The most active bitter principle isolated from neem seeds is azadirachtin, a limonoid biogenetically related to nimbin[5,7,17,28,30,55]. It has been evaluated as a strong anti-feedant to locust at 40 micrograms/litre concentration resulting in complete cessation of feeding[6]. Subsequently it has been reported to be an effective anti-feedant to *Plutella xylostella* and *Heloithis virescens*[39]. Azadirachtin is very sensitive to acids and alkalies but is stable under neutral conditions. It is highly photosensitive and loses its activity on exposure to sunlight. Azadirachtin content of neem seeds varies markedly depending on the origin of the seed material, soil properties, light, temperature, humidity and exposure to UV radiation[12,51]. Investigations over the past two decades have shown that azadirachtin is one of the most potent growth regulator and feeding deterrent ever assayed. It is structurally related to the insect hormone called *ecdyson*. The growth disturbances caused by it are attributed to the interference in normal hormonal balance of a particular insect[48].

Rembold et al., (1987) have reported the isolation of azadirachtin B from neem seeds as a minor constituent alongwith azadirachtin[37]. Azadirachtin A (the main azadirachtin) and azadirachtin B exhibit insect growth inhibiting activity. Another very interesting compound isolated from neem seed oil is meliantriol. It is the first locust anti-feedant to be reported from any Melia species. Unlike other locust anti-feedants, it is a C-30 protolimonoid[24]. Salanin, a limonoid isolated from neem seed oil showed powerful feeding deterrency but did not influence insect molts. The migratory locust, *California red scale, Striped cucumber* beetle, horseflies and the Japanese beetle have been strongly deterred in laboratory and field experiments[18,54].

7-Deacetyl-17, β-hydroxyazadiradione was also isolated from neem seeds. It was found to be an insect growth inhibitor of *Heliothis virescens*[25]. From neem seed oil 1, 3 diacetylvilasinin, 3-deacetyle salanin and salannol all showing strong antifeedant activity camparable to azadirachtin have also been isolated. Salanin[18], 1-tigloyl-3-acetylvilasinin and salannolacetate also isolated from seed oil were found to exhibit antifeedant activity.

Fresh matured leaves, on steam distillation gave an odorous viscous essential oil. This esential oil showed anti fungal activity against *Tricophyton mentagrophytes* in vitro. A 1%

Table-1 : *Important Commercially Available Neem Based Pesticidal Products in India*

Sl. No.	Trade Name	Active Ingredients	Manufacturer M/S	Biocidal Activities
1.	Godrej Achook	Azadirachtin Azadiradione Nimbocinol Epinimbocinal	Bahar Agrochem & Feed (P) Ltd., Lote Parshuram, Taluka Khed, Ratnagiri - 415722	Antifeedant, Male sterlity, Chitin inhibitor, Growth disruptent, Ovicidal
2.	Field Marshal	Azadirachtin	Khetiwadi Shiyabave, Vadodara - 390 001	Antifeedant, Repellent
3.	Jawan Crop Protector	Azadirachtin	MCDA Agro Pvt. Ltd. Bombay - 400 001	Antifeedant, Repellent, Growth Disruptor
4.	Margocide CK 20% & Margocide CK 80%	Azadirachtin (0.03% W/W) (0.15% W/W)	Monofix Agro Prod. Ltd., V. G. Limbikai Building, Gokul Road, Hubli - 580 030	Antifeedant, Repellent, Growth Disruptor
5.	Neemark	Azadirachtin (0.03%)	West Coast Herbo-Chem Pvt. Ltd., 105/B Rajaji Nagar, III rd cross Road, Tumkur Rd. Bangalore - 560 022	Antifeedant Nematicidal Synergist
6.	Neemgold	Azadirachtin (0.15% EC)	Southern Petrochemical Industries Corporation Ltd. Madras - 600 001	Antifeedant
7.	Nimbicidine	Azadirachtin (0.03%)	T. Stanes & Co. Ltd. 8/23-24, Race course Road, Coimbatore-18	Antifeedant, Metamorphosis disrupto Synergist.
8.	RD-9 Ropellin	Neem oil 93 EC containing Azadirachtin (300 ppm)	ITC Ltd., ILTD Div. IBD, 6-3-1110, Amrutha Mall, Begumpet, Hyderabad - 500016	Antifeedant Repellent
9.	Wellgro	Neem Kernel Powder	ITC Ltd., ILTD Div. IBD, 6-3-1110, Amrutha Mall, Begumpet, Hyderabad - 500016	Repellent, Fungus inhibitor, Antiviral, N-loss Preventor
10.	Sukrina	Azadirachtin (1500 ppm) Meliantrial & others	Canster Pvt. Ltd. Madras - 600116	Anifeedant, Repellent
11.	Neemol	Azadirachtin	Meenal Oil & Agro Industries, Ahamdabad - 380009	Antifeedant
12.	Neem-guard	Kernel extract	Akshay Chemicals, Bombay - 400 052	Repellent, Metamorphosis Disruptor

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13.	Nethrin	Oil	Amitul Agrochem Pvt. Ltd., Gorakhpur (UP)	Pesticidal
14.	Bioneem	Azadirachtin (0.03% EC)	Ajay Biotech Lab. A 12/5, Kubera Park, Kanchhawa, Pune - 411 040	Aphid, Jassid Spotted Boll worm
15.	Nimbasol	Azadirachtin (1500 ppm)	Nimba Food & Chem. Pvt. Ltd., 14-A/10 Western Extn., Pusa Road, New Delhi	Whitefly, Bollworm, Leafroller
16.	Neemazal	Azadirachtin	EID Parry (I) Ltd. Farm Input Div., 234, NSC Bose Road, Madas - 600 001	Aphid, Leaf Hopper Whitefly
17.	Rakshak	Azadirachtin (1500 ppm)	Murkumbi Mfg., 1438/2, Kalmath Rd. Belgaum - 590 002	Thrip, Aphid, Jassid

petroleum ether extract obtained from dried neem leaves showed 100% mosquito larvicidal activity at 0.2% concentration. White crystalline flakes, having no optical rotation, obtained from the petroleum ether extract were found to exceed or equal to the larvicidal activity of pyrenthrum extract[8].

Almost every part of the neem is bitter but the seeds possess maximum deterrency. To explore the possibility of preparing pesticide formulations, it has been found that neem seeds are the richest source of active ingredients. On an average neem seed consists of 45% kernel and 55% shell. The seed kernel contains 40-45% of oil being used in a number of pesticide formulation besides its other industrial applications. Presently two types of pesticide formulations are being produced all over the world. The oil based formulations in which the active constituent azadirachtin, isolated from neem seeds incorporated back into the neem oil being the safe carrier for highly sensitive azadirachtin are widely used pesticide formulations. These formulations also contain other limonoids but azadirachtin is the chief ingredient and its concentration can be managed as per requirement. Other formulations are alcohol based in which azadirachtin and other bitters are extracted with alcohol and the concentrated extract are used for spray on crops.

Most of the insecticides used today are organo-phosphorous compound used during World War II for mass destruction of human beings by Germany. These synthetic pesticides are not degradable and pass on the poison to the next in chain. Hence the urgency of using safe material as pesticide which should be biodegradable after doing its job, is greatly stressed. Neem constituents offer a novel approach in pest management through their diversified biocidal activites. Unlike synthetic pesticides that harm both pest and predators, cause development of resistance by pest, resurgence of pest, leave toxic residues in food, water, air and soil thereby causing disruption of the ecosystem balance, neem derivatives are selective, biodegradable, relatively safe, economical and beneficial to non target organism and man.

The number of neem tree in India is estimated to be about 18 million with a potential of about 540,000 metric tonnes of seeds every year. But only 25% of the total production of neem seeds is being collected. Hence, there is a great need to develop proper techniques for

harvesting, storage and processing in order to utilize the available potential of neem seed. The use of neem seed derivatives capable of affecting insect pest in many ways, offer a harmonious and non-violent approach to pest management. Considering these values of neem and keeping an eye on Indian as well as Western market, some Indian companies have launched neem based pesticides (Table-1) during past few years.

According to a report the annual consumption of pesticides in India is worth Rs 2000 crore. In the next decade the neem based pesticides are expected to cross the 10% mark of the total pesticide consumed in India and it would be Rs 150 crores as on today basis. The total resources of neem available in the world market would be worth SD $ 750 Million. It is very small amount considering the total world market of pesticides. Therefore, coordinated efforts are earnesly needed to develop and promote neem based pesticide formulations so that they can be able to fetche higher return in Indian as well as International markets.

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