REVIEW OF LITERATURE
2.1 Effective Use of Plant Extracts Against Insect Pests.

Mane (1968) studied the efficacy of aqueous suspensions of neem seed kernels as antifeedants against the larvae of *Euproctis lanata* Walk., *Spodoptera litura*, *Utehesia pulcchella* L. and the adults of *Acrida exultala* Walk. and *Aulaccophora fovicollis* Lucas. are the leaf feeding pests. In tests with neem seed suspension spray against *Euproctis lanata*, it was found that absolute protection to castor leaves could be offered at 5 per cent concentration. In *Spodoptera litura* it was effective against third instar larvae in reducing the feeding to the extent of 79.2 per cent. Repellent action was also observed to be effective against *Utehesia pulcchella*. Rajendra and Gopalan (1979) reported the insecticidal activity of acetone extracts of *Acorus calamus* L. Garlic, *Datura stramonium* and *Ocinum sanctum* L. by topical application to fifth instar nymphs of *Dysdercus cingulatus*, third instar larvae of *Spodoptera litura* and *Pericallia ricini*. Extracts from all the four plants caused significant mortality in *Spodoptera litura*. Garlic was found to be most effective by giving 90.05 per cent mortality at 50 µl/larvae. *Datura stramonium* at 50 µl per nymph causes 95 per cent mortality to *Dysdercus cingulatus* and high concentration (250 µg/larvae) caused 75 per cent mortality to *Spodoptera litura*.

*Parthenium hysterophorus*, a noxious and highly persistent weed, has been reported to possess antifeedant property when assayed on the third instar larvae of *Spodoptera litura* (Gajendran and Gopalan, 1982). Azadirachtin isolated from neem causes some disruption in behavior and development, besides exhibiting strong antifeedant activity to *Heliothis zea* Boddie. and *Spodoptera frugiperda* Smith. Kubo and Klocke (1982) also found inhibition of larval ecdysis in *Heliothis zea* *S. frugiperda*, *Heliothis virescence* Fab. by
azadirachtin. Methanolic extracts of neem seed kernels exhibited strong antifeedant and growth regulator activity. A positive correlation was found between the age of the residues and the mean percent of living larvae, larval weight and the pupal weight, (Meinser et al., 1983). Sayed (1983) reported that the treatment with neem seed extract from 0.2 to 0.5 per cent concentration caused 100 per cent mortality of first to fifth instar larvae of Spodoptera litura. Larval treatment also caused pupal mortality and adult deformities. Eggs dipped in neem seed suspension failed to hatch. Kumar et al., (2003) the studies demonstrated that, the biological efficacy of eight commercial neem formulations (CNFs) was investigated in two separate studies. The assays were conducted against second instar larvae of diamondback moth, Plutella xylostella, at different time of intervals from the date of manufacture of formulations.

Tripathi and Rizvi (1985) found crude extract of Ailanthus excelsa Roxb., Juiperus recurva Buch., Clerodendron infortanatum L. and Hibicus sabdariff L. possess the antifeedant activity against Bihar hairy caterpillar. According to Chockalingam et al., (1986), excelsa offered 89.67 per cent protection to the crop from Diacrisia oblique Walk. Extracts of Eucalyptus leaves prolonged the larval duration of Spodoptera litura by two days when fed with the castor leaves treated with 300 and 400 ppm of the extract. Aqueous extract of neem seed kernels and pepper fruits caused deterrent and antifeedant effect against Ootheca bennigseni Wseise., larvae of Maruca testulalis Greyer and Heliothis armigera (Hongo and Karel, 1986). Oleic and linolic acid in the seed oil of Datura aldawees, Brassica lattifolia L., Polyalthis longifolia, and Annona squamosa L. possesses antifeedant activity against Spodoptera litura (Kumar and Thakar, 1988). Clerodane deterpenoids from labiate plants found to possess antifeedant property against
Spodoptera littoralis and Heliothis armigera (Simmonds et al., 1989). Aqueous and alcohol extracts of Euphorbia sps. and Ipomoea carnea exhibited antifeedant activity to larvae of Spodoptera litura (Mani et al., 1990). Patel et al., (1990a) found that a commercial neem product, Neemguard causes high degree of antifeedant action to Amsacta moorei Buttl., but neem seed suspension spray at 5 per cent inflicted significantly higher mortality (44%) of Amsacta moorei. Custard apple leaf extracts caused 32.22 per cent mortality of larvae while Calotropis procera L., Argemoni maxican L., Catharanthus roseus L. and Datura suaveolens L induced higher larval mortality than neem (Patel et al., 1990b). According to Devaprasad et al., (1990) methanolic fraction of Allium sativum L., Ocimum sanctum L., Acorus calamus L., neem seed kernel and ethanolic extracts of Tribules terrestris L. resulted morphological deformities in Spodoptera litura. The results of Koshiya and Ghelani (1990) reflect the antifeedant activity in different plant extracts against the third instar larvae of Spodoptera litura. Leaf and seed extracts of neem and karaṇja seeds were highly effective at 15 and 5 per cent concentration compared to other botanical tested. Sesquiterpine polyester from Celastrus angulatus L. had strong insecticidal and antifeedant effects against Heliothis armigera, Aphis gossypii G. and Pieris rapae L. (Wang et al., 1991). Neem rind and neem seed kernel extract proved maximum protection to chickpea damage by preventing the feeding by Heliothis armigera, and thus enhanced yields (Dubey et al., 1991). Anwar et al. (1992) reported that Azadirachta indica leaf powder fed to Heliothis armigera caused failure of pupation and adult emergence. Extract of Podocarpus nagi L. caused feeding deterrence, reduced growth and pupation in Heliothis virescenc (Zhang et al., 1992).
Crude extracts of the roots of *Inula recemosa* Hook. and *Saussurea lappa* Clark. at 0.025 to 5 per cent significantly reduced the damage by larvae of *Spodoptera litura*, caused mortality of larvae to 50 per cent and pupation was affected adversely at highest concentration (Bhatalal et al., 1993). The methanolic extract from *Coptis chinensis* Salisb. showed a potent larvicidal activity against *Plutella xylostella* (Kwecow et al., 1994). Seed extracts of three non meliaceae plants, namely custard apple, jatropha, and mahua were evaluated in comparison with a commercial neem formulation individually and combinations on bollworms *Earias vitella* Des, *Heliothis armigera* and *Spodoptera litura* under laboratory conditions. All the extracts affected the test larvae by direct or interference with metamorphosis both, individually and in combinations. Among the test spices of *E. vitella* and *Heliothis armigera* were more susceptible than *Spodoptera litura* (Ganesan et al., 1995).

### 2.2 Use of Botanical Pesticides in Mosquito Control

In recent years, several plants have been tested and found effective especially against mosquitoes of different species in India as well as in other countries (Patterson et al., 1975; Cupp et al., 1977; Angerilli, 1980; Zebitz, 1984; Patil, 2003).

Extract from more than 325 different plants have been tested for their efficacy on larvae of *Aedes aegypti* and from these initial tests, 16 plants were selected and further studied for their biological activity (Patterson et al., 1975). The isolation and characterization of plant compounds having properties similar to insect hormones have also been suggested for their possible use in control of mosquito population (Bowers et al., 1966; Russell and Fenemore, 1971). Supavarn et al., (1974) using the methanol extracts of plant species from
seventeen families, found that in addition to acute toxicity, compounds from several of these plants significantly lengthened larval and pupal development period of *Aedes aegypti* and suggested that this might be due to interference with normal hormonal activity. Spielman and Lemma (1973) noted that a butanol extract of the soapberry plant (*Phytolacca dodecandra*) was active against larvae of *Aedes aegypti, Culex pipiens, Culex molestus* and *Anopheles quadrimaculatus*. The effects of 6, 7-dimethoxy-2, 2-dimethyl chromene (prococene II), a botanical derived compound, on primaginal development in *Aedes aegypti* were determined by exposure of eggs, larvae and pupae. The results revealed that, newly hatched larvae when exposed to doses ranging from 2 to 4 ppm prevented adult emergence, fourth instar larvae when exposed to doses 1 to 10 ppm inhibited pupation, pupal and egg stages were found insensitive to concentrations up to 10 ppm (Cupp *et al.*, 1977). A study was designed to measure the toxicity of certain species of aquatic vegetation extracts against mosquito larvae and to measure the influence of these same extracts on mosquito oviposition behaviour (Angerillis and Beirne, 1974). Extracts of eight species of freshwater vegetation were tested for toxicity against larvae of *Aedes aegypti* L. and all extracts were reported to be toxic (Angerilli, 1980). The efficacy of 38 indigenous species of seeds were evaluated for their mosquito larvicidal potential in the laboratory and seven of them (*Capsella bursa-pastoris, Descurainia sophia, Eruca sativa, Prunella vulgaris, Saliva moorcroftiana, Cardamine hirsuta, Blepharis edulis*) were found to be effective in trapping and killing the larvae of *Culex quinquefasciatus* and *Aedes aegypti* (Sharma and Wattal, 1982). Petroleum ether extracts of ten indigenous plants (*Vinca rosea, Lencus aspara, Clerodendron inerme, Pedalium murax, Tumera ulmifolia,*)
Parthenium hysterophorus, Rauwolfia canescens, Croton sparsiflorus, Calotropis and Adathoda species) were studied for the larvicidal activity against the colonized strains of Culex quinquefasciatus, Anopheles stephensi and Aedes aegypti. Among these Croton sparsiflorus showed 100 per cent mortality even at 1 ppm, while extracts from other plants were effective only at higher concentrations ranging between 50 and 100 ppm (Kalyanasundaram and Das, 1985). Different concentrations of hot and cold water extracts of castor (Ricinus communis) leaves were tested against Anopheles stephensi, Culex fatigans and Aedes aegypti and reported that at 119 ppm of the active compound vicinin, the solution exhibited 100 per cent ovicidal and larvicidal activity, but not adulticidal activity (Vasudevan et al., 1989). The methanol extract of Ageratum conyzoides was used against preimaginal stages of Anopheles stephensi and deformities in the development were reported (Saxena and Saxena, 1992). Effect of acetone extract of Ocimum sanctum leaves against fourth instar larvae of Anopheles stephensi at different dosage levels were studied. At low levels prolonged larval stage with the pupae being intermediate forms and at high levels larvae did not complete their development and died (Bhagat, 1992). The effect of secondary plant metabolites especially alpha terthienyl, exerting phototoxic action in Aedes aegypti through inhibition of certain enzymes and generation of singlet oxygen was studied and reported (Nirsarkar et al., 1992). The toxicity of powdered seeds of the soapberry plant, Phytolacca americana, for Anopheline and Culicine larvae was tested under laboratory conditions and powder appeared to be effective against Anopheles gambiae at dosages lower than 400mg/litre (Torre et al., 1992). Alkaloids isolated from Annona squamosa showed larvicidal growth regulating and chemosterilant activities against Anopheles stephensi at
concentrations of 50 to 200 ppm and 52-92 per cent mortality was reported (Saxena et al., 1993). The toxic effects of plant hydrocarbon and saponin preparations were studied in comparison with dimethoate against the fourth instar larvae of Culex fatigans. The LC$_{50}$ was 11.5 ppm for the hydrocarbon, 58 ppm for saponin and 46 ppm for dimethoate (Tabassum et al., 1993). The petroleum ether extract of Ageratum conyzoides was used to observe its antijuvenile potential on the development of Culex quinquefasciatus. Concentration of 10 ppm caused 100 per cent mortality of the fourth instar larvae (Saxena et al., 1994). In a report whole plant soxhlet extractions for the three Tagets species showed that the Tagets minuta extracts provided LD$_{90}$ for 4 and 8 ppm against Aedes aegypti by Perich et al (1994). Kumari et al., (1994) reported that crude extract of Ocimum sanctum at various dilutions in acetone showed insecticidal activity on the formation of pupae and on the emergence of Aedes aegypti and resulted in 90 per cent mortality at 1400 ppm. Application of Tagets minuta floral extract to silica gel chromatography produced 2 fractions with the hydrogenate part was 20-30 times more toxic to larvae and 12-13 times more toxic to adults of Aedes aegypti and Anopheles stephensi respectively than the oxygenate part was reported by Perich et al., (1994). It was reported that the alcoholic and phenolic constituents of essential oils of Mentha piperita, Acorus calamus, Anethum sowa, Piper nigrum, Pongomia glabra and Azadirachta indica were considerably toxic to egg hatching of Aedes aegypti (Singh and Upadhyay, 1993). Extracts of stilt root samples of Rhizophora apiculata were studied for mosquito larvicidal against Aedes aegypti and reported by Thangam et al., (1994). Larvicidal activity of partially purified extracts of leaves of Vitex nigundo, Nerium oleander and seeds of Syzygium jambolanum on different instars of Culex
*Culex quinquefasciatus* and *Anopheles stephensi* was estimated and reported considerable larval mortality by Pushpalatha and Muthukrishnan (1995). Laboratory studies were conducted with the crude ethanolic extract of *Cannabis sativa* an indigenous plant, to evaluate its insecticidal properties against the larval stages of *Anopheles stephensi*, *Culex quinquefasciatus* and *Aedes aegypti* mosquitoes. A concentration of 4.0 percent induced 100 per cent mortality in all the 3 species in 24 hours of exposure (Jalees *et al.*, 1993). Neem plant is one of the well-known, insecticidal plants. Till now studies on toxicity of different parts of neem plant have been reported (Attri and Prasad, 1980; Zebitz, 1984; Chavan and Nikam, 1988; Sagar and Sehgal, 1997; Murugan *et al.*, 1996; Boschitz and Grunewald, 1994; Sinniah *et al.*, 1994; Sharma, 2001; Nagpal, *et al.*, 2001; Mitchell *et al.*, 1997). "Neem oil extractive" a waste from neem oil refining was found to be an effective mosquito larvicide, causing complete failure of the first instar larvae of *Culex fatigans* to emerge successfully as adults at 0.005 per cent concentrations (Attri and Prasad, 1980). Bioassays against fourth instar larvae of *Aedes aegypti* were conducted with neem seed kernel extracts obtained by extraction with water and organic solvents and results showed a conspicuous growth disrupting effect (Zebitz, 1984). Antipupational effect of neem oil and neem seed kernel extract (NSKE) was evaluated against *Anopheles stephensi* and found that neem oil (5%) was more effective than NSKE resulting 99.3 per cent and 65.9 per cent mortality respectively (Murugan *et al.*, 1996). Acetone extract of neem seed coat was used against *Aedes aegypti* and *Culex quinquefasciatus* to assess its toxicity, growth regulating capacity and impact on hatchability. A concentration of 20 ppm and 40 ppm causing 100 per cent
mortality in first instar larvae of *Culex quinquefasciatus* and *Aedes aegypti* was reported by Sagar and Sehgal, 1997.

### 2.3 Efficacy of Botanicals under Field Conditions Against Lepidopterous Pests.

Asari and Thomas (1974) examined the effects of aqueous extract of five available plant materials against brinjal pests. They found that none of the extracts were effective against fruit borer and leaf roller, but an extract lemon grass prepared by grinding 10 grams of green leaf in one litre of water caused statistically significant reduction in aphid population at 5 per cent concentration.

Attri (1975) compared the antifeedant properties of neem oil extract, a byproduct of the refinement of neem oil for soap or pharmaceutical purposes, and water extract of neem seed kernel. He found that water extract exhibited the feeding *Schistocerca gregaria* Fab. on the sprayed host plants. The active substance present in neem seed was hydrophilic in nature. So absolute deterrency was achieved at as high as two per cent oil extract as against, as low as 0.05 per cent with water extract of the kernel.

Aqueous neem extracts at 0.1 per cent gave good protection to onion crop from *Liriomyza trifolii* Burgess (Fagoonee and Toory, 1984). Neem seed kernel extract, neem oil and honge oil when applied to bengal gram against *Heliothis armigera* at 3 and 5 per cent concentrations resulted in lowering pod damage to be 0.05 and 3.10 respectively compared to 7.45 per cent in untreated check. However, yield remained unaffected (Kumar and Sangappa, 1984). Ethanolic extract of neem seed kernel lowered the incidents of *Heliothis armigera*, *Maruca testulalis* and *Melanagromyza obtusa* Malloch on pigeon pea. The extract offered less protection to pods as compared to fenvalerate against lepidopterous borers (Singh and Singh, 1985). Sachan and Lai (1990) opined that neem seed kernel
extract and neem leaf extract has good scope for controlling *Heliothis armigera* on chickpea than on pigeon pea. In three successive field evaluation carried out at MRS, Dharwad, Margocide C. K at 0.7 per cent emerged as most effective formulation than Margocide O. K, and neem leaf extracts introducing leaflet damage by defoliators (Anonymous, 1994b).

Repelin was found effective when applied at 1.5 per cent at ten days interval synchronizing with flower initiation, 50 per cent flowering and pod maturity of medium duration pigeon pea crop. This treatment could reduce the pest to a tune of 1.3 eggs/5 twigs, 5.3 larvae/5 plants and 7.9 per cent bored per pods. The untreated control recorded 9.0 eggs, 15 larvae and 20.67 per cent bored pods. Its efficacy also reflected in grain yields (8.3 Q/ha) with an increase of 3.2 q/ha over untreated check (Trumala and Venugopal, 1990). Aqueous extract of neem seed kernel at 4 and 5 per cent concentrations recorded significant reduction of diamond back moth. Long term use of extracts for the management of insecticide resistance strain of *Plutella xylostella* under IPM programme is possible (Srinivasan and Moorthy, 1993). Combination of neem with synthetic insecticides (deltamethrin, methaudophos and cypermethrin) exhibited higher larval mortality of *Plutella xylostella* (Facknath, 1993).

2.4 Use of Botanicals Against Castor Semilooper, *Achaea janata* L.

Active principle lycorine from the plant *Hymenocallis littorallis* Salisb possesses antifeedant properties against *Achaea janata* (Singh and Pant, 1978). Jamil *et al.*, (1984) assayed the petiole extract of water hyacinth against *Achaea janata* and *Dysdercus cingulatus* Fab. No detectable effects on moulting were observed when larvae and pupae of *Achaea janata* were treated topically, but it prevented moulting fifth instar nymph into adult *Dysdercus cingulatus* Fab.
According to Chari and Muralidharan (1985) neem seed kernel suspension at 2, 3 and 5 per cent and neem leaf suspension at 5 and 10 per cent concentrations exhibited antifeedant activity to fourth instar larvae. Acetone extracts of black pepper (Piper nigrum) seeds caused morphogenic effects in final instar of Achaea janata (Osmani et al., 1987).

Effect of injected azadirachtin to two lepidopterans, Achaea janata and Spodoptera litura Fab. was studied by Rao and Subrahmanyam (1987). The effective dose was 4.1 and 1.1 µl/g gram body weight of Achaea janata and Spodoptera litura, respectively. Larval and pupal periods were unaffected. Fecundity of Achaea janata was reduced to half. Deshpande et al., (1988) studied the effect of acetone extract from Catharanthus roseus Forsk. on growth and development of Heliothis armigera Hub. Spodoptera litura and Achaea janata. Higher larval mortality of neonatal larvae was recorded, when exposed to 500-ppm concentration. There was significant decline in percent pupation and normal adult emergences in all the three species while fourth instar larvae of Achaea janata and Heliothis armigera were least susceptible to extracts, those of Spodoptera litura succumbed completely.

Plant extract of Annona reticulata, Vitex nigundo, Diospyros montana Roxb. and Azadirachta indica were reported to possess insecticidal property against Achaea janata (Grainge and Ahmed, 1985). Phadnis et al., (1988) isolated two Clerodane type diterpenoids with antifeedant properties against Achaea janata. Oil from Trachyspermum and Cedrus deodara Roxb. acted as antifeedants against Achaea janata (Tare and Sharma, 1958). Prakash et al., (1989) tested several semisolid crude plant extracts isolated by soxhlet extraction with solvents against the third instar larvae of Achaea janata at 1000 and 500-
ppm concentrations. Among them, products from *Azadirachta indica* seeds vemidin and neemol, exhibited absolute antifeedant activity. The per cent protection afforded against *Achaea janata* by azadirachtin was dependant on concentration (Ramachandran *et al.*, 1989). Acetone extracts of *Cassina glauca* Rottb. exhibited good antifeedant activity and fractionation and sub-fraction narrowed down the ingredient and enhanced the effective dose (Deshpande *et al.*, 1990). Extracts of *Leucas cephalotus* Spreng, *Pogostemon parviflorus* Benth. *Pogostemon parparasiens* Dail. and *Salvia plebia* showed antifeedant activity against *Achaea janata* (Sharma *et al.*, 1992).

Cold alcohol extract of *Clerodendron inerme* exhibited up to 95 per cent mortality in *Achaea janata*. However, dilution of these extracts in water resulted total failure of the biological effects. Thus, it is apparent that water medium detoxifies or inactivates the active molecules responsible for inducing adverse effects on test insects (Holihosur *et al.*, 1996a). They also noticed that petroleum ether extract from leaves of *Clerodendron inerme* and stem of *Bouganvillea glabra* Choisy. contained highest ovicidal activity causing failure of hatching in 85 per cent of eggs. The products when injected were totally ineffective to induce larval mortality. *Clerodendron inerme* leaf dust proved to be the best effective formulation causing 95 to 100 per cent mortality of fifth instar larvae. Impairment, growth and development by causing abnormalities in pupal and adult stages reflected juvenile hormone mimic activity in the formulation (Holihosur *et al.*, 1996b). Water extract from neem seed kernel at 5 per cent, *Citrullus colocynthus* 10 per cent and *Datura stramonium* L. leaves 10 per cent were found to be most promising in protecting the leaf damage from *Achaea janata* (Dodia *et al.*, 1995).
According to Schmutterer (1990), who reviewed the information on properties and potential of neem based natural pesticides; the neem derivates could be very suitable for integrated pest management. They are primarily feeding poisons for nymphs/larvae of phytophagous insects, and therefore, they show a considerable selectivity towards natural enemies of pests. Neem products can be mixed with other byproducts or with synergists to increase their efficacy, if necessary. Phadnis et al., (1988) isolated two Clerodane-type diterpenoids with antifeedant properties against Achaea janata from the leaves of Polyalthia longifolia. Leaf and stem extracts of Clerodendron inerme and stem of bracts of Bougainvillea glabra have exhibited around 87 per cent mortality in Achaea janata. While leaf extracts of Clerodendron inerme exhibited antifeedant, repellent and JH mimic activity, leaf powder interfered the moulting process resulting in 95 per cent larval mortality. Flower and root extracts of Clerodendron inerme and bract and stem extracts of Bougainvillea glabra have also shown ovicidal effect (Holihosur et al., 1993). Singh and Jalali, (1994) reported that the oil of Taramira, coconut, sunflower, safflower and castor were found to check the egg laying of pulse beetle on gram seeds. It normally delayed the developmental period of the insect by 6 to 14 days. Swarna Dhingra (1998) evaluated the relative toxicity of emulsions of various pyrethroid and nonpyrethroid insecticides against the larvae of Achaea janata L. On the basis LC₅₀ values, cypermethrin, deltamethrin, fenpropathrin, fenvalerate, methylparathion and pyrethrin respectively were more toxic than endosulphan. A comparison of the relative resistance based on LC₅₀ value of Achaea janata, Spilosoma obliqua Walk. and Spodoptera litura Fab. to insecticides indicated higher susceptibility of Achaea janata amongst these three pests.
Mechanical extracts of green leaves of lantana, sanhund, aloe and the ether extract of dried rhizomes of sweetflag (Pandey et al., 1977) were tested for their antifeedant, repellent and insecticidal properties against third instar larvae of mustard sawfly. The antifeedant and repellent activity of sweetflag at 0.5 and 0.1 per cent proved best and treated leaves were not even nibbled by starved larvae. Strong contact toxicity was also observed in case of sweetflag. Meisner and Mitchell, (1983) reported that the methanol fraction of the leaves Thalspi arvense and Lunaria annua plants deterred feeding when added to the surface of acceptable radish leaves against striped flea beetle, Phyllostreta striolata. Saponins in both the plants are highly deterrent. Effect of powdered rhizomes of Acorus calamus at 1 per cent level (w/w) proved complete protection in initial testing and after 2 months of storage by Harish Chander and Ahmed (1986). Powdered leaves of Clerodendron inerme, Tylophora asthmatica, Justicia betonica and Cestrum nocturnum were the next best for reducing adult emergence at 2 and 5 per cent levels.

Murali Baskaran et al., (1997) reported that the fourth and fifth instar larvae of Spodoptera litura were treated with 10 per cent aqueous extract of Tribulus terrestris L. to study the influence on larval biomass and virus yield produced in vivo. Variation in the efficacy in deltamethrin formulated alone and in combination with five non-toxic vegetable oils, viz., sesame, karanj, neem oil, citronella oil and piperonyl butoxide in four ratios (1:1, 1:2, 1:4, 1:8) was evaluated against the adults of Tribolium castaneum by Sridevi and Dhingra (2000). All the vegetable oils showed synergistic effect except neem oil, which exhibited additive effect. Raman et al., (2000) reported that field evaluation of custard apple (Annona squamosa L.) and neem (Azadirachta India A. Joss)
formulations against castor semilooper (*Achaea janata* L.) indicated that reduction in the larval population. The activity of botanicals decreased to some extent three days after treatment.

Chimbe and Galley (1996) reported that dried and powdered tissue from 12 Central African plants of medicinal importance in Malawi proved to be protectants against stored grain against insects. Chen *et al.*, (1996) suggested that the effect of chinaberry fruit extracts on land mortality, feeding inhibition and reproduction on the diamond back moth, *Plutella xylostella* L. The larvae usually died from failure in moulting. Fecundity of the resulting females from the larvae treated with 0.5% extract was also reduced. The extracts significantly decreased egg hatching when the eggs were dipped directly into test solutions at 1.0% or above. Antifeedant and insecticidal activities of neem, garlic and datura plant part extract (Chauhan and Qudri, 1989) were tested against okra fruit borer. Highest efficacy of neem, garlic, and datura extracts was obtained at 1250, 2000 and 2250 ppm concentration.

Mathur *et al.*, (1990) reported that Karanjin treated third instar larvae of flesh fly, *Sarcophaga ruficornis* manifested three types of morphogenetic forms viz., larval-pupal intermediates, pupal-adult intermediates and deformed adults. With increase in concentration of Karanjin (2000-3500 ppm), more larval mortality and few pupal intermediates were obtained at lower concentration (1000-2000 ppm) the percentage of pupal-adult intermediates and deformed adults were more pronounced. The preparation from 35 plant species proved to be effective against the potato tuber moth, *Phthorimaea operculella* either in the storage (non-refrigerated) or in the laboratory was reported by Das (1995).
Preliminary investigations with ethanolic extracts from four Nigerian plants (Ewete et al., 1996) *Piper guineense*, *Cedrela odorata* L., *Dennettia tripetala* G. and *Aframomum melegueta* in artificial diets significantly reduced larval growth of European corn borer, *Ostrinia nubilais* Huber. A post digestive toxicity of the extract *Pipper guineense* and *Cedrela odorata* extracts showed the best potential for development as botanical insecticides.

Baskaran and Janarthanan (2000) reported that the effects of dust formulations of certain plant were evaluated on the development of *Sitotroga cerealella* and *Callosobruchus chinensis* on paddy and cowpea in storage. Complete protection to cowpea seeds was observed as evidence by no adult emergence and weight loss. Prospectives of botanical and microbial products as pesticides were reported by Jaya Verma and Dubey (1999). Their efficacy in management and merits over the existing synthetic pesticides has also been studied.

Opender Koul (1985) reported the azadirachtin showed disrupted growth more severely when given along with foliage to early larval instars of *S. litura* Fab growth regulatory activity was observed. Ramanathan et al., (1997) reported the effect of leaf extract on *Pongamia glabra* (Fabaceae) on histological changes of fat body of *Periplaneta americana* (Linn) adult male. Baldwyn et al., (1992) found that six amide alkaloids of *Piper guineense* were tested for antifeedant activity against fifth instar larvae of *Chilo partellus* in choice assays. The results suggested that the presence of a methylene dioxybenzene and an alicyclic amide group in the compound might be crucial for high antifeedant activity. Insecticidal properties of rhizomes of sweetflag, *Acorus calamus* against rice weevil, *Sitophilus oryzae* Linn. The petroleum ether and alcoholic extracts of rhizomes of
sweetflag were made separately by cold method proved to be high contact toxicity.

Rao and Sharan Dhingra (1997) reported the synergistic activity of some vegetable oils in mixed formulations with cypermethrin against different instars of *Spodoptera litura* Fab. Srimmannarayana and Raghunatha (1985) reported, certain plant chemicals may not be possessing insecticidal principals but positively possess antifeedant properties. The antifeedant property is also useful to control agricultural pests.

Saxena (1983) reported that the pesticides would remain indispensable to avert crop losses caused by pests. Due to use of synthetic pesticides the residual problem, detrimental effects on non-target organisms, including man, was observed. Naturally occurring pesticides of plant origin or microbial origin was proved to be better for insect pest management. Pandey *et al.*, (1976) proved that use of some plant powders and oils like neem, sweetflag, leaves of adhatoda and sadabahar showed protectants and repellent property against pulse beetle. Roy Choudhury (1993) reported the chloroform extracts of *D. podocarpa* and the methanol extracts of *C. siphonanthus* appeared to be the best effective antifeedant and insecticidal chemicals against the adults of *Sitophilus oryzae* (Linn).

The growth and development and reproductive potential of an insect depend on food consumption and utilization. Ayyangar and Rao (1989) reported that the effect of azadirachtin altered the midgut enzymes of *Spodoptera litura* (Fab). Change in haemolymph constituents of *Spodoptera litura* under the influence of azadirachtin was reported by Ayyangar and Rao (1990). The lack of difference in the concentration of haemolymph constituents between untreated
(normal) and alcohol treated (control) larvae clearly showed that alcohol does not have any adverse effect on the insect. Duke (1995) reported synergies among natural pesticides make them more efficacious than solitary synthetic "bullets", synergic mixes should be the pesticides of the future. Such pesticides could be economically attractive and environmentally advantageous.

2.5 Early Work on Insecticidal Properties of Clerodendron Species

There have been few reports published on the use of Clerodendron inerme extracts against insect pest. Harish and Ahmed (1986) have reported the effective use of leaf powder of Clerodendron inerme against rice moth, Corcyra cephalonica, Staint. as antifeedent. An antifertility effect of Clerodendron siphonathus against Callosobruchus chinensis has been demonstrated (Pandey and Khan 1998, 1999, 2000). The chemical constituents of Clerodendron species have also been examined (Bhakuni et al., 1962; Goswamy and Kotoky 1995). Clerodendron inerme cold alcohol extract (10%), dust 5% Neemguard (0.3%) established superiority in suppressing early, late and mixed population of Achaea janata. Though yield was no par, highest C:B ratio (1:5.75) was recorded with Clerodendron inerme 5%, dust compared to neem based products (Basappa, 1995). The active component, Clerodin has been identified (Choudhary and Datta, 1951; Goswamy and Kotoky 1995). Clerodendrin A and B have been identified as deterpine compounds from Clerodendron extract which work as antifeedants and insecticidal activities have also been ascertained (Kato and Munakata, 1972; Manukata, 1977; Kato et al., 1973; Hosozawa et al., 1974; Ahmed, et al., 1978; Tripathi and Rizvi, 1985 and Roy Choudhary, 1994).