REVIEW OF LITERATURE
2.1 Use of Botanicals Against Castor Semilooper *Achaea janata* L.

Active principle lycorine from the plant *Hymenocallis litoralis* 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 Rao and Subrahmanyam (1987). The effective dose was 4.1 and 1.1 µl/gram body weight of *A. janata* and *S. litura*, respectively. Larval and pupal periods were unaffected. Fecundity of *A. janata* was reduced to half. Deshpande *et al.*, (1988) studied the effect of acetone extract from *Catharanthus roseus* Forsk. (Celastraceae) 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 per cent pupation and normal adult emergence 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, 1988). 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 extracts 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.*, 1996 a). 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.*, 1996 b). Water extract from neem seed kernel at 5 per cent, *Citrullus colocynthus* 10 per cent and *Datura stromonium* L. leaves 10 per cent were found to be most promising in protecting the leaf damage from *Achaeza 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 bioproducts or with synergists to increase their efficacy, if necessary. Phadnis *et al.* (1988) isolated two Clerodane-type diterpenoids with antifeedant properties against *Achaeza 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 *Achaeza 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 *et al.* (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 pyrethroids and nonpyrethroids 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* Wlk. and *Spodoptera litura* Fab. to insecticides indicated higher susceptibility of *Achaea janata* amongst these three pests.

Mechanical extracts of green leaves of lantana, sanhund, sukhadarshan and aloe and the ether extract of dried rhizomes of sweetflag (Pandey et al., 1977) were tested for their antifeeding, 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, *Phyllotreta 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 of 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 (DBH), 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 hatch 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 (Earias vittella). 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 five Nigerian plants (Ewete *et al.*, 1996) *Piper guineense* Schum and Thonn (Piperaceae), *Cedrela odorata* L. (Meliaceae), *Dennettia tripetala* G. Baker (Annonaceae) and *Aframomum melegueta* in artificial diets significantly reduced larval growth of European corn borer. *Ostrinia nubilalis* Huber. A post digestive toxicity of the extract *Piper* guineense and *Cedrela odorata* extracts showed the best potential for development as botanical insecticides.

Baskaran and Janarthanan (2000) reported that the effect of dust formulations of certain plant was 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.

Oponder 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* (Vent) (Fabaceae) on histological
changes of fat body of *Periplaneta americana* (Linn) adult male. Baldwyn Torto *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 may be crucial for high antifeedant activity. Insecticidal properties of rhizomes of sweetflag, *Acorus calamus* against rice weevil, *Sitophilus oryzae* Linn. The ether, petroleum ether and alcoholic extracts of rhizomes of sweetflag were made separately by cold method proved to be high contact toxicity.

Rao and Swaran Dhingra (1997) reported the synergistic activity of some vegetable oils in mixed formulations with cypermethrin against different instars of *S. litura* (Fabricius). Srimmannarayana (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.

R. C. Saxena (1983) reported pesticides will remain indispensable to avert crop losses caused by pests. Due to use of synthetic pesticides the residual problem, detrimental effects on nontarget organisms, including man, is observed. Naturally occurring pesticides of plant origin or microbial origin is 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 depends on food consumption and utilization. Ayyangar and Rao (1989) reported that the effect of azadirachtin altered the midgut enzymes of *Spodoptera litura* (Fabr). 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. James A 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.

2.2 Bioefficacy of the selected formulations against other Lepidopteran pests.

Mane (1968) studied the efficacy of aqueous suspensions of neem seed kernels as antifeedants against the larvae of *Euproctis lanata* Wlk. *S. litura* *Utehesia pulchella* L. and the adults of *Acrida exultala* Wlk. 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 for the reducing the feeding to the extent of 79.2 per cent. Repellent action was also observed to be effective against *Utehesia pulchella*. 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 *D. cingulatus*, third instar larvae of *S. litura* and *Pericallia ricini* Clb. 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 μl/larvae. *Datura stramonium* at 50 μl per nymph causes 95 per cent mortality to *Datura singulatus* 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 behaviour and development, beside exhibiting strong antifeedant activity to *Heliothis zea* Boddie. and *S. frugiperda* Smith. Kubo and Klocke (1982) also found inhibition of larval ecdysis in *H. zea S. frugiperda, Heliothis virescense* 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 per cent 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.

Tripathi and Rizvi (1985) found crude extract of *Ailanthus excelsa* Roxb., *Juiperus recurva* Buch., *Clerodendron infortanatum* L *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* Wlk. 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. and 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., *Polyalthia longifolia*, *Annona squamosa* L. possesses antifeedant activity against *S. litura* (Kumar and Thakar, 1988). Clorodana diterpenoids from labiate plants found to possess antifeedant property against *Spodoptera littoralis* and *H. armigera* (Simmonds *et al.*, 1989). Aqueous and alcohol extracts of *Euphorbia* sps and *Ipomoea carnea* exhibited antifeedant activity to larvae of *S. litura* (Mani *et al.*, 1990). Patel *et al.* (1990 a) found that a commercial neem product, Neemguard causes high degree of antifeedant action to *Amsacta moorei* Buttler., 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 proceara* L., *Argemoni maxicana* L., *Catharanthus roseus* L and *Datura suaveolens* L induced higher larval mortality than neem (Patel 1990 b). 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 *Tributes terrestris* L. resulted morphological deformities in *S. 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 karanja 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 *H. armigera*, *Aphis gossypii* G. *Pieris rapae* L. (Wang *et al.*, 1991). Neem rind and neem seed kernel extract proved maximum protection to chickpea damage by

Crude extracts of the roots of *Inula recemosa* Hook and *Saussured 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 (Bhathalal *et al.*, 1993). The methanolic extract from *Coptis chinensis* Salisb showed a potent larvicidal activity against *Plutella xylostella* (Kweow *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 sps, *E. vitella* and *Heliothis armigera* were more susceptible than *Spodoptera litura* (Ganesan *et al.*, 1995).

### 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.
Attari (1975) compared the antifeedant properties of neem oil extract, a biproduct 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 deterrenacy was achieved at as high as two per cent oil extract as against, it was 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 trifoli* Burgess (Fagoonee and Toory, 1984). Neem seed kernel extract, neem oil and honge oil when applied to bengal gram against *Heliothis armigera* at three and five 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 Yasabir Singh, 1985). Sachan and Lal (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, 1994 b).

Repelin was found effective when applied @ 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 the tune of 1.3 eggs/5 twigs, 5.3 larvae/5 plants and 7.9 per cent bored 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 (Tirumala 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).

*Clerodendron inerme* cold alcohol extract (10%), dust (100%) 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* (100%) dust compared to neem based products (Basappa, 1995).