Future of Botanical Pesticides in rice, wheat, pulses and vegetables pest management

Anand Prakash, Jagadiswari Rao and V. Nandagopal

ABSTRACT

Use of botanicals is now emerging as one of the important means to be used in protection of crop produce and the environment from pesticidal pollution, which is a global problem. In this chapter, the authors focus on the future of botanical pesticides with special references to agriculture. Two main aspects of botanical pesticides , one search and exploitation of new botanicals as pesticides including isolation, identification and evaluation of the active components and another use of botanicals in agriculture in different forms like direct spray applications of the various plant materials, soil amendments for different plant parts, intercropping of biologically active plants with the main crop, botanical grain protectants, use of botanical based synthetic pesticidal formulations and also use of botanicals as synergists/ binders for synthetic pesticides.

Key words: Botanical pesticides, neem, *Ageratum, Vitex, Pongamia, Pyrethrum*, rice, wheat, pulses

INTRODUCTION

In recent years the use of synthetic insecticides in crop protection programmes around the world has resulted in disturbances of the environment, pest resurgences, pest resistance to pesticides and lethal effect to non target organisms in the agro-ecosystems in addition to direct toxicity to users. Therefore, it has now become necessary to search for the alternative means of pest control, which can minimize the use of synthetic pesticides. Botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides as they possess an array of properties including toxicity to the pest, repellency, antifeedance, insect growth regulatory activities against pests of agricultural importance (Prakash and Rao, 1989, 1986, 2003; Prakash *et al*.,1987, 1989, 1990). In fact botanical pesticides are in use in Indian agriculture for over a century to minimize losses caused by pests and diseases (Prakash *et al*.,1990, 1997; Parmar and Dev kumar 1993). Botanical pesticides have many advantages over synthetic pesticides which includes:

i. botanical pesticides in general possess low mammalian toxicity thus constitute least or no health hazards and environmental pollution,
ii. there is practically no risk of developing pest resis tance to these products, when used in natural forms,
iii. these causes less hazards to non-target organisms and pest resistance has not been reported except synthetic pyrethroids,
iv. no adverse effect on plant growth, seed viability and cooking quality of the grains and
v. botanical pesticides are less expensive and easily available because of their natural occurrence especially in oriental countries.

Some of the botanical like neem, bel, senwar, pyrethrum, tobacco, karanj, mahua and sweet flag etc. have already attained the status of potential pesticides of plant origin to be used in IPM of crop field insects as well as in storage ecosystems (Prakash and Rao, 1997). Future of botanical pesticides in agriculture can be emphasized in following two main directions.

(i) Search of flora for biopesticidal properties

a. Search of flora for biopesticidal properties against common agricultural pests
b. Isolation, identification and evaluation of the active components of the plant products
c. If active components are economic and biologically very effective, synthesis of the components for commercial use.

(ii) Utilization of botanicals in pest management

a. Direct spray applications of various extracts of biologically effective plant products like leaves, stem, roots and whole plants especially for the control of soft bodied insect pests, which feed on the leaves and tender plant parts as flowers and developing grains etc. Aphids, jassids and even caterpillars can be managed by these applications,
b. soil amendment of the effective plant materials for the control of the soil inhabiting pests like white grubs and root-knot nematodes. Amendment of de-oiled cakes of neem, groundnut, sesamum, castor, mahua and karanj etc. are known potential examples to minimize root-knot nematodes populations and losses caused by them,
c. intercropping/mixed cropping of the biologically active plant/ crop with the main crop to minimize the pest incidences. Intercropping of rocket salad, *Erica sativa*

with mustard crop is known to reduce the incidences of mustard aphids and intercropping of marigold with tomato or brinjal is found to minimize incidences of root-knot nematode, *Meloidogyne incognita*,

d. use of botanical as grain/potato protectants against insects in storage. A number of plant materials like leaves of senwar, bel, wild sage, lantana, neem etc. are known to protect stored cereals and potato in storage from the insect pests, whereas a number of vegetables oils like castor, sesamum, linseed, mustard and groundnut etc. effectively controlled the infestation of bruchids in pulse storage,

e. use of botanicals as synergists/ binders for synthetic pesticides to enhance the biological activity of the pesticides. Pyrethrum with peperonyl butoxide; sesamum oil with permethrin dusts and neem oil with DDT are the known examples for the control of storage pests, and

f. use of botanical based synthetic/ commercial formulations for the pest management in agriculture. Several such formulations based on neem and tobacco have already been registered in India and now available for commercial use and export.

Rice and wheat

The major insect pests of rice are categorized as pink borer (*Chilo partellus*), rice earhead bug (*Leptocorisa acuta*), leaf folder (*Cnaphalocrocis medinalis)* and white–backed planthopper (WBPH), *Sogatella furcifera,* whereas wheat aphid (*Aphis maidis*) was common pest in wheat cultivation (Atwal, 1993; Garg, 1996). Against stem borers, botanicals are not found to be effective because of their nature of damage and development inside the stem (Prakash *et al*., 1989) (Table 1). Against *L. acuta,* a number of botanicals *viz*., 5 per cent aqueous leaf extract of king of bitters *(A.paniculata),* 3 per cent oil emulsion spray of neem *(A.indica),* seed extract of orange *(C.reticulate)* and leaf extract of lemon grass *(C.citrates)* are found to protect developing rice grains(Gupta *et al*., 1990). Seed oil (1 %) extracted from custard apple and sprayed on the rice plants not only reduced infestation of rice leaf folder and rice green leafhoppers but also checked rice trungo virus (Narasimhan and Mariappan, 1980.) Neem kernel extract after mixing with 0.16 percent teepol was reported to show juvenile hormone mimic activity and inhibited larval development of *C. medinalis* (Schmutterer *et al*., 1983) and also found to reduce the population of WBPH, when sprayed on the rice crop (David, 1986; Rajasekaran *et al.,* 1987; Mohan and Gopalan; 1990). Similarly, 1 per cent neem oil spray on the rice plant reduced the incidences of leaf folder (Singh *et al*.,1990, Mohan *et al*., 1991), whereas neem cake (de-oiled) amendment in the soil @ 150 kg/ha and neem oil spray at 10 days intervals were found to check the infestation of *C. medinalis* (Krishnaiah and Kalode, 1990). Oil of polang *(C. inophyllum)* or seed oil of mahuwa *(Madhuca indica)* and karanj *(Pongamia glabra)* as 1 per cent formulation was also reported to minimize the infestation of rice leaf folder (Narsimhan and Mariappan, 1988). Root soaking of rice seedlings with neem kernel extract reduced the incidences of WBPH (Saxena *et al*., 1987), whereas neem oil (1 %) spray using 7.5 kg/ha with teepol controlled the attack of *S. furcifera* (Sontakke, 1993) and showed anti-feedant activity to this plant hopper(Saxena *et al.,* 1984). Similarly, 5 % neem cake extract spray reduced emergence of WBPH (Ramraju and Sundarababu, 1989). Against wheat aphid *(Aphis maidis)* aqueous leaf extract of Indian aconite *(Aconitum ferox* Wall.) found in Kumaon hills and alpine Himalayas, was reported to be highly toxic to this aphid *(Siphocornye indobrassicae).* Neem extract and azadirachtine affects the biology of brown planthopper, *Nilaparvatha lugens* (Stal) (Senthil Nathan *et al*., 2007). Very recently it was reported that food consumption, utilization and detoxification enzyme activity of *Dysoxylum* triterpenes on rice leaffolder larvae (Senthil Nathan *et al.,* 2007).

Pulses and Vegetable Crops

Gram pod borer *(Helicoverpa armigera)* is found to be major insect pest of chickpea, tomato and pigeonpea, whereas white grubs like *Anomala dimidiate, Holotrichia seticollis* and *H. longipennis;* cutworm (*Agrotis ipsilon*) and blister beetles *(Mylabris phalerata)* and *Epicauna mannerheimmi* are main pests of soybean and other kharif crops grown in Kumaon hills. Hairy caterpillar (*Spilosoma obliqua*) is reported to be a major pest of soybean, whereas mustard aphid *(Aphis erysemi)* is found to be regular and major pest of vegetables and mustard in addition to its act as a vector for Yellow Mosaic Virus of blackgram. Cabbage aphid *(Brevicornye brassicae)* is also reported as an important pest of cabbage in hilly areas (Garg, 1996; Garg and Sachan, 1992).

Against *H. armigera* a number of botanicals viz., neem kernel extracts (38.57%) and neem oil (5%) sprays were found to be effective in reducing the populations of this pest in chickpea (Siddappaji *et al*., 1986; Rao and Srivastava 1985 and Sinha 1993), whereas Nemidin-9, a neem - based formulation inhibited the development of this pest by 70 per cent at 1000 mg/litre concentration spray application (Nelson *et al*., 1993). Similarly, aqueous leaf extract of rose periwinkle *(Catharanthus roseus)* spray on blakgram also reduced its population (Rajasekaran *et al*., 1987). Karanja oil (2 %) was reported to prolong its larval development and growth inhibiting activity (Bajpai and Sehgal, 1994). Nicotine sulphate solated from west tobacco leaves was found to be highly toxic to this borer (Patel *et al*., 1990). Two formulations of nicotine i.e. Nicotine 40 per cent and 10 per cent DP have already registered in India for their commercial use and export. Losses due to mustard aphid *(Lipaphis erysimi)* could be minimized by spraying neem leaf and neem karnel extracts on mustard crop (Atwal and Pajni, 1964). Neem oil (1.5 per cent) spray showed 100 per cent mortality to this aphid (Mani *et al*., 1990). Intercropping of the seasonal herb

Table 1. Pesticidal activity of plant products tested against insect pests of paddy fields

Plant Taxonomic status & (common name)	Plant part, formulation & dose/ conc.	Test insects	Biological activity	Citations
Ageratum conyzovides Linn. (Asteraceae) (Goat weed)	Precocene I & II	*Leptocorisa chinensis*	Toxic to the adults & nymphs	Lu, 1982
Andrographis paniculata (Burn f.) Wall ex. Nees (Acanthaceae) (king of bitters)	Aqueous leaf extract	*Leptocorisa acuta*	Protect rice panicle, when sprayed with the extract	Gupta *et al.*, 1990
Annona squamosa Linn. (Annonaceae)(Custard apple/ sweet sop/supper apple)	Leaf and fruit extracts	Green leafhopper (GLH) - *Nephottetix virescens*, Brown planthopper (BPH) - *Nilaparvata lugens*	Insecticidal activity	Mariappan *et al.*, 1982 a,b; Epino & Saxena, 1982
	Seed oil	GLH	Effectively reduce survival of adults	Mariappan and Saxena, 1983
	Neem oil + custard apple (1:4) mixture or alone	GLH	Reduced population	Kareem *et al.*, 1987a
	Seed oil	Rice leaffolder (RLF) - *Cnaphalocrocis medinalis* and GLH	Reduce survival of LF and Tungro transmission	Narsimhan and Mariappan,1985 Mariappan *et al.*, 1988
Artememisla kurramensis Linn. (Asteraceae)	Seed oil alone or in combination with organic materials	White backed planthopper (WBPH)- *Sogatella longifurcifera*, *Sogata striatus*, *Perkinsiella insigris* and *Toya attenuata*	Insecticidal activity	Khan and Khan, 1985
Azadirachta indica A. Juss. (Meliaceae) (Neem)	Neem leaf bitters **(NLB)**	GLH, BPH	Reduced oviposition & development of test insects, when sprayed on rice seedlings	Kareem *et al.*, 1989a
	Fractions of methanolic extract of neem seed	RLF & *Mythimna separata*	Showed JH mimic activity to the test insects	Schmutterer *et al.*, 1983
	Neem coated urea as soil application	GM, GLH & RLF	Reduced incidences in paddy	David, 1986
	5% aqueous neem seed kernel extract **(NSKE)**	GLH	ovipositional by seedling root-dip for 24 hrs.	Kareem *et al.*, 1987a
	10% NSKE pre-sowing seed treatment	BPH	Reduced population & enhanced seedling growth	Kareem *et al.*, 1987b

	Seeding Root soaking NSKE (5%) its foliar spray soil incorporation	BPH, WBPH, & GLH	Inhibited growth & development	Saxena *et al*., 1987
	NSKE application using ULV sprayer	BPH, RLF	Checked incidences of the test insects	Rajasekaran *et al.*, 1987a
	Young rice seedling when soaked in NSKE	BPH & GLH	Reduce nymphal develop and growth inhibiting activity	Kareem *et al.*, 1988a,b
	NSKE	GLH	Reduce survival, antifeedant	Narsimhan & Mariappan,1988
	Neem seed bitters 0.25%	BPH & GLH	Reduced egg laying and adult emergence	Kareem *et al.*, 1989a
	NSKE admixed with carbofuran		Reduced infestation of GLH and tungro	Kareem *et al.*, 1989b
	NSKE 2% - germinated seeds	BPH & GLH	Checked adult emergence	Kareem *et al.*, 1989c
	NSKE	GLH	repellant	Songkittisuntron,1989
	NSKE 5%+0.16% teepol spray	LF	Reduced population significantly	Mohan and Gopalan, 1990
	5% NSKE spray	LF & grass hopper	Reduced incidence/ protect more	Dhahiwal *et al.*, 1990a
	NSKE 5% spray at 21 DAT	*Hydrellia philippina*	Reduced incidence	Bhatia *et al.*,1994
	NSKE 5%	YSB	Reduced WEH & Insecticidal	Dash *et al.*,1995
	Neem oil spraying protect rice crop	*Hydrelha phillipina*	Antifeedant	Murthy, 1975
	Neem oil spraying protect rice crop	BPH	Strong repellency	Balasubramanian, 1979, Saxena *et al*., 1979.,
	Neem oil spraying protect rice crop	BPH and ragged stunt virus	Antifeedant activity	Saxena *et al*., 1981a
	Neem oil 10% Neem oil spraying protect rice crop	LF GLH	Antifeedant Reduced life span of GLH and antifeedant	Saxena *et al*., 1981b Mariappan *et al.*, 1982a
	Neem oil spraying	GLH & RTV	Population reduction	Mariappan and Saxena,1983
	Neem oil spraying	II & III instar of BPH	Antifeedant	Chiu *et al.*, 1983
	Neem oil spraying at early vegetative stage protect rice crop	*Maliarpha seperatella, Sesamia calamistis, Diapsis macrophthalma and D.apicalis*	population reduction	Ho and Kibuca,1983

	Neem oil spraying	BPH,WBPH and GLH	Antifeedant, inhibit growth and development	Saxena *et al*., 1984a
	Neem oil spraying	Predatory bug *Cyrtorhinus lividepennis*	Toxicity	Saxena *et al*., 1984b
	5% Neem oil Neem oil coated urea	GLH *Hydrelhia philippina, N. virescens* and BPH	Antifeedant Reduced incidence	Heyde *et al.*, 1984 Krishnaiah and Kalode.,1984
	Neem oil	*L.oratorius*	Deformity	Saxena *et al*.,1985
	5% neem oil	BPH and Ragged stunt virus (RSV)	Reduced survival and incidence of RSV	Saxena and Khan, 1985a
	Neem oil odour	GLH	Disturbed feeding and longivity	Saxena and Khan, 1985b
	0.5-5% neem oil	*N. verescens*	Redued growth and development	Heyde *et al*., 1985
	Neem oil	BPH	Insecticidal activity	Velusamy *et al.*, 1987
	1% neem oil	BPH and WBPH	Reduced emergence	Ramaraju & Sundarababu, 1989
	Neem oil treated BPH	BPH	Continuous abdominal movement and Prolonged pre-maturing period	Saxena *et al*., 1989
	3%neem oil	GM	Reduced infestation	Samlo *et al.*, 1990
	1-4% neem oil	LF and YSB	Reduced incidences	Singh *et al.*, 1990
	5%neem oil	*L. acuta*	Reduce population	Gupta *et al*., 1990
	1% neem oil	*N. virescens*(NV), YSB,GM,RH and *Hydrelhia philippina* - HP	Disrupted the growth of 1st instar NV and affected the oviposition of YSB, GM, RH and HP	Krishnaiah and Kalode, 1991
	2% neem oil	LF, *Hieroglyphus baniana*	Reduced infestation	Mohan *et al*., 1991
	4%neem oil	YSB	Reduced WEH in field	Dhaliwal *et al.*, 1993
	Neem oil @7.5 kg/ha	BPH and WBPH	Effectively controlled infestation	Sontakke, 1993
	3%neem oil spray at 21 DAT	*Hydrelhia philippina*	Reduce damage	Bhatia *et al*., 1994
	1.5%neem oil 0.05 % monocrotophos	YSB	Effectively controlled DH formation	Bhatia *et al.*, 1994
	Neem kernel powder suspension	BPH and WBPH	Reduce honey drew secretion and antifeedency	Chiu *et al*.,1983
	Neem kernel powder with carbofuran	GLH and Tungro	Controlled Tungro	Kareem *et al*., 1988b

	3% Neem kernel powder	*N. virescencs*	Inhibited nymphal growth	Krishnaiah and Kalode, 1990
	5% de-oiled neem cake(DNC)	BPH & WBPH	Reduced honey dew secretion	Chiu *et al.*,1983
	neem cake application	BPH	Reduced population	Saxena *et al.*, 1984b
	Neem cake coated ura	*Hydrelhia philippina* and GLH	Reduced incidences	David, 1986
	Neem cake extract 5% spray	BPH & WBPH	Reduce emergence	Ramaraju and Sundarababu, 1989
	Neem cake + 150 kg/ha 3% neem oil spray	LF	Effectively checked insect infestation	Krishnaiah *et al.*, 1990Krishnaiah and Kalode, 1990
	Neem cake with urea	GLH and WBPH	Reduce population	Viswanathan & Kandiannan, 1990
	DNC application in Azolla @250 kg/ha in rice	*Nymphula responsalis, N. enixalis,Nymphula sp., Cryptoblabes gnidiella*	Toxicity to larvae and pupae	Sasmal, 1991
	DNC extract 10%	LF and *Hieroglyphus baniana*	Reduce pests incidences	Mohan *et al.*, 1991
	Neem cake @ 150 kg/ha in soil	*Hydrelhia philippina*	Reduce damageof whorl maggots	Bhatia *et al.*, 1994
	Neemax spray	WBPH	Controlled the pest	Shukla *et al.*, 1991
	Welgro spray	WBPH	Controlled the pest	Shukla *et al.*, 1991
	Welgro2% foliar spray	GM and YSB	Reduced incidences	Nanda *et al.*,1993
	Nemidin 1000ppm	WBPH	Inhibit the development of larvae	Nelson *et al.*, 1993
	0.5 and 1.0% Achook spray	*L. acuta*	Effectively controlled the pest	Prakash and Rao, 1994
	Margoside CK and Margoside OK 1%	5th instar BPH	57-80% mortality	Jena and Dani 1994
	Neem limonoides - seedling root dip	GLH	Antifeedency	Saxena & Boncolin, 1988
Calophyllum inophyllum (Polang/und), Indian lurvel	1%seed oil of Indian lurvel	GLH & RTV	Check population and RTV transmission	Narsimhan & Mariappan, 1988
	Oil spray	LF & GLG	Reduced survival antifeedant	Mariappan *et al.*, 1988
	1%seed oil and 2% extract	BPH&WBPH	Reduce nymphal and adult emergence	Ramaraju and Sundarababu, 1989
	Sed oil 5000ppm on BPH and 2500ppm on GLH	BPH & GLH	Disrupt growth and reduce incidences	Krishnaiah and Kalode, 1990

Catharanthus rosesus (rose periwinkle)	Aqeuous leaf extract	YSB	Insecticidal activity	Satpathy, 1983
Citrus reticulate (orange)	Seed extract in water protected rice	*L. acuta*	Insecticidal activity	Gupta *et al.*, 1990
Croton sparsiflorum (Jamalghota/ croton)	Seed oil	GLH	Reduced survival and longevity	Narsimhan & Mariappan, 1988
Cymbopogan citrutus (Lemon grass)	Leaf extract spray	*L. acuta*	Protected the paddy grains	Gupta *et al*, 1990
Echinochloa crusgalli (Barnyard grass)	Transaconitic acid isolated from *E. crusgalli*	BPH	Antifeedant activity	Kim *et al.*,1976
Eclipta alba (Morchand)	Root and shoot extracts	BPH	Antifeedant actvity	Rao and Prakash, 1979
Eruca vesicaria (Taramina or Rocket salad)	Seed oil spray on rice crop	*Sogatella longifurcifera*, *Sogata striatus*, *Perkinsiella insigns* and*Toya attenuata*	Controlled the test insects	Khan and Khan, 1985
Gynandropsis pentaphylla	Petroleum seed extract	BPH	Reduced oviposition	Reddy and Urs,1988
Lantana camara Linn. (Verbenaceae)	Flower extract in water	BPH	Toxicity, when tested as topical application	Morallo-Rajessus (1984)
Madhuca indica J.F. Gmel. (Sapotaceae) (Mahua)	Seed oil	GLH, RLF, Rice tungro virus (RTV)	Reduced survival of the insects & disease	Narsimhan and Mariappan, 1988; Mariappan *et al.*, 1988
	1% seed oil & 2% seed extract	BPH & WBPH	Reduced adult emergence	Ramraju and Sunder Babu, 1989
Melia azedarach Linn. (Meliaceae)	Seed oil (0.04%)	Yellow stem borer (YSB), *Scirpophaga incertulas*, BPH & WBPH	Antifeedant & insecticidal activity	Hu *et al.*, 1983
	Leaf & seed extract	YSB	Antifeedant	Wen, 1983
	Seed extract in P.ether	Nymphs of BPH	Antefeedant	Chiu *et al*,1983
	Seed oil with diazinon	Rice gall midge (GM)-*Orseolia oryzae*	Synergestic effect	Chiu, 1989
Melia toosendan (Linn) Juss (Meliaceae) (China berry)	Seed oil & extract in ether	White veined rice armyworm, *Leucania veralba*, BPH, GM, YSB	Insecticidal/ antifeedant activity	Chiu, 1982
	Toosendanin Isolated from its seed	*Mythimna separeata*	Strong antefeedancy	Shi *et al.*, 1986
Oryza sativa Linn	Extract of rice variety TKM-6	Sriped Stem Borer (SSB), *Chilo suppressalis*	Strongly oviposition & antifeedant	Dhaliwal *et al.*, 1990 a

	Extracts of rice varieties Taitung-16 & Chianan-2	SSB	High mortality to 5th Instar larvae & pupae. Deformed pupae	Dhaliwal *et al.*, 1990 a
	Steam extracts of Taitung-16, Extracts fractioned (hexane + diethyl ether - 9+1.	SSB, BPH	Highly toxic to larvae, nymphs	Dhaliwal *et al.*, 1990 b
	Sterols & asparagin	BPH	Inhibite development	Yoshio *et al.*, 1982
	Pentadecanol TKM-6	*C.suppressalis*	100% larval mortality	Dale, 1990; 1992
Pongamia glabra Vent (Fabaceae) (Puna oil tree/ Kharanja)	Oil	GLH & LF	Reduced survival	Mariappan *et al.*, 1988
	1% oil and 2% seed extract	BPH & WBPH	Reduced emergence of the hoppers	Ramaraju & Sundar Babu, 1989
	Oil	*Chilo partellus*	Reduced survival of the larvae	Sharma & Bhatanagar, 1990
	Mixture of pongamia & neem oil (1:1)	GM & YSB	Safely protected paddy from the test insects	Nanda *et al.*, 1993
Rhododendron molle Linn. (Ericaceae)	Root leaf & flower aqueous & alcohol extract	YSB	Toxic	Chiu, 1982
Tagetes ereeta Linn. (Asteraceae) Aztee marigold	Aqueous root extract	GLH & BPH	Toxicity	Morallo-Rajissus & Eroles, 1978; Morallo-Rajissus & Decena, 1982
Tagetes pafula Linn. (Asteraceae) marigold	Aqueous root extract	GLH	Toxicity	Morallo Rajissus & Eroles, 1978 French
	Aqueous root extract	BPH	Toxicity	Morallo-Rajissus, 1982
Tinospota rumphi Boel. (Menispemaceae) Makabuhai	Root & stem incorporation with soil	GLH	Iinsecticidal activity against GLH	Del Fierro & Morallo- Rajessus, 1976; Morallo-Rajessus & Silva, 1979
Tripteryguim wilifordril Hook (Celastraceae) (Thunder God vine)	Root & Bark powder	Larvae of YSB	Toxicity/ Antifeedant activity	Chiu, 1982
Vitex negundo Linn. (Verbenaceae) (Indian privet)	Petroleum ether leaf extract	LF	Pupal Malformation	Sukumaran *et al*, 1987

rocket salad, *Eruca sativa* Mull. with mustard crop reduced the incidences of this aphid effectively (Dilawari and Dhaliwal, 1992). Similarly, aqueous leaf extract of English basil *(Hyptis suavelobens),* an aromatic herb found in north India was reported to be highly toxic to this aphid, when sprayed on the cabbage crop(Roy and Pandey, 1991). Further, karanja (a flavonoid) isolated from de-oiled cake of karanja *(Pongamia glabra)* was found to be very toxic to mustard aphid (Parmar and Gulati, 1969).

Against cabbage aphid, *Brevicornye brassicae* leaf extract of *Annona squamosa* and 12 per cent leaf extract of neem were found to show strong anti-feedancy to this aphid, whereas 0.5 per cent neem oil spray on cauliflower showed repellency to *B.brassicae* (Singh and Sharma, 1986). Losses caused by hairy caterpillar *(Spilosoma oblique)* could be minimized by sprays of aqueous leaf extracts of *Euphorbia royleana* or *Lantana camera* (Sharma *et al*., 1982). Leaf extracts of *Linodenbergia grandifolia,* a perennial diffused herb, Velvet bean (*Macuna cochinensis)* and *Passiflora mollissima* showed anti-feedancy to this pest (Tripathi *et al.*, 1987, Premchand 1989). Further, 5 percent leaf extract of *Nyctanthes arbortritis* , an ornamental shrub of Himalayan tract is also reported to show anti-feedancy to *S. oblique*(Sharma *et al.* 1992; Tripathi *et al*., 1987). Mohanty *et al.* (1988) also found seed oil fraction of *P. glabra* and seed oil of babchi *(Psoralea corylifolia)* to show anti-feedant activity to this pest. Further, aqueous leaf extract of needle wood *(Schima khasiana*), a perennial tree found in east Himalaya from Nepal to Khasi Hills showed strong anti-feedancy to *S. oblique* (Tripathi *et al*., 1987), whereas Sharma *et al.* (1992) found whole plant extract of *Swertia chirayita* (a perennial herb in north India) to show anti-feedancy to this pest. From maize *(Zea mays),* an active component DIMBOA (2,4-dihydroxy-7-methoxy-2H-1, 4-benzoxazin-3 (4H)-one) to show antibiosis to this pest (Hariprasad and Kanaujia, 1992).

Potato

Some of the important insect pests of potato like potato tuber moths *(Phthorimaea operculella, Polyphagous defoliator, Henosepilachna vigintioctopuntata)* and plant sucking aphid *(Myzus persicae),* a vector for Potato Virus Y disease are known to cause considerable losses in potato cultivation in sub-hill and hill regions (Misra, 1993). Rhizome extract of *Acorus calamus,* leaf extract of *Ageratum conyzoides* were reported to show 42 per cent mortality to the 3rd instar larvae of potato tuber moth(Pandey *et al*., 1982). NSKE (5 per cent) and seed extract of *Jatropha curcas* and karanj also found to inhibit the oviposition of this moth (Shelke *et al*., 1987), whereas spray application of neemrich (a neem based formulation) protected the crop against this pest. Further dried leaves powder to *Eucalyptus globulus* as well as *Lantana camera* as 2.5 cms layer protected potato in storage from this pest upto 6 months(Lal, 1987).

Against epilachna beetle (*H. vigintioctopunctata),* rhizome extract of sweet flag, *Acorus calamus* showed toxicity to this beetle (Chandel *et al.*, 1987),whereas its oil@10-200 ul/100cc in controlled condition showed fumigant action against this pest. B-asarone an active component isolated from whole plant extract of *Ageratum conyzoides* showed growth regulating activity against the pupae of this beetle. Aqueous crude leaf extract of *A. squamosa* 0.5 per cent spray application on the crop gave 100 per cent protection against II and III instar grubs of this beetle and showed anti-feedancy and also 1 percent aqueous neem leaf extract and petroleum extract of *Eucalyptus globulus* and leaf extract of *Vinca rosea* petroleum ether extract of *Parthenium hysterosphorius* and whole plant extract of yellow berries night shade,*Solanum xanthocarpum* were reported to show reduction in the population of this pest (Chitra *et al*., 1991, Dhandapani *et al.*,1985). Chandel *et al.* (1987) found not acetone stem extract of *Cyprus rotundus;* petroleum ether extract of *Gynandropsis gynandra* and black cumin (*Nigella sativa*) and acetone extract of dried stem of *Strychnos nux-vomica* showed toxicity to this polyphagous beetle. Against aphid (*Myzus persicae), Pyrethrum* and dried flower powder *Chrysanthemum cinararifolium* along with piperonyl butoxide as aerosol applications effectively controlled this aphid, whereas a rotenoid,pachyrhizone isolated from fruit and seed extract of *Pachyrhizus angulatus* was found to show high toxicity to this pest (Jacobson, 1975). Joshi *et al.* (1978) reported aqueous leaf extract of wild tobacco (*Nicotiana gossei)* as a highly toxic formulation against *M. persicae.*

Storage Insects

A number of plant materials like leaves of senwar, begonia, wild sage(*Vitex negundo*), *Lippia geminate* and bel, *Aegle marmelos* have been found as effective grain protectants @ 1 per cent w/w admixed with the grains and recommended for the management of rice stored insects (Prakash and Rao, 1984,1986) (Table 2), whereas leaves of senwar and oils of sesamum, groundnut, castor, mahua, linseed and mustard admixed with the pulse grains@ 1 per cent w/w successfully controlled the infestation of bruchids in storage (Prakash and Rao, 1989; Kumari *et al*.,1990).

Nematodes Management

Root-knot nematodes (*Meloidogyne incognita, M. hapla* and *M. javanica)* are reported to be problems in potato and other kharif crops, whereas *M. graminicola* is the main nematode pest in rice in hill cultivation, in addition to cyst nematode, *Globodera rostochinensis* and *G. pallida* in potato (Misra, 1993). Oil amendment of a number of botanical products like chopped leaves of king of bitters, *Andrographis paniculata* in vegetable crops (Goswami and Vijayalakshmi, 1985), *Argemone mexicana* for papaya cultivation (Reddy *et al*., 1990), neem for pointed gourd (Verma and Anwar, 1995), dried leaves of *Calotropis gigantean* in betel vine cultivation (Sivakumar

Table 2. Plant products found to show grain protection/or inhibit life stages of storage insects of rice (Source: Prakash and Rao, 1997)

Name of plant	Product and its dose	Insect against tested	Condition of experiment	Result obtained
Acorus calamus (sweet flag)	Rhyzome extract and methanol@ 20ml/100g	4,5	L	Significantly reduced larval and pupal population
Adhatoda vasica (Malabar nut tree)	Leaves extracts in water 20ml/100g or root powder @2%w/w	1,2,3,5	L	Showed 69% grain protection
Aegle marmelos (bael)	Leaf powder@2%w/w	1,2,3,4,5,6	L,N	Showed 85% grain protection for 180 days
Allium cepa (onion)	Bulb extract(crude) 0.02%@20ml/ 100g	1,2,3,6	L	Toxic to *C.cephalonica*
Allium sativum (garlic)	Bulb extract 0.02%@20ml/ 100g and also 2 lit/100kg	1,2,3,6	L,N	Promising grain protection up to 180 days
Annon squamosa (super apple)	Leaves extracts in water 20ml/ 100g and root powder @2%w/ w	4,5	L	Inhibited the development of insects
Argemone mexicana (prickly poppy)	Leaves extracts in water 20ml/100g	3	L	Showed 78% grain protection for 90 days
Azardirachta indica(neem)	Oil and extract, each 0.02%@2lit/ 100kg	1,2,3	N	Showed 86% grain protection for 180 days
Azardirachta (neem)	Oil and extract, each 0.02%@2lit/ 100kg	1,2,3	L	Protected paddy grains *indica* significantly
Callophyllum inophyllum(undi)	Cake@2%w/w	1,2,3	L,N	Showed promising grain protection but showed adverse effect on seed viability
Cannabis sativum (bhang)	Leaves @2%w/w	1,2,3	L,N	Showed 59% protection under laboratory tests only
Cleistanthus collinus(karada)	Leaves extracts in methanol 20ml/100g	4,5	L	Showed Larval mortality to *O.surinamensis*
Citrus aurantium (sour orange)	Peel extract in water 20ml/100g	3,5	L	Showed 80% significant grain protection
Crotalaria juneca(junjunea)	Leaves extract and root extract 20ml/100g	3	L	Showed repellency to adults
Curcuma longa (turmeric)	Powder of roots @0.5%w/w	3,5	L	Showed 73% grain protection
Chrysanthemum 0.01%@2Lit/100kg (pyrethrum)	Flower head extract (2EC)	1,2,3	L,N	Showed 62% grain *cineraraefolium* protection up to 120 days
Eclipta alba (mochrand)	Leaf and root extract @ 20ml/100g	1,3,5	L,N	Ovicidal to *S.cerealella*
Euphorbia pulcherrima (poinsettia)	Leaves extract @ 20ml/100g	3	L	Toxic to *S. oryzae*

Ganoderma lucidum	Fruit extract @20ml/100g	3	L	Toxic to *S. oryzae*
Hibiscus rosa (rose in China)	Flower extract @20ml/100g	3	L	Toxic to *S. oryzaechinensis*
Ipomoea cornea (morning glory genus)	Leaves extract @ 20ml/100g	4,5	L	Toxic to *S. surinamensis* and *T.castaneum*
Lippia geminate (wild sage)	Leaves powder @2%w/w	1,2,3,4,5,6	L,N	80% grain protection for 270 days
Madhuca latifolia (mahuwa)	Cake @2%w/w	1,2,3	L,N	Effective to protect grain under laboratory conditions only
Piper nigrum piper)	Seed extract @ 20ml/ 100g	1,2,3	L	Protected grain only against *S.* (black *oryzae* and *R. dominica*
Pongamia glabra (kharanga cake)	Cakes@2%w/w	4,5	L	Checked the larval and pupal development of insects
P.pinnata	Cakes@2%w/w	4,5	L	larval and pupal development
Vitex negundo	Leaves @2%w/w	1,2,3,4,5,6	L	85% grain protection (begonia) against boring insects for 270 days

Test insects: 1.*S.cerealella* 2. *R.dominica* 3. *S.oryzae* 4. *O.surinamensis* 5. *T.castaneum;* 6. *C.cephalonica*

and Marimuthu, 1986), whole plant vilayati mehendi *(Clerodendrum inerme*) in okra (Patel *et al*., 1990), leaves of marigold (*Tagetes erecta)* for tomato and brinjal (Reddy *et al*.,1990) and *Parthenium hysterophorous* in plantain (Jacob *et al*., 1990) has been found to be very effective in minimizing the losses due to root-knot nematodes. Similarly, neem oil-cake for soil amendment @ 1.5 t/ha in okra (Reddy and Khan, 1990), yellow mustard de-oiled cake @ 2.5t/ha in tomato and okra (Singh and Sitaramaiah, 1971), oil cake of polang (*Calophyllum inophyllum)* in rice (Prakash *et al*., 1990), safflower *(Carthamus tinctorius)* in tomato (Goswami and Vijayalakshmi 1986); mahua, *Madhuca indica* in the peat soil for plantain cultivation (Jacob *et al.*, 1990) have shown effective protection against root-knot nematodes. Further, intercropping of marigold with either tomato, brinjal and wheat also showed promising reduction in the root galling or incidences of root-knot nematodes (Reddy *et al*., 1990).

REFERENCES

Atwal,A.S. and Pajni, H.R. 1964. Preliminary studies on the insecticidal properties of drupes of *Melia azadirachta* against caterpillars of *Pieris brassicae* Linn. *Indian Journal of Entomology,* **26:**221-227.

Atwal,A.S.1993.Agricultural pests of India and South East Asia.Kalyani Publications New Delhi, 527 **PP**.

Bajpai, N.K. and Sehgal, V.K.1994. Effect of neem products, nicotine and karanj on survival and biology of pod borer, *Helicoverpa armigera* Hubn. of chickpea. *Proc. II AZRA Conference on Recent Trends in Plant, Animal and Human Pest Management: Impact on Environment.* 48 **PP**.

Balsubramanian, M. 1979. Pest management studies for rice brown plant hopper in Tamil Nadu, Agricultural University. *In recent trends in brown plant hopper control*. Colloquium on rice brown plant hopper, Coimbatore, *India,* 9-10.

Bhatia, A., Alam, N., Hameed, S.F. and Singh, R. 1994. Effectiveness of neem products *(Azardirachta indica* A. Juss.) against whorl maggot, *Hydrellia philippina* Ferino in rice field. *Oryza,* **31:** 69-70.

Chandel, B.S., Pandey, U.K. and Kumar, A.1987. Insecticidal evaluation of some plant extracts against *Epilachna vigintioctopuncata* Fabr.(Coleoptera: Coccinellidae). *Indian Journal of Entomology,* **49**(2):294-296

Chitra, K.C., Reddy, P.V.R. and Rao, K.P. 1991a. Effect of certain plant extracts in the control of brinjal spotted leaf beetle, *Henosepilachna vigintioctopuncata* Fabr. *Journal of Applied Zoological Research,* **2**(1): 37-38

Chiu, Shin-Foon., Huang, B. and Hu, M.Y.1983. Experiments on the use of seed oils of some meliaceous plants on antifeedants in brown plant hopper control. *Acta Entomologica Sinica,* **26**(1):1-9

Chiu,Shin-Foon.1982. Experiments on insecticidal plants as a source of insect feeding inhibitors and growth regulation with special reference to Meliaceae. *Plant Protection*. South China Agriculture College, Cuangzhon, China, 42 **P**.

Chiu,Shin-Foon.1989.Recent advances in research on botanical pesticides in China. In *Insecticides of plant origin, ACS Symposium Series 387 of III Chemical Congress of North America,195th National Meeting of American Chemical Society held at Toronto Ontari* , Canada., 69-77 **PP.**

Dale, D. 1990. Resistance factors in pest control – A case study in rice. *In National Symposium on 'Problems and Prospects of Botanical esticides in Integrated Pest Management* **.** 30. **PP**

Dale, D. 1992. An allomone in rice plant against stem borer,*Proc.First National Symposium. 'Allelopathy in Agro-ecosystem*Eds.Tauro, P. and Narwal, S.S., **PP** 171-174.

Dash, A., Senapati, B. and Samalo, A.P. 1995. Evaluation of neem derivatives against tissue borers of rice. *Journal of Applied Zoological Research,* **6** (1): 35-37.

David, P.M.M.1986. Effect of slow release nitrogen fertilizers and the foliar spray of neem products on rice pests. *Madras Agriculture Journal,* **73**(5):274-277

Del Fierro,R.S. and Morallo-Rajessus, B.1976. Preliminary study on the insecticidal activity on makebuhai, *tinospora rumphil* Boerl. *Youth Res. Apprenticeship Actiob Bogr.Rep.Soc. for Adv. Res.* 9 **P**.

Dhaliwal, G.S., Jaswant Singh and Dhaliwal, V.K. 1993. Potential of neem in insect pest management in rice. *World Neem Conf., Bangalore, India.* (Abstract) 16 **P**.

Dhaliwal,G.S., Pathak, M.D. and Vega,C.S.1990a. Effect of plant extracts of rice varieties on insect pests and predator complex of rice crop. *In National Symposium on 'Problems and Prospects of Botanical Pesticides in IntegratedPest Management.* 20. **PP**

Dhaliwal,G.S.,Pathak,M.D. and Vega,C.S.1990b. Effect of different fractions of stem distillate extracts of rice variety on brown plant hoppe and striped stem borer. *In National Symposium on 'Problems and Prospects of Botanical Pesticides in Integrated Pest Management*. 29.**PP**

Dhandapani, N., Rajendran, N.S. and Abul, K.A. 1985. Plant prodicts as anti-feedants to control insects.*Pesticides* **19**(11): 53-60.

Dilawari, V.K. and Dhaliwal, G.S.1992. Allelo-chemicals interaction between *Eruca sativa* Linn. and *Lipaphis erysimi* Kalt.*In Agro-ecosystems.*(Taro T and Narwal SS eds). 160-161 **PP**.

Epino, P.B. and Saxena, R.c. 1982. Neem, chinaberry and custard apple : Effect of seed oils on leaf and plant hoppers pests of rice. *Philip. Assoc. Entomol. Conv. Baguna, Philippines,* 23 **P**.

Garg, D.K. and Sachan SK.1992. Seasonal abundance of insect pests associated with soybean under hill conditions.*Journal of Applied Zoological Research,* **3**(1):68-70

Garg, D.K.1996. Certain parasites and predators of crop pests in hilly regions of Uttar Pradesh. *Journal of Applied Zoological Research,* **7**(1):55-56

Goswami, B.K. and Vijayalakshmi, K.1985.*In vitro* and pot culture studies on the effect of dry products of *Andrographis paniculata, Calendula officinalis, Ephydra fluctunus* and *Solanum khasianum* on *Meloidogyne incognita. Indian Journal of Nematology***, 15**(2): 264-266.

Goswami, B.K. and Vijayalakshmi, K.1986. Efficacy of some indigenous plant materials and non-edible oil seed cakes against *Meloidogyne incognita* in tomato. *Indian Journal of Nematology,***16:** 280-281.

Gupta, S.P., Prakash, A. and Rao, J. 1990. Bio-pesticidal activity of certain plant products against rice earhead bug, *Leptocorisa acuta* Thunb. *Journal of Applied Zoological Research,* **1**(2):55-58.

Hariprasad, Y. and Kanaujia, K.R.1992. Evidences of allelopathic chemicals in castor and maize against *Spilosoma oblique* Walk.*Proc. First Natl.Symp. Allelopathy in Agro-ecosystems.* 175-176 **PP** .

Heyde, J.V.d., Saxena, R.C. and Schmutterer, H. 1984. Effect of neem derivatives on growth and fecundity of rice pest,*Nephotettix virescens* Distt. *Bull. Soc. Entomol. Suisse* **57**(4):423.

Heyde, J.V.D., Saxena, R.C. and Schmutterer, H. 1985. Effect of neem derivatives on growth and fecundity of rice pest, *Nephotettix virescens* (Homoptera : Cicadellidae). *Zeitschrft fur pflanzenkrankhettan and pflanzenchutz* **92** (4): 346-354.

Ho, D.T. and Kibuka, J.C., 1983. Neem *(Azardirachta indica* A. Juss.) products for control of rice stem borers. *International Rice Research Newsletter,* **8**(5):15-16.

Hu,J., Yang,J. and Chen,L. 1983. A preliminary study on the antifeedant and toxic properties of China berry ,*Melia azardirach* Linn. seed oil against major insect pests of rice.*Scientia Agriculture Sinica,* 5:63-69.

Jacob, A., Bai, H.J. and Kuriyan, K.J.1990. Plant products as an alternate to nematicides for nematode management in banana.*Natl.Symp. on Problems and Prospects of Botanical Pesticides in IPM* at CTRI., 45-46 **PP.**

Jena, M. and Dani, R.C.1994. Effectiveness of neem based formulations against rice brown plant hopper, *Nilaparvata lugens. Oryza,* **31**(4):315-316.

Joshi, B.G, Ram, P.G. and Sitaramaiah, S.1978. Neem kernel suspension protects tobacco nurseries. *Indian Farming,* **28**(9):17-18.

Kareem, A.A. , Saxena, R.C. and Justo, H.D. 1987b. Evaluation of neem seed kernel and neem cake as pre-sowing seed treatment with paddy to afford protection against early stage pests and their effect on seed germination and seed vigor if any. *In Botanical Pest Control in Rice Based Cropping Systems.* 11 **PP**.

Kareem, A.A. Boncodin, M.E.M. and Saxena, R.C. 1988b. Neem seed kernel neem cake powder and carbofuran granules mixture for controlling green leaf hopper (GLH) and rice tungro virus (RTV). *International Rice Research Newsletter*,**13**(3) : 35.

Kareem, A.A. Saxena, R.C. and Justo, H.D. 1987a. Evalua tion of neem seed kernel (NSK) and neem bitters (NB) through seedling root-dip against rice green leaf hopper. *In Botanical Pest Control in Rice Based Cropping Systems.* 13 **PP**.

Kareem, A.A., Saxena, R.C. and Boncodin, M.E.M. 1988a. Effect of neem seed treatment on rice seedling vigour and survival on brown plant hopper (BPH) and green

leaf hopper (GLH).*International Rice Research Newsletter*, **13**(1):27-28.

Kareem, A.A., Saxena, R.C. and Boncodin, M.E.M. 1989b. Neem-carbofuran mixtures against *Nephotettix virescens* Dist. (Homoptera : Cicadelidae) and its transmission of tungro associated viruses. *Journal of Applied Entomology*, **108:** 68-71.

Kareem, A.A., Saxena, R.C., Boncodin, M.E.M. and Malaba. M.T. 1989a. Effect of neem seed & leaf bitters on oviposition and development of green leaf hopper (GLH) and brown plant hopper (BPH). *International Rice Research Newsletter,* **14**(6):26-27.

Kareem, A.A., Saxena, R.C., Boncodin, M.E.M. Krishnaswamy, C. and Sheshu, D.K. 1989c. Neem as seed treatment for rice before sowing : effects on two homopterous insects and seedling vigour. *Journal of Economic Entomology,* **82**(4): 1219-1223.

Khan, M.A.J. and Khan, R.J. 1985. Insecticidal effect of indigenous vegetable oils (*Taramira* and *Artemisia*) on some rice delphacids in Pakistan, *Pakistan Journal of Scientific and Industrial Research*, **28**(6): 428-429.

Kim,M., Koh,H.S.,Obota, T.,Fukami, M.and Ishii,S.1976. Isolation and identification of trans –aconitic acid as an antifeedant in barnyard grass against the brown plant hopper, *Nilaparvata lugens*.Stal. *Applied Entomology Zoology,* **11**(1): 563-570.

Krishnaiah, N.V. and Kalode, M.B. 1990. Efficacy of selected botanicals against rice insect pests under green house and field conditions. *Indian Journal of Plant Protection,* **18:** 197-205.

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.

Krishnaiah, N.V., Kalode, M.B. and Pasalu, I.C.,1990. New approaches in utilization of botanicals in rice insect pest control. *In National Symposium on Problems and Prospects of Botanical Pesticides in Integrated Pest Managemen, India* 17 **P**.

Krisnhaiah, N.V. and Kalode, M.B. 1984. Evaluation of neem oil cake and other edible oil cakes against rice pests. *Indian Journal of Plant Protection,***12** (92):104-107.

Kumari K, Sinha MM,Mehto DN and Hameed SF. 1990. Effect of vegetable oils as protectants against pulse beetle, *Callosobruchus chinensis* Linn. *Bull.Grain Tech,* **28**(1):58-60.

Lal L.1987. Studies on natural repellents against potato tuber moth,*Phthorimaea operculella* Zell. in country stores.*Potato Research* , **30**(2):329-334.

Lu, R.D.1982. A study of insect anti-juvenile hormones chemical composition of *Ageratum conyzoides* Linn. and its action against insect. *Insect Knowledge,***19** (4):22-25.

Mani, A., Kumudanathan, K. and Jagadish, C.A. 1990. Relative efficacy of neem oil and endosulfan against insect pests of mustard.*Neem News Lett,***7**(2): 129-131.

Mariappan, V., Jayraj, S. and Saxena, S.c. 1988. Effect of nonedible seed oils on survival of *Nephotettix virescens* (Homoptera : Cicadellidae) and on transmission of rice tungro virus. *Journal of Economic Entomology,* **85** (5):1369-1372.

Mariappan, V., Saxena, R.C. and Ling, K.C. 1982a. Effect of custard apple oil and neem oil on the life span of rice tungro virus transmission by *Nephotettix virescens*. *International Rice Research Newsletter,* **7**(3):13-14.

Mariappan, V., Saxena, R.C. and Ling, K.C. 1982b. Effect of custard apple and neem seed oils on the survival of *Nephotettix virescens* Distt. and its transmission to rice tungro virus. *Phillip. Assoc. Entomol. Conven. Baguina, Philippines.*, May, 1982 10 **P**.

Mariappan,V.,Jayaraj,S. and Saxena,S.C.1988.Effect of non edible seed oils on survival of *nephotettix virescens*(Homoptera:Cicadellidae) and on transmission of rice tungro virus.*Journal of Economic Entomology*, **85** (5): 1369-1372.

Marippan, V. and Saxena, R.C. 1983. Effect of custard apple oil and neem oil on survival of *Nephotettix virescens* and on rice tungro virus transmission. *Journal of Economic Entomology*, **76** (3):573-576.

Misra, S.S.1993. Potato pests and their management. *Journal of Appllied Zoological Research*, **4**(1):27-32

Mohan, K. and Gopalan, M. 1990. Studies on the effects of neem products and vegetable oils against major pests of rice and safety to natural enemies. **In:** *National Symposium on Problems and Prospects of Botanical Pesticides in Integrated Pest Management* 10-11 **PP**.

Mohan, K., Gopalan, M. and Balasubramanian, G. 1991. Studies on the effects of neem products and monocrotophos against major pests of rice and their safety to natural enemies. *Indian Journal of Plant Protection,* **19:** 23-30.

Mohanty,K .K., Chakraborty, D.P. and Roy, S.1988. Antifeedant activity of oil fractions of some leguminous plants against *Diacrisia oblique. Indian Journal of Agricultural Sciences,* **58** (7): 579-580.

Morallo-Rajessus,B. and Decena, A.1982. Isolation, purification and identification of the insecticidal principles from *Tagetes* spp. *Philippines Journal of Crop Science,* **7**: 31-36.

Morallo-Rajessus,B. and Eroles, L.C. 1978. Two insecticidal principles from marigold (*Tagetes* spp) roots. *Philippines Entomologist*, **4**(1/2):87-97.

Morallo-Rajessus, B. and Silva, D.1979.Insecticidal activity of selected plants with emphasis on marigold(*Tagetes* spp) and makabuhai(*Tinospara rumphii*). *NRCP Ann. Report for 1976,Univ. of Philipp. Los Banod, Mimeo, Philippines,* 25 **PP**.

Morallo-Rajessus,B.1982.Dept . of Entomology Univ. of Philippines Pers. Commn in Michael *et al*., 1985. Plant species reportedly possessing pest control properties. *An EWCIUH DATA BASE,Univ. of Hawaii***,** 249 **PP**.

Morallo-Rajessus,B.1984.Status and prospects of botanical pesticides in Philippines.IISEARCA

Conf.Chair Lecture, University of Philippines at Los Banos,College of Laguna, Philippines, 19 **PP**.

Murthy, K.S.R.K.1975. Biology and control of whorl maggot, *Hyderellia* sp. on paddy. *Rice Res. Sta., Bapatla (A.P.) Pers. Comm.* In: *Report of Directorate of Non-edible Oils and Soap Industries* (Ketkar, C.M ed), K.V.I.C., Bombay, India, 117-176 **PP**.

Nanda, N. K., Parija, B., Nanda, B., Dash, D.D. and Pradhan, N.C.1993. Bio-efficacy of neem derivatives against the paddy insect pest complex. *World Neem Conference,* 14 **PP**.

Narasimhan,V. and Mariappan,V.1988. Effect of plant derivatives on green leaf hopper (GLH) and rice tungro (RTV) transmissions. *International Rice Research Newsletter,* **13**(1):28-29.

Nelson, S.J., Sundarababu, P.C., Rajavel, D.S., Srimmannarayana, G. and Geetanjali, Y. 1993. Antifeedant and growth inhibiting effects of azardirachtin-rich neem fractions on *Sogatella furcifera* Horvath, *Spodoptera litura* Fabr. and *Helicoverpa armigera* Hubn. *World Neem Conference,* 10 **PP**.

Pandey, U.K., Srivastava, A.K., Chandel, B.S. and Lekha, C.1982. Response of some plant origin insecticides against potato tuber moth,*Gnorimoschema* operculella Zell. affecting solanaceous plants.*Z. fur Angewandte Zoology,* **69** (3):267-270.

Parmar, B.S. and Dev Kumar, C. 1993. Botanicals and Bio-pesticides.*Westvill Publishing House, New Delhi.,* 199 **PP.**

Parmar, B.S. and Gulati, K.C.1967. Synergists of pyrethrin-II: Karanjin.*Indian Journal of Entomology,* **31**(3):239.

Patel, H.R, Patel, D.J., Patel, C.C. and Thaker, N.A.1990. Affectivity of *Clerodendron inerme* Linn. and Periwinkle,*Catharanthus roseus*(Linn.) G. Don. for management of root-knot nematodes in okra. *Natl.Symp. on Problems and Prospects of Botanical Pesticides* 40-41**PP**.

Prakash A. and Rao J.1997. Botanical pesticides in agriculture.CRC Lewis Publs. Boca Raton, USA.481 **PP**.

Prakash, A. and Rao, J.1984. Wild sage leaves a paddy grain protectant in storage.*Oryza,* **21:**209-213

Prakash, A. and Rao, J.1986. Evaluation of plant productsas anti-feedant against the rice storage insects.*Proc. Symp. Resid. and Environt. Pollutioa.* 201-205 **PP**.

Prakash, A. and Rao, J.1989. Begunia leaves: a pulse grain protectant. *Indian Journal of Entomology,* **51**(2):192-195.

Prakash, A. and Rao, J.1994. Bio-deterioration of paddy seed quality due to insects and mites and its control using botanicals. *Annual Report of ICAR Ad-hoc Scheme (1993-1994),C.R.R.I., Cuttack, India,*.37 **PP**.

Prakash, A. Rao. and Jagadiswari, 2003. Management of rice storage incest. CRRI, Tech. Bull. 17, 4 **PP.**

Prakash, A., Rao, J., Gupta, S.P. and Binh, T.C.1989. Evaluation of certain plant products as paddy grain protectants against Angoumois grain moth. *Journal of Nature Conservation,* **1:**7-13.

Prakash, A., Rao, J., Pasalu, I.C. and Mathur, K.C.1987. Rice storage and insect pest management.BR Publishing Corpn. New Delhi. 337 **PP**.

Prakash, A., Tiwari, S.N. and Rao, J.1990. Exploitation of natural plant products for management of pests and diseases in rice ecosystems.*Proc. Symp.Growth, Dev. Resource Conserv.* 23-36 **PP**.

Premchanda. 1989. Presence of feeding deterrent in the velvet bean, *Mucuna cochinensis* Roxb. *Indian Journal of Entomology,* **51**(2):217.

Rajasekaran, B., Jayraj, S., Raghuramman, S. and Narayan swamy, T. 1987a. Use of neem products for the manage ment of certain rice pests and diseases.In: *Mid Term Appraisal Works on Botanical Pest Control of Rice Based Cropping System,* 13 **P.**

Ramraju, ,K. and Sundara Babu,P.C.1989. Effect of plant derivatives on brown plant hopper (BPH) and white backed plant hopper (WBPH) nymphs emergence in rice. *International Rice Research Newsletter,* **14**(5):30.

Ramraju, K. and Sundarbabu, P.C.1989. Effect of plant derivatives on brown planthopper(BPH) and white-backed planthopper(WBPH) nymphs emergence in rice. *International Rice Research Newsletter,* **14**(5):30.

Rao, R.S.V. and Srivastava, K.P.1985. Relative efficacy of neem formulations against gram pod borer.*Neem News Letter.,* **2**(3):28-29.

Rao,P.R.M. and Prakasa Rao,P.S. 1979. Effect of biocides on brown plant hopper adults on rice. *International Rice Research Newsletter,* **4**(3):20.

Reddy, G.V.P. and Urs,K.C.D.1988.Effect of plant extracts on brown plant hopper (BPH) oviposition. *International Rice Research Newsletter,* **13**(4):42.

Reddy, R.P. and Khan, RN.1990. Management of root-knot nematode infesting papaya by soil incorporation of some plant leaves. *Natl.Symp. on Problems and Prospects of Botanical Pesticides in IPM.* 42 **PP**.

Roy, D.C. and Pande, Y.D. 1991. Effect of *hyptis suaveolens* (L.) Poit. leaf extract on the population of *Lipaphis erysimi* Kalt. *IV Natl. Symp. on Growth, Dev. and Control Tech. of insect pests.* 37 **PP** .

Samalo, A.P. Senapati, B., Satpathy,C.R. and Jacob, T.J. 1990. Effect of neem derivatives on incidence of somI*Presented in National Symposium on Problems and Prospects of Banotanical Pesticides in Integrated Pest Manage ment* 16 **PP**.

Sasmal, S. 1991. Bionomics and control of pests of *Azolla pinnata* R.Br. *Ph.D. Thesis, Utkal University, Bhubaneswar, India,* 168 **PP**.

Satpathy, J.M. 1983. Plant Species Reportedly Possessing Pest Control Properties. *An EWC/UH DATA BASE, University of Hawaii,* 249 **PP**.

Saxena, R.C. and Boncolin, M.E.M. 1988. Effect of neem seed bitters (NSB) on green leaf hopper (GLH) feeding. *International Rice Research Newsletter,* **3**(1): 27.

Saxena, R.C. and Khan, Z.R. 1985a. Electronically recorded disturbance in feeding behaviour of *Nephotettix*

virescens (Homoptera : Cicadellidae) on neem oil treated rice plants. *Journal of Ecology and Entomology,* **78:** 222-226.

Saxena, R.C. and Khan, Z.R. 1985b. Effect of neem oil on survival of *Nilaparvata lugens* (Homoptera : Delphacidae) and on Grassy Stunt and Ragged Stunt Virus transmission. *Journal of Economic Entomology,* **78:** 647-651.

Saxena, R.C. Justo, H.B. and Epino, P.B. 1984b. Evaluation and utilization of neem cake against the rice brown plant hopper, *Nilaparvata lugens* (Homoptera : Diphacidae). *Journal of Economic Entomology,* **77 :** 502-507.

Saxena, R.C., Chiu, S.R., Mariappan, V. and Kalode, M.B. 1985. Evaluation and utilization of neem Azardirachta indica A.Juss) seed derivatives for management of rice insect pest. *International Rice Research Conference.* 30 **PP.**

Saxena, R.C., Epicnoc, P.B., Tu, C.W. and Puma, B.C. 1984a. Neem, Chinaberry and custard apple: antifeedant and insecticidal effects of seed oils on leaf hopper and plant hopper pests of rice. *Proc. II. Intn. Neem Conf., Rauisch- Holzhousen Castle FRG,* 403-412 **PP**.

Saxena, R.C., Justo, H.D. and Rueda, B.P. 1987. Neem seed bitters for management of plant hopper and leaf hopper pests of rice. *In Mid-Term Appraisal Works on Botanical Pest Control in Rice Based Cropping systems* 19 **PP**.

Saxena, R.C., Liquido, N.J. and Justo, Jr., H.D. 1979. Neem oil : an antifeedant to brown plant hopper. *Proc. X Ann. Conf. of the Pest Control Council of the Philippines held at Manila,* 25 **PP**.

Saxena, R.C., Liquido, N.J. and Justo, Jr., H.D. 1981a. Neem oil : a potential antifeedant for the control of the rice brown plant hopper, *Nilaparvata lugens, Proc. I.International Neem Conference* .171-188 **PP** .

Saxena, R.C., Waldbauer, G.P., Liquido, N.J. and Puma, B.C. 1981b. Effect of neem oil on the rice leaf-folder, *Cnaphalocrosis medinalis.* Proceeding I. *International Neem Conference,* 189-203 **PP**.

Saxena, R.C., Zhang, Z.T. and Boncodin, M.E.M. 1989. Effect of neem oil on courtship signals and mating behaviour of brown planthopper (BPH) female. *International Rice Research Newsletter,* **14** (6):28-29.

Schmutterer, H., Saxena, R.C. and Heyde, J. Von Der.1983. Morphogenetic effects of some partially purified fractions and methanolic extracts of neem seeds on *Mythimna separate* Walk. And *Cnaphlocrosis medi nalis* Guen. *Zeitschrift fur Agwandte Entomologie,* **95**(3):230-237.

Senthil Nathan, S., Choi, M.Y., Paik, C.H., Seo, H.Y., Kim, J.D. and Kang, S. M. 2007. The toxic effects of neem extract and azadiractin on the brown planthopper, *Nilaparvatha lugens* (Stal). *Chemosphere,* **67:** 80 – 88.

Senthil Nathan, S., Choi, M.Y., Paik, C.H. and Seo, H.Y. 2007. Food consumption, and detoxification enzyme activity of the rice leaffolder learvae after treatment with *Dysoxylum* triterphenes. *Pesticide Biochemistry and Pgysiology,* **88**: 260 – 267.

Sharma, I.N.S., Singh, A.K and Singh, S.P.1992. Allelopathic potential of some plant substances as anti-feedants against insect pests of jute.*Proc. First Natl. Symp.Allelopathy in Agro-ecosystems,* Indian Society of Allelopathy, HAU, Hisar, India.157-176 **PP**.

Sharma,V.K. and Bhatnagar,A.1990. Studies on the effects of non-edible seedoils on *Chilo partellus* Swinh. *In National Symposium on Problems andProspects of Botanical Pesticides in Integrated Pest Management* 19 **PP**.

Shelke, S.S., Jakhav, L.D. and Salunkhe, G.N.1987. Ovicidal action of some vegetable oils and extracts against storage pests of potato, *Phthorimaea operculella, Zell.Biovigyanam,* **13**(1):40-41.

Shi,Y.S.,Wang,W.P., Liao,C. and Chiu, S.F.1986. Effect of toosandanin on the sensory inputs of chemoreceptors of army worm larvae *Mythimna separate. Acta Entomologica Sinica,* **29**(3): 233-238.

Shukla, B.C., Kaushik, U.K. and Gupta, R. 1991. Field evaluation of botanicals for management of rice insect pests. *Proc. Botanical Pest Control Project. Phase-II, Mid-term Project Review Meeting, Dhaka, Bangladesh,* 39 **PP**.

Siddappaji, C., Kumar, A.R.V. and Gangadhar, R.1986. Evaluation of different insecticidal sprays against the chickpea borer, *Heliothis armigera* Hubn. *Pesticides,* **20:**13-16

Singh, J.R.,Sukhija, H.S. and Singh, P.1990. Evaluation of neem oil rice leaf-folder and stem borer. *In National Symp. on Problems and Prospects of Botanical Pesticides in Integrated Pest Management,* 19 **PP**.

Singh, K. and Sharma, P.L.1986.Studies on anti-feedant and repellant qualities of neem against aphid,*Brevicornye brassicae* Linn. on cauliflower and cabbage. *Research and Development Report,* 3**(1):** 33-35.

Singh, R.P., Singh, Y. and Singh, A.P.1990. Evaluation of neem oil against rice leaf folder and stem borer. . *Natl.Symp. on Problems and Prospects of Botanical Pesticides in IPM* at CTRI, Rajamundry (AP),India,21-22 Jan, 1990. 19 **PP.**

Singh, R.S. and Sitaramaiah, K.1971. Control of root-knot nematode through organic and inorganic amendments in soil.II.Effects of oil cakes and sawdust. *Indian Journal of Mycology and Plant Pathology,***1**(1):20-29.

Sinha, S.H.1993.Neem in the integrated management of *Helicoverpa armigera* Hubn. in chickpea. *World Neem Conference,* Bangalore. 6 **PP**.

Sivakumar, M. and Marimuthu, T.1986. Efficacy of different organic amendments against phytonematodes associated with betel vine.*Indian Journal of Nematology*,**16**(2):278.

Songkittisuntron, U. 1989. The efficacy of neem oil and neem extracted substances on the rice leaf hoppers *Nephotettix virescens* Dist. *Journal of National*

Research Council Thailand, **21**(2) : 37-48.
Sontakke, B.K.1993. Field efficacy of insecticide alone and in combination with neem oil against insect pests and their predators in rice. *Indian Journal of Entomology,* **55**(3): 260-266.
Sontakke, B.K.1993.Field efficacy on insecticides alone and in combination with neem oil against insect pests and their predators in rice.*Indian Journal of Entomology,* **53**(3):260-266.
Sukumaran,,D.,Kandaswamy,C. and Srimmannarayan, G.1987.*Vetex negundo* Linn.- a potential plant for control of rice pest. *Proc. Symp. Alternatives to Synthetic Insecticides* : 71-74.
Tripathi, A.K., Rao, S.M,, Singh, D., Chakraborty, R.B. and Bhakuni, D.S.1987. Antifeedant activity of plant extracts against *Diacrisia oblique* Walk.*Current Science,* **56**(12):607-608.
Velusamy, R., Rajendran, R. and Sundarbabu, P.C. 1987. Effect of three neem products on brown plant hopper (BPH) oviposition. *International Rice Research Newsletter,* **12**(2) :36.
Verma, A.C. and Anwar, A. 1995. Integrated nematode management by using leaves of medicinal plants in pointed gourd, *Trichosanthes dioca* in field. *In Natl. Symp. on Nematode problems of India-An Appraisal of nematode management with eco-friendly approaches and bio-compounds,* IARI New Delhi,24-26 march 1995. 18 **PP**.
Viswanathan, R. and Kandiannan, K. 1990. Effect of urea applied with neem cake on disease intensity and insect population in rice fields. *International Rice Research Newsletter,* **15** (5):20.
Wen,T.C.1983 Department of plant protection Jaingsu Acad. Sci. Nanging, China, Pers. Commn. in Michael *et al*., 1985.Plant species Reportedly Possessing Pest Control Properties.An *EWC/UH DATA BASE, University of Hawaii, 249* **PP**.
Yoshio, S., Noboru, M., Kiyomitsu, I., Chukichi, K., Susuma, K. and Takahashi, H.1982. Sterols and asparagin in the rice plant indigenous factors related to resistance against brown plant hoppers,*Nilaparvata lugens. Agriculture and Biological Chemistry,* **46** (12): 1877-1879.

Anand Prakash*, Jagadiswari Rao and V. Nandagopal
Central Rice Research Institute, Cuttack, -753006, India
**,Corresponding author. E-mail: prakas52@yahoo.com*