REVIEW OF LITERATURE

2.1 Effect of indigenous products.

Several indigenous practices are in vogue in our country which are being promoted in recent past. After knowing the ill effects posed by insecticides on the beneficial fauna and to the living beings, there is great awakening to look back to olden days of agriculture. Investigations are required to emerge with suitable indigenous technology on every crop, especially the vegetables which are consumed daily (raw or cooked) in large scale. There are innumerable pest control practices under adaptation at villages and other remote areas in plains and hills of the country. Much of the efforts of researchers on plant products is directed towards finding out newer application areas for the various plant products. But, attention with regard to the stabilization of plant products against photo, thermal, microbial and enzymatic degradation over a period of time during storage under different conditions is lacking. Hence, the information available on the related aspects has been scanned. The information on the use of indigenous products for the management of cabbage pests are meager. However, an effort has been made to collect the information on the use of indigenous products on cabbage as well as other crops and presented below.

Kanvarjibhai (1993) prepared extract by using green chilli and garlic which is mixed with water in the proportion of 1:2 and sprinkled over many crops infested by aphid and other sucking pests and reported the consistent efficacy of the mixture for more than five years.

Thomas (1994) found that hot water extract of highly pungent chilli along with few bits of asafoetida to be quite effective against leafhopper and mite pests. Garlic bulbs were (200g) crushed and soaked in kerosene (200 ml) for 24 h and then mixed with ground chilli (25 g) along with 10 ml of soap solution. When 20 ml of the extract was diluted in one litre of water and sprayed on the crops gave good control of the sucking pests (Thomas, 1995).

Bhaskaran (1995) reported that effect of traditional pest control measures against major pests of rice. The results indicated that brown plant hopper population was
suppressed (6.96 hoppers/hill) in plots treated with leaves of asafoetida mixture followed by tobacco leaf waste extract. The treatment applied with rice bran, kerosene recorded lowest green leafhopper population whereas, the least leaf folder damage was registered in plots sprayed with lime + ash and green chilli extract

Vijayalakshmi et al. (1996) reported garlic extract alone and in combination with other plant extracts viz., chilli, ginger, neem, tobacco and even cow urine was found effective against sucking pests like aphids, whiteflies, thrips and mites and the extract was effective up to 13 days of application.

Kasyapa (1998) reported that chilli + garlic solution and NSKE spray were the common practices used by local farmers for pest management. Among different botanicals tested by Sridevi (1998), NSKE (5%) proved to be effective in reducing sucking pests population in sunflower and all botanicals were found to be safer to natural enemies and pollinator

Mallikarjun Rao et al. (1998) reported the effectiveness of garlic extract in combination with other extracts like neem, chilli, ginger, tobacco and cow urine against H. armigera and S. litura upto 13 day of spray.

Sudhakar et al. (1998) observed the effect of fertilizer and insecticides on brinjal shoot and fruit borer Leucinodes orbonalis Guane. Among the different treatments shoot infestation and per cent fruit damage was least in soil application of neem cake (2 t/ha) and this was on par with vermicompost @ 6.6 t/ha.

Narayanasamy (1999) studied the insecticidal activity of 23 selected traditional pest control practices (plant extracts) against pests of rice viz., brown plant hopper and leafhopper under laboratory condition. The most effective practices against brown plant hopper was spraying the extract of garlic + kerosene (39.29% mortality) followed by neem oil and rice bran + kerosene

Natarajan et al. (2000) studied the efficacy of some botanicals like NSKE, garlic kerosene extract and Vitex extract against the leafhopper, A. biguttula biguttula on okra and found that garlic kerosene extract recorded the lowest number of leafhoppers.
Baisen and Hajra, (2001) reported that reduced jassid population on tea plants was recorded in garlic (21.35/plant) and Margosa (2.94/plant) treated plots followed by Margoconeem (3.47/plant).

Krishnamoorthy and Krishnakumar (2001) carried out a study from IIHR, Bangalore, revealed that soil application of neem cake 250 kg/ha reduced the tomato fruit borer *H. armigera* incidence to 13.21 per cent as compared to 33.23 in untreated control.

Lakshmanan (2001) reported that garlic bulb extract alone or in combination with kerosene, neem oil, chilli and other extracts effectively managed sucking pests like aphids, whiteflies, thrips and tetranychid mites infesting several crops. The herbal pesticides were prepared by immersing leaves (possessing bitter taste) in cow urine over a week period.

Ukey and Sarode (2001) reported that on chilli crop treatments comprised of neem seed extract (NSE), monocrotophos, cowdung, cow urine and turmeric alone and in mixtures, the lowest bud borer (1.42%) infestation was observed with 5% NSE as seedlings dip and 5% NSE+0.05% monocrotophos spray after transplanting.

Mallapur (2002) evaluated indigenous materials like nimbecidine (5ml/l), GCK (garlic chilli kerosene extract) 0.5%, nimbecidine (2.5 ml/l), GCK alone (0.5 and 1.0%), turmeric +cow urine (25%) and cow urine (17%) for the management of chilli pests. Among the different treatments GCK (5%) + nimbecidine (2.5 ml/l) recorded less percentage of fruit damage due to fruit borer *H. armigera* and highest yield (11.3 q/ha).

Purwar and Yadav (2002) evaluated the efficacy of different insecticides against the leaf folder (*Nacoleia* spp.). It was found that after 3 and 7 days, no infestation was recorded in plots treated with Dimilin and cow urine. The study ranked the following insecticides, based on their efficacy against the leaf folder as Hostathion 40EC > Dispel > Dimilin 25 WP > NSKE 4% > cow urine 20% > NSKE 6% > cow dung ash.

Barapatree and Lingappa (2003) conducted on study in the laboratory to determine the larvicidal and antifeedant properties of plant extract against the third instar larvae of *H. armigera* by topical application larval mortality was recorded at 24, 48, 72 and 96 hours after treatment and percent cumulative mortality were calculated.
The result showed that cow urine + half dose of quinalphos and cow urine + half dose of endosulfan proved superior to other by causing maximum larval mortality (88.89%) followed mixture of *Pongamia pinnata* + *Aloe vera* + *Azadirachta indica* + cow urine and NSKE both being on por with each other by causing (70.37%) mortality therefore larvicidal action increased with increase in duration from 24 hrs to 96 hr. *Pongamia pinnata* + *Aloe vera* + *Azadirachta indica* + cow urine and NSKE exhibited highest degree of larvicidal and anti-feedant activity.

Patel *et al.* (2003a) studied that cow urine has some insecticidal properties but it needed enrichment to enhance this effect therefore cow urine alone and with some plant extract and some botanical preparation were tested against *Lipaphis* and the results proved to be significantly superior over control in reducing the *Lipaphis* populations.

Patel *et al.* (2003b) tested the efficacy of cow urine alone and in combinations with some plant extracts against sucking pests of cotton. The results revealed that all the treatments proved significantly superior to control to reduce the sucking pests population. It was also found that although, applications of cow urine 20 per cent alone was found to be effective to reduce the aphid population, its insecticidal effect could be further enhanced by enriching it with other botanical products. Further it was concluded that enrichment of cow urine with various botanicals enhanced the insecticidals property.

Purwar and Yadav (2003) determined the efficacy of pesticides from different origin against tobacco caterpillar *Spodoptera litura* on soybean. Conventional synthetic insecticides i.e. Dimlin (Diflubenzuron). Entomo-pathogenic fungi *Beaveria bassiana* showed more effectiveness than botanical i.e neem seed kernel extract and animal origin pesticides i.e. cow urine and cow dung ash for suppressing the population of tobacco population.

Shukla *et al.*, (2003) tested the efficacy of different botanicals formulations in combination with cow urine against sucking pests and capsule borer. Results revealed that the sucking pest population was significantly low in 10 and 20 per cent cow urine treatments however efficacy of cow urine was higher when it was fortified with various plant products.
Mallapur and Lingappa (2005) evaluated indigenous materials against chilli pests and the results revealed that the least leaf curl index (LCI) against both thrips (0.4LCI) and mite (0.8 LCI) was observed in garlic chilli kerosene extract (0.5%) + nimbevidine. The next best treatments included turmeric + cow urine (2.5%) and GCK (1%) alone. The highest yield was obtained in GCK + nimbevidine treatment followed by insecticide application and GCK alone.

Boomathi et al. (2006) tested the combined action of neem seed kernel extract and cow excreta on biological activities of H. armigera. NSKE 5% + cow urine + cow dung extract 5% treatment was found to be the best exhibiting toxic effect on eggs and larvae of H. armigera. The larval growth index was also low in H. armigera fed with NSKE % cow urine 5% + cow dung extract 5%, while high anti-aviposition and antifeedant induce and low total development growth index by H. armigera were recorded in NSKE followed by NSKE + cow urine + cow dung.

Hedge and Nandihalli (2009) studied different indigenous products NSKE (5%), GCKE, sweet flag extract (5%), garlic extract (5%), cow dung (10%) and cow urine (10%) tried individually and in combination with endosulphan (0.07%). GCKE was significantly superior in reducing the fruit borer damage to the tune of 64.83 per cent with higher fruit yield of 35.87 q/ha. The highest incremental benefit: cost ratio was noticed in endosulphan treatment (15.00).

Singh et al., (2009) reported the comparative bio-efficacy of nine cow urine, indigenous plants extracts and Nimbicidine against diamond back moth (DBM), Plutella xylostella, Pieris brassicae Lin. And cabbage aphid (CA), Brevicoryne brassicae Lin. On cabbage cv. Pride of India. The results revealed that Nimbicidine (2000 ml/ha) was the most effective against DBM with mean larval population of 9.32/plant as compared to 12.85 to 22.29/plant in cow urine plant extracts and 39.20/plant in untreated check. Nimbicidine at the same dose was also found effective against CB with (1.24 larvae/plant) mean larval population in comparison to 2.32 to 6.29 larvae/plant in rest of the insecticidal treatments and 16.14/plant in untreated check. The effectiveness of Nimbicidine was closely followed by Jatropha gossypifolia and Melia azedarach with lower mean population of 2.32 and 3.17 larvae/plant. The significantly highest yield
The avoidable loss due to DBM, CB and CA infestation varied from nil in Nimbicidine to 37.93 per cent in untreated check. Among the plots treated with insecticides maximum avoidable loss (24.78%) was computed in the plots treated with Acorus calamus extract.

2.2 Effect of bioagent.

Plant protection research has generated many technologies using flora and fauna. A few have been standardized for commercial application, and are claimed to provide better pest control and crop economics than the conventional chemical control, when used in conjunction with other pest control measures. The strategy is often referred to as ‘Integrated Pest Management’. Nevertheless, the adoption of biopesticides and bioagents remains extremely low owing to a number of factors relating to technology, socio-economic, institutional and policy. Concurrently, agricultural production continues to be constrained by a number of biotic and abiotic factors. For instance, insect pests, diseases and weeds cause considerable damage to potential agricultural production. Evidences indicate that pests cause 25 percent loss in rice, 5-10 percent in wheat, 30 percent in pulses, 35 percent in oilseeds, 20 percent in sugarcane and 50 percent in cotton (Dhaliwal and Arora, 1996). The losses though cannot be eliminated altogether, these can be reduced. Use of biological agents to manage crop pests is a key component of IPM. The successful use of several entomophages and entomopathogens has projected biological control as a promising alternative to the chemical control.

The available literature on evaluation of biogents and NSKE pertaining to the objectives envisaged has been reviewed and given below.

**Rajamohan and Jayaraj (1978) B.t.** Berliner @ 3 kg/ha was more effective than the spray of insecticides in reducing the larval population of *P. xylostella* in the initial period after treatment. Almost similar trend was obtained using Bt products SAN-145 at 0.5 kg (Anon., 1989).

**Amonkar et al. (1985)** reported that Bt sub species Kenyae, Bt sub species aizawai and Bt. Sub species Kurstaki (all at 108 spores/ml) were found effective against first instar larvae of *S. litura* after 72 hours of spray in a laboratory study. However, the
per cent larval mortality of *S. litura* on cauliflower with *B.cereus* (8 x 108) and Bt (7.4 x 108) was 40.0 and 51.3 per cent respectively under field condition (Zoz, 1990).

**Kulkarni et al. (1995)** evaluated Wock biological 01 (halt), a *Bacillus thuringiensis* based test insecticide of Wockhardt Ltd, Bombay at different dosages in combination with 50% of recommended insecticides in comparison with Delfin (another commercially available Bt-based insecticide) and untreated control on a farmers field in the vicinity of Agricultural Research Station, Niphad, during the 1994 rabi season. The treatment with Delfin 50WG@0.5 kg/ha was found to be beneficial for the control of DBM even so, the treatment with Wock, Biological 01@1.0kg/ha was found equally effective against DBM on cabbage.

**Miranpuri and Khachalourians (1995)** conducted two year laboratory and field studies using 2 entomopathogenic fungi *Beaveria bassiana* and *Verticillium lecanii* against *Acyethosiphon macrosiphum*. In laboratory bioassays, various strains of *B.bassiana* and *V.lecanii* gave 70% aphid kill compared with 35-46.5 with various strains of *B.bassiana* and 17% for untreated controls. Field tests using 2 applications of *V. lecanii* resulted in significant decline in the aphid population compared with that on control (locater-treated) plants.

**Nagamani et al. (1995)** reported that thuricide (0.08%) and acephate (0.075%) and half the concentration of acephate (0.0375%) with thuricide (0.08%) proved excellent in reducing the population of the tobacco caterpillar on cabbage.

**Hazarika and Puzari (1997)** conducted a field trial for 4 years (1989-93) in different rice season in various areas, endemic to rice hispa, *Dicladispa armigera* to assess the efficacy of a mycopathogen, *B. bassaina* for controlling the insect multi-locational field trials with *B. bassiana* (10 million spores/ml dilution) 1% neem seed oil and a conventional insecticide(0-072% monocrotophos) revealed that the mycopesticide was superior to neem-seed oil but at par with monocrotophos in controlling the rice hispa leading to an increase in yield.

**Selman et al.,(1997)** studied the effect of entomopathogenic fungus, *B.bassiana* on the mature larvae of *Plutella xylostella* under two temperature regimes. All the isolates were significantly pathogenic against *P. xylostella* larvae. Isolate 274 and 373 caused a
higher mortality at 20± and 24°C, respectively. The results also showed goodness and considerable homogeneity in most of the isolates.

**Vendenberg et al. (1998)** reported that in growth chamber studies conducted at 21 or 26°C and 60 or 90% RH, neither temperature nor humidity affected the survival of larvae, but treatment with fungal spores always provided significantly greater mortality than in control. In two greenhouse traits, one application of *B. bassiana* spores suspended in water or oil significantly affected larval populations compared to controls. In the field trial, both treatment and insect stage at treatment (2nd and 3rd to 4th instars) significantly affected larval survival. The fungus formulated as a wettable powder at two rates and as an emulsifiable suspension at a high rate, provides significant reductions in larval counts.

**Facknath (1999)** studied the IPM approach for *Plutella xylostella* (the diamondback moth DBM), a serious pest of cruciferous crops, and various methods are being invested at the University of Mauritius(UOM) and the Ministry of Agriculture. At the UOM, methods have so far concentrated on the development of botanical pesticides, cultural practices such as intercropping and use of a trap crop, as well as combinations of botanicals and intercropping. *Plutella* research at the University has also included use of bacterial pathogen, namely *Bacillus thuringiensis*, as well as host-preference studies. In association with the indigenous and introduced biocontrol agents affecting DBM, and the normal practice of using overhead sprinkler irrigation, which is known to have a reducing effect on *Plutella* populations, the combination of experiments actually represent an IPM strategy, which can serve as a basis for a more structured and comprehensive package for the Integrated Management of *Plutella xylostella* in Mauritius.

**Gujar and Kalia (1999)** studied the bioactivity of *Bacillus thuringiensis* subs. Kurstaki serotype 3a,3b (Dipel)and one of its components *viz.* Cry1AB against the larvae of the diamondback moth, *Plutella xylostella* collected from different geographical regions of the country. Further studies using *B. thuringiensis* subsp. Kurstaki (Dipel) showed that Delhi and Punjab populations were less susceptible with mortality ranging from 0 to 27.3% as compared to Karnataka population showing mortality from 86.6 to 93.3% within 24hr for the concentrations ranging from 0.35ppm to 35 ppm of *B.thuringiensis* subs kurstaki.
Joshi et al. (1999) evaluated five *Bacillus thuringiensis* Berliner formulations against *Plutella xylostella* (Linnaeus) revealed that Biobit (1-2 kg/ha), Dipel 8L and Delfin (1.5-2 kg or l/ha) were equally effective but better than standard endosulfan 35EC (@0.5 & 1 l/ha). The results of the other biopesticides at higher dosages (2 kg or l/ha) were also quite encouraging.

Kulkarni et al. (1999) revealed that the treatment with Delfin 50 WG @ 0.5 kg/ha and Halt 1.0 kg/ha was found to be superior in reducing the DBM infestation at 3, 7 and 10 days after application and increasing the yield of cabbage and quality heads.

Marcano et al. (1999) evaluated pathogenicity of *B. bassiana* and *Paecilomyces fumosoroseus* to adults of *Cylas formicarius* by immersing insects in suspension of 1.3-1.4x 10^8 conidia/ml for 5 minute. Treated insects were kept at 12; 12, 22-29°C and 90% RH. A reduction of movement and feeding was observed after 45 hrs. and death of specimens after 72 hrs. Total mortality was higher with *B. bassiana* in its commercial and reactivated forms (98.34 and 96.6%).

Waghmare et al. (2000) reported that the efficacy of some biopesticides alone and in comparison with endosulfan against cabbage aphid and diamond back moth in RBD at central Farm, M.A.U Parbhani. Nimbecidine, NSKE and B.t.k gave significant control of cabbage against diamond back moth. Highest yield of marketable heads (100q/ha) was obtained from NSKE 5% treatment.

Chakraborti (2001) reported the integrated treatment with inclusion of double spray of phosphamidon + neem cake + azadiractin was the best treatment against DBM and aphids. This treatment was significantly superior to chemical check and also was quite safe to predator coccinellids, syrphids and spiders.

Chatterjee and Senapati (2001) reported that highest suppression of 88.85% and 90.54% larval population was achieved from combined spraying of *Bt* (0.05%) + azadirachtin - 1500 ppm (0.15) recorded 87.43% and 84.85% after 3 and 14 days of spraying respectively. It was conducted that overall efficacy of joint action of the above pesticides as well as solo application of *Bt* and avermectin were more effective against diamond back moth than conventional pesticides.
Chavan et al. (2001) studied cabbage and tomato intercropping involving 4 lines of cabbage with 2 lines of tomato. Cabbage was sprayed with four sprays of NSKE 3 per cent and Bt at 0.1 per cent alternatively at 15 days interval. The results indicated that tomato intercropped in cabbage helped in keeping DBM at low level.

Gloriana et al. (2001) opined that the late instars of S. litura was susceptible to B. bassiana and B.t at high doses of entomopathogens. The LC50 values of these were 2.9 log conidia/ml and 17.3 log cells/ml for B. bassiana and B.t. respectively.

Arora et al. (2003) studied on the toxicity of some newly introduced and few commonly used insecticides and undertaken against the third instar larvae of Plutella xylostella collected from cauliflower fields around Hisar, Haryana. The insect was reared in the laboratory for two generations and exposed to different concentrations of insecticides tested. The LC50 tested values of spinosad, Bacillus thuriengensis var. kurstaki, cartap hydrochloride, cypermethrin, dichlorophos, malathion, carbaryl, endosulfan and monocrotophos were 0.00033, 0.01493, 0.01758, 0.02502, 0.04530, 0.22310, 0.032265, 0.50192 and 1.36697 per cent respectively. Spinosad, the least used was the most toxic being 4151.42 than monocrotophos, the most commonly used insecticides.

Purwar and Yadav (2003) reported that the efficacy of pesticides from different origin against tobacco caterpillar Spodoptera litura on soybean. Conventional synthetic insecticides i.e. Trizophos was found effective followed by chitin inhibitor i.e Dimlin (Diflubenzuron). Entomo-pathogenic fungi Beaveria bassiana showed more effectiveness than botanicals i.e neem seed kernel extract and animal origin pesticides i.e. Cow urine and cow dung ash for suppressing the population of tobacco population.

Singh et al. (2003) conducted bioassay test under laboratory conditions to assess the efficacy of commercial Bacillus thuringiensis var. kurstaki (Btk) (Biolep) formulations against different larval instars of diamond backmoth (DBM), Plutella xylostella L. The result indicated that commercial Btk formulation was found to be highly effective against third and fourth instar DBM larvae .The neonate larvae were found to be tolerate when composed to later instars. Relative susceptibility of all the four instars to
Biolep was also calculated on the basis of their LC50 values. The results obtained on sensitivity of different larval instars to Btk formulation were discussed.

Gauraha et al. (2004) studied the bioefficacy of three native insect pathogens viz., Bacillus thuringiensis (Berliner)(GAU TOBI), Heterorhabditis sp.(GAU AO2) and Metarrhizium anisopliae var. Anisopliae (Metachnikoff) Sorokin (GAU Ma) for microbial control of Diamondback moth (Plutella xylostella Linn.) and head borer Helicoverpa armigera (Hub) on cabbage (Brassica oleracea var. capitata L). Result exhibited that treatments of insect pathogens like bacteria, fungus and nematodes remained significantly superior over control. Maximum larval mortality was in Bt (65.0 and 67.50%) followed by Heterorhabditis (42.50 and 42.0%) and M. anisopliae (30.0 and 35.0%) of P. xylostella and H. armigera, respectively. Study indicated that laboratory augmented native insect pathogens were found very effective in suppression of insects and B. thuringiensis was found best amongst them.

Mahesh and Man (2007) evaluated the commercial formulation of Bacillus thuringiensis Berliner biz., Delfin @ 1000g/ha, Delfin @ 750 g /ha Bt. PDKV @ 1000 ml /ha, Bt. PDKV@ 750 ml/ha, Halt@ 1000g /ha, Halt @ 750g /ha, Dipel 8L@ 1000ml/ha, Dipel @ 750 ml/ha and carbaryl @ 0.2 per cent against brinjal fruit and shoot borer (Leucinodes orbanalis Guen.) on experimental field. Result showed that, out of four treatment application, the lowest shoot infestation was observed in the standard insecticide carbaryl @ per cent. Among the Bt. formulation the lowest infestation was observed in Dipel 8L @ 1000 ml ha-1 as compared to control and other treatments.

Gedia et al. (2008) observed the efficacy of various commercially available biopesticides, viz., Bacillus thuringiensis var. kurstake (Btk), Nuclear Poly- hydrosis Virus (NPV) alone and in combination with reduced dose of insecticides viz., endosulfan chloropyrifos and evaluated against Spodoptera litura on castor (pooled means of 2003-2004 and 2004-2005) under field conditions and revealed that efficacy and economics of various bio pesticides alone and in combination with conventional insecticidal treatments are equally effective.

Singh et al. (2008) evaluated Bacillus thuringiensis var. kurstaki formulation viz. delfin, dipel, halt, biobit, biolep, bioasp, botanical insecticide neemgold, nematode
(Steinerma feltiae), green commandos and endosulfan insecticide against lepidopterous pests of cabbage under field conditions. Delfin was very effective in reducing the population the cabbage webber, Crocidolomia binotalis (67.6%) and diamondback moth, Plutella xylostella (57.1%). Dipel was equally effective against tobacco caterpillar Spodoptera litura, which recorded 55.4% reduction. All the test insecticides were found to be safe and did not show any adverse effect on coccinellid population under fields conditions.

Ambethgar et al. (2009) studied the compatibility of Beauveria bassiana (Balsamo) Vuillemin (isolate BbCm KKL 1100) with twelve insecticides and three neem formulations and was examined on agar plate to develop suitable combination for the management of insect pests in rice fields. All chemical and botanical insecticides inhibited mycelial growth of B. bassiana either partially or completely depending on their concentration (10 x, 1x and 0.1 x, where x = treated concentration). Chemical insecticides completely inhibited the mycelial growth of B. bassiana, while the neem formulations inhibited 70-86% biomass production of the fungus at 10 x concentration. At 1 x concentration, carbofuran caused total inhibition, but all other insecticides caused 47.4-75.5% inhibition. However, at 0.1 x concentration only neem seed kernel extract, chlorpyriphos and dimethoate exhibited 22.2%, 27.3% and 32.6% mycelia inhibition respectively and these could be used with B. bassiana in the field condition.

Palande and Pokharkar (2009) conducted a Biointensive Integrated Pest Management (BIPM) module with parasitoid and microbial agents and evaluated in comparison with recommended chemical control schedule of Maharashtra state against pest complex on cabbage. The chemical control schedule consisting sprays of dimethoate 0.03 percent, endosulfan 0.07 per cent, quinalphos 0.05 per cent, and cypermethrin 0.0075 per cent given 10 days interval commencing from 15 days after transplanting resulted in minimum mean surviving pest population (0.91 aphid/3 leaves, 1.11 larvae of DBM/plant,0.51 larva of H. armigera/plant) with 59.00,55.60 and 74.63 per cent reduction in aphid, DBM and H.armigera population respectively. Also, this treatment recorded maximum of 383.7 q/ha marketable cabbage heads and proved to be the most effective. The BIPM module formed statistically comparable with the chemical control
schedule in respect of surviving population of DBM and *H.armigera* after three weeks treatment initiation and yield parameters.

### 2.3 Effect of insecticides and in combination with neem products.

Insect cause enormous damage to our crops and forest tress. These insects has been especially problematic because populations in several parts of the world have developed resistance to most of the commercial insecticides, including some growth regulators of insecticides (Perez et al., 1997). This coupled with the awareness of the environment consequences of excessive pesticides use, encourages further interest in non-chemical methods of control. For sustainable production it is necessary to get rid of insect pests which can be detrimental to crops, for which proper plant protection measures should be taken.

The available literature on chemical pesticides alone and in combination with NSKE pertaining to the objectives envisaged in the introductory chapter is reviewed here under.

**Krishnaiah and Mohan (1983)** evaluated new insecticides for the control of *Plutella xylostella* Linn, *Crocidolomia binotalis* (Zell), *Lipaphis erysimi* (Kalt) and *Myzus persicae* (Sulz) on cabbage. Quinalphos, methamidophos, dioxathion and endosulphan gave effective control of *P.xylostella* over a fortnight while Dipel, Dipel+, monocrotophos, phosalone, phenthoate, methomyl and malathion suppressed the population for a week. Monocrotophos, quinalphos, metamidophos, chloropyriphos and endosulfan controlled the population of mustard aphids for 2 weeks. Effective control of green peach aphid was offered only by methamidophos and quinalphos for a fortnight and by endosulfan for a week.

**Peter et al. (1989)** carried out two field trials during June-October 1987 and Jan-April 1988 at Hosur in Tamil Nadu to assess the bioefficacy of Cartap hydrochloride (Padan 50 SP) at 5 dosage levels against the Diamondback moth on cabbage. Quinalphos @ 250g a.i/ha was used as the standard for both trials. The results indicated that Cartap hydrochloride@200g a.i/ha may be considered as the minimum effective dosage for the control of this pest on cabbage.
Rajasri et al. (1991) reported that Triazophos and Phosolone (0.1%) caused 90% mortality of Scirtothrips dorsalis and Myzus persicae and 78 per cent of mortality of H. latus. Triazophos (0.1%) and 0.1% fenvalerate were effective against the N. armigera and Spodoptera litura. Neem oil, Neem guard, repilin and biosol gave significant control of the pests, but were less effective than the synthetic insecticides.

Brar and Singh (1992) tested seven insecticides for three years to determine their comparative efficacy against the larvae of Plutella xylostella (L). Fenvalerate @50.0 and 37.5g, deltamethrin 10.5 and 7.5g and fluvalinate 81.2 a.i/ha were adjudged the best while quinalphos @500g, endosulfan 525g and cypermethrin 37.5g were the second best in performance against the pest. Alfamethrin @25 and 18.7g, quinalphos @375g and cypermethrin 25g, quinalphos 375g and cypermethrin 25g proved better than fluvalerate 50g, quinalphos 250g and endosulfan 350g than fluvalerate 50g, quinalphos 250g and endosulfan 350g a.i/ha which were the least effective in controlling the diamondback moth larvae.

Chawla and Joia (1992) conducted a bioassay of field populations of the diamond back moth, Plutella xylostella (L) from major vegetable growing areas of Punjab using quinalphos as the test insecticide. The larval populations highly susceptible to quinalphos initially acquired resistance in about 3 years of its introduction in Punjab. Testing of various populations during subsequent years showed that resistance to quinalphos in the diamond back moth remained at almost the same levels.

Murthy et al. (1993) tested neem extracts for the control of S. litura on tobacco in the laboratory and nursery in India. Dichloroethane extract was more effective than neem seed kernel suspension. Laboratory studies indicated that dichlorathane extract and neem cake could prevent damage by S. litura.

Chari et al. (1993) carried out the efficacy of neem formulations tested against the larvae of Spodoptera litura. The repilin dichloroethane extract and neem seed kernel suspension gave the best protection laboratory test. In nursery tests, these three formulations gave significant protection to seedling after spraying.

Dhawan and Simuwat (1995) compared three botanical insecticides- RD-9 repilin (1 and 2%), neemark (0.5 and 0.75%) and neem rich 20EC (0.1 and 0.15%) with
quinalphos (0.2%) as standard against larvae of the *Helicoverpa armigera* in cotton field. All botanical were also compared with quinalphos against *S. litura* in the laboratory. Repilin and neemrich at the highest concentration were more effective than the neemark in the crop spraying but not effective as quinalphos. All the insecticide caused 100 per cent mortality of *S. litura*.

**Bomford and Isman (1996)** reported on deterrence of Azadirachtin in its form and as a constituent of neem seed extract to 5th instars a larva of *S. litura* was measured using cabbage leaf disc assay. Paired choice assay in which larvae could choose between feeding on a treated an untreated leaf disc for 2h were conducted at 24h interval throughout the 5th instars. In addition, no choice assay in which larvae could feed on only one leaf disc for 1.5h conducted consecutively over a 6h period at the beginning of the 5th instars. The effect of hunger and habituation in the no choice tests were portioned after repeated exposure larvae become desensitized to pure azadirachtin in both choice test but did not desensitized to neem containing the same absolute amount of Azadirachtin in choice test. Hunger was responsible approximately one third of desensitization response in the no choice test sensitively to azadirachtin was independent of age within the 5th instrars.

**Jain and Gupta (1996)** studied the effectiveness of four synthetic pyrethroids (SP) viz. permethrin, cypermethrin, fenvalerate and decamethrin at two doses level was tested against the diamond back moth (DBM) infesting cabbage. As compared to control all four SP were effective in reducing pest population, however among them decamethrin @20g a.i/ha proved most effective as it gave highest reduction of DBM population (88%). Maximum yield of cabbage (234q/ha) was also obtained from 20g ai/ha of decamethrin spray. The lower dose of (10 g a.i/ha) was next in order of effectiveness and yield than control but inferior to decamethrin. Thus, the spray of decamethrin @10g ai/ha was found most effective against DBM on cabbage.

**Renuka and Regupathy (1996)** monitored insecticide resistance to *Plutella xylostella* in different locations of Tamil Nadu. Resistance to fenvalerate, quinalphos, monocrotophos, cartap hydrochloride and carbosulfan was assayed following vial method, using the discriminating doses of fenvalerate 115 ppm, quinalphos
To address this issue, Tambe et al. (1997) conducted a field experiment on a farmer’s field at Dhakambe, District Nasik during Rabi season, 1995-96. In this experiment, insect growth regulator, Cascade (flufenoxuron) at 20, 30, 40 and 80 g a.i/ha, fenvalerate 40 g a.i/ha, Delfin WG 0.5 kg/ha and Padan 400 g/ha were evaluated against cabbage diamondback moth. Results of the experiment indicated that higher dose of Cascade i.e. 80 g a.i/ha was found significantly superior to remaining treatments in reducing the infestation of DBM at 3, 7 and 10 days after application and increased the yield of cabbage. However, it remained at par with Cascade 40 g a.i/ha at 7 and 10 days after application.

Nagesh and Verma (1997) studied the comparative efficacy of certain eco-friendly pesticides (viz., Neem, Bacillus thuringiensis, Diflubenzuron, Lufenuron and Cartap) and synthetic organic insecticides (viz., endosulfan, Chlorpyrifos, Quinalphos, Phosalone and Cypermethrin) against the diamondback moth (DBM) during the 1995-96 rabi season in cabbage at IARI, New Delhi. Padan followed by Match and Biolep were found to be effective in controlling the DBM. Hence, a sequential spray with these chemicals of different modes of action can be recommended to solve the problem of development of resistance in the above pest. Profitable yields were also recorded in these treatments.

Venkateswarlu et al. (1998) demonstrated that neem oil at 8 and 16% exhibited complete repellent and antifeedant activity against larva of S. litura on urd bean leaves. At 0.5 per cent 4 per cent repellency and antifeedant activity was increased with concentration.

Shankar and Parmar (1998) reported on azadirachtin content and bio efficacy of neem fruit extract attained from the north, south, east, western sides of three marked trees at different stage of fruiting revealed no significant effect of the sampling direction on azadirachtin content. There was also no effect on the growth and antifeedant activity of azadirachtin against S. litura.
Dhaliwal and Arora (1998) evaluated 2 formulation of neem Achook and Nimbicidine for the control of insect on cabbage. The neem formulations were evaluated at 1, 2 and 4 kg ha\(^{-1}\) and compared to 0.5 kg a.i. / ha endosulfan used as control. The mortality of insect was highest with 4kg/ha of the neem formulation, seven days after treatment, mortality of *S. litura* in Achook was 81.66, 70.66 and 85.66 per cent where as with *Pieries brassicae*, it was 80.00, 73.00 and 86.66 per cent Endosulphan was the most effective against the entire insect pest followed by Achook and Nimbicidine.

Li –Yunshou et al. (1999) evaluated the efficacy of some botanical antifeedant on the feeding behavior of *Spodoptera litura*. Fifth instars larvae were fed on cabbage leaves sprayed with azadirachtin. Their feeding activity being significantly less than the control. It was concluded that this could be used as indices for evaluation for the effect of the antifeedancy.

Vyas et al. (1999) found the efficacy of neem extract which exhibit significant control of many crop pests. Neem formulation was in a water soluble form containing azadirachtin, azadirachtin and nimbocinol + epinimbounol at 300, 500 and 2000 ppm respectively. These preparations were used on important noctuid pests (*Spodoptera litura* L.). Different growth disruption such as larval duration, pupal weight, percentage pupation, pupal duration and total development growth index indicated that all plant products affected the test larvae by either direct killing or through interference with metamorphosis. It was clearly suggested that formulation of neem products can be supplemented in an environmentally friendly pest control programme.

Obulapathi et al. (2000) compared the efficacy of different chemical and botanical pesticides against the tobacco caterpillar (*Spodoptera litura*) on groundnut. The treatments comprised of six botanical pesticides (Repiline, Neemguard, Achook, Nimbicidine, Margosal and Suneem, all applied at 1% concentration) and three conventional insecticides. The botanical pesticides recorded 64.20 to 54.23 per cent population reduced over the control.

Peter et al. (2000) found that the commercial formulation of the actinomycetes *i.e.*, spinosad 2.5 SC was effective in reducing the population of *C. binotalis* upto 7 days.
Umeda et al. (2000) reported at three days after the first application, RH-2485, Success, Proclaim, Avaunt and Larvin reduced the total number of diamondback moth (DBM) larvae to less than 2.0 larvae per 10 plants compared to the untreated that had 7.0 larvae/10 plants. Alert, Kryocide and S-1812 treated cabbage exhibited 4.0 to 5.0 larvae/10 plants and Lannate was intermediate with 2.7 total larvae/10 plants. Following a second application, Success and Proclaim completely controlled DBM for one week. Success, Proclaim, Alert and Larvin continued to offer very good control of DBM for two weeks after the second application. S-1812 performed similarly to Lannate.

Ghosh et al. (2001) evaluated to select insecticides compatible with integrated management of cabbage pests for terai ecological situations. It revealed that synthetic pesticides (malathion and DDVP @0.05% a.i) effectively controlled all the pests of cabbage in complex and thereby produced higher yield of cabbage over biologically originated pesticides. Avermectin (0.01%) was almost equally effective against the pests of cabbage. Among the biologically originated pesticides, avermectin (0.01%) though found more efficacious against pest complex but higher yield of cabbage was obtained from Bt (Halt)(42.40 t/ha) than avermectin (42.29 t/ha). Although, the highest yield of cabbage was obtained from DDVP (43.61 t/ha), closely followed by malathion (42.81 t/ha) but difference in yield among different pesticides was non-significant. Considering overall performance of pest suppression yield of cabbage and impact of pesticides on health and environment avermectin @ 0.01% and Bt (Halt) 5 x 10 7 spores/mg@1g/l are the best suited for the management of pest of cabbage.

Nathuram et al., (2001) observed the comparative efficacy of some insecticides against DBM on cabbage. Quinalphos followed by endosulfan, biobit, biolep, cypermethrin and fenvalerate treatments were found to be most effective in controlling the DBM, Whereas the treatments of Cartap hydrachloride, NSKE and neem oil were found to be less effective in controlling the target pest. The bio-efficacy of these chemicals was found to be more or less similar during all the three years of study.

Rao and Lal (2001) evaluated insecticides belonging to different groups in the field against diamond back moth on cabbage c.v golden acre. Treatments comprised of 0.7% endosulfan, 0.1% malathion, 0.002% deltamethrin, 0.1% imidacloprid, 0.05%
cartap hydrochloride, 0.025% diflubenzuron, 0.5% Achook (neem preparation) and a control. Cartap hydrochloride, deltamethrin, endosulfan and imidacloprid recorded the maximum larvae mortalities. Achook was the least effective treatment against larvae population of *Plutella xylostella*.

Singh and Prasad (2001) observed on chilli attacked by a serious pest, chilli pod borer, *Spodoptera litura*, in an area in Manipur which was never reported before. The seasonal incidences population builds up and biology were studied under laboratory conditions. It has highest infestation from July to August. Although it has been found active throughout the year, emergence of adult generally occurred during night time. The entire life cycle was completed within 50.57 ± 1.30 days during April to May and 40.02 ± 0.54 days during July to August.

Babu et al. (2002a) from their experiment concluded indoxacarb, a new chemical was found to be effective against *P. xylostella* which follows abamectin under laboratory condition. Further the same workers (2002b) based on their field experiments stated that indoxacarb @29 g a.i./ha was effective in reducing the larval population of DBM on cauliflower and there by increasing the yield.

Karmarkar et al. (2002) conducted persistent toxicity of neem products i.e. neem oil, nimbicidin, Neemark and Nimbitor against *S. litura*. Based on the mean percent protein against second instar larvae 2 per cent Nimbitor persisted for four days after application.

Manjanaik et al. (2002) tried seven tested insecticides (Phosolone 0.05%, Quinalphos 0.05%, monocrotophos 0.05%, dimethoate 0.03%, Chlorpyriphos 1 ml/lt and carbaryl 0.02%) and a plant product (Neem oil 6 ml/lt) against *Spodoptera litura*. All chemical treatment resulted in higher crop protection compared to the control and neem oil.

Liu et al. (2003) reported indoxacarb @ 0.05 to 0.07 kg a.i./ha was effective against DBM by suppressing the larvae below economic threshold level. In addition indoxacarb was as effective as spinosad and significantly more effective than emamectin benzoate.
Pandey and Raju (2003) evaluated the susceptibility of different larval instars of DBM to leaf residues to different novel as well as eco-friendly insecticidal formulations of Lufenuron, Diafenthiuron, endosulfan and (neem seed kernel extract) NSKE, individually at their recommended concentrations in the laboratory. The cumulative mean per cent mortality varied from 80.00 to 96.67 percent among 1st, 2nd and 3rd instars larvae of DBM up to 96 to 120 hours of insecticidal exposure. The pupae formed (from 4th instar larvae which were treated with lufenuron, diafenthiuron and NSKE) into immature forms and died in pupal stage.

Rahman and Kananjia (2003) reported the effect of sub lethal dose of neem formulation i.e. Multineem, Nimbicidin and neem seed kernel extract against S. litura treatment with NSKE at all tested doses resulted in lower larvae length and weight.

Bhargava (2003) carried out an experiment to determine the effect of neem seed extract on S. litura the longevity of an unmated male and female in the control was 9.87 and 10.93 days which were reduced to 6.47 and 7.20 days at 5.0 per cent.

Khan et al. (2003) observed 52 per cent and 27 per cent antifeedant activity with azadirachtin mixed with neem oil and butylated hydroxisole (BHA), respectively and azadirachtin A gave 10 % antifeedant activity alone

Pramanik and Chatterjee (2003) determined the comparative efficacy of certain chemical insecticides (novaluron, acetamiprid and cartap hydrochloride) and microbial insecticides [Bt Kurstaki, spinosad and abamectin] against diamondback moth, Plutella xylostella (L)]. Each insecticide was sprayed twice at 15 days interval. The larval count per plant was taken 1 day before and 3, 7 and 10 days after each spray. All the insecticides tested significantly reduced the pest population compared to control. Spinosad @0.005% was most effective on the basis of pest population per plant and increase of yield over untreated check. Average data analysis showed the order of efficacy of different insecticides was spinosad>B.t.kurstaki>abamectin>cartap hydrochloride>acetamiprid>novaluron.

Sharma et al. (2003) evaluated the efficacy of neem gold (0.15% azadirachitin from Azadirachita indica) for its effect on haemogram and ultra structure of haemocytes
of *S. litura* and all treatment of neem gold (500,1000,1500ppm) in artificial diet of the last instar larvae of *Spodoptera litura*.

**Srivastava and Pande (2003)** reported indoxacarb 14.5 SC to be highly toxic to *S. litura* larvae under laboratory conditions with 0.004 per cent by causing 92.8 percent mortality.

**Bhavani and Punnaiah(2004)** reported the field efficacy of Insect Growth Regulator, flufenoxuron (cascade) at 0.1 per cent was found to be significantly superior in controlling *C. binotalis* by recording low population of the pest.

**Binage et al. (2004)** carried out an experiment under field conditions on cabbage pests (aphids, diamondback moth, tobacco caterpillar), in order to evaluate the efficacy of different botanical pesticides along with and in combination with endosulfan and cypermethin. Among different botanicals, 5% neem seed extract (NSKE) +0.33% of endosulfan was found to have the lowest infestation of tobacco leaf eating caterpillar (0.47 larvae/plant).

**Karabhantal and Awaknawar (2004)** conducted field trials during 2001 and 2002 kharif season in Karnataka, India, to determine the efficacy of indoxacarb (469g/ha) spinosad (30g/ha), β-cyfluthrin (7.81g/ha) thiocarb (469 g/ha), methomyl (125g/ha), alanycarb (281g/ha) and endosulfan (438g/ha) against tomato fruit borer, *H. armigera*. They reported that spinosad gave the maximum larval mortality after 10 days of first second, third and fourth spray. Spinosad treatment recorded the lowest percentage of fruit damage and highest yield, yield, increase compared to the control and additional return, whereas indoxacarb recorded the highest expenditure and lowest cost benefit ratio in tomato crop.

**Gupta and Raghuraman (2004)** bioassayed lab study using a control group consisted of *Spodoptera litura* which was reared on artificial diet without any neem treatment. Different concentrations of neem (1500 ppm, Achook, 50, 000 ppm Neemazal and 60,000 ppm Neem juvena Triguard) were prepared by serial dilution method and than bio efficacy was studied. The formulation containing azadirachtin rich content were highly toxic to *Spodoptera litura*. 
Nirmal and Singh (2004) studied the insecticide resistance in diamond backmoth, *Plutella xylostella* Linn. It has been monitored in different locations in and around Hyderabad, Andhra Pradesh. Resistance to six insecticides was tested using topical and leaf residue bioassay methods. Among the insecticides viz., endosulfan, monocrotophos, malathion, acephate, carbaryl and cartap hydrochloride tested, high resistance was recorded in monocrotophos.

Vastrad et al. (2004) studied and conducted on sample size requirement and bioassay methods for monitoring insecticide resistance in diamondback moth (DBM), *Plutella xylostella* L. at University of Agricultural Sciences, Dharwad during 1997-99. Three sample size of 50, 100 and 150 larvae and three bioassay method viz. leaf dip, larval dip and vial assay were tried under laboratory. A sample size of 50 larvae was found adequate for monitoring insecticide resistance. However, leaf dip method was found ideal for monitoring insecticide resistance which was further confirmed by the field validation studies.

Joia et al. (2005) raised diamondback moth populations under controlled conditions in the laboratory from field collected larvae and pupae. Toxicity of commonly used insecticides 3rd instar larvae was assessed using leaf disc dip technique of bioassay during 1998-2001. Compared with base-line values, as high as 2986, 3516, 3050, 218 and 38 times, resistance was observed in cypermethrin, flavalerate, deltamethrin, quinalphos and chloropyriphos, respectively. However, the larvae were more susceptible to organochloride insecticides.

Satpathy et al. (2005) carried out a field trial to test the efficacy of chlorfenapyr 10SC @ 75 and 100g ai/ha against diamondback moth (DBM) in cabbage along with recommended check endosulfan @ 700g ai/ha, Bt at 500 g ai/ha and untreated control. On the basis of post-treatment larval population, chlorfenapyr was found to be most effective against DBM. There was significantly less infestation at both the test concentrations (100g a.i/ha and 75g a.i/ha) of chlorfenapyr @ 75g a.i/ha provided optimum control of DBM over endosulfan and Bt.

Sengutuvam et al. (2005) conducted field trials to assess the efficacy of neem/melia products in controlling the pests including fruit borer, leaf hopper and white
flies in tomato. Application of neem seed kernel, extract (NSKE) and melia seed kernel extract (MSKE) was superior to other botanical though endosulfan was found to be the best treatment in checking the pest complex.

Shelkar et al. (2005) observed that cotton and castor bean neem seed kernel extract and fed to S. litura to determine the effect of bio pesticides on the consumption digestion and utilization of food consumption index was lowest in cotton and castor beans treated with neem oil.

Singh et al. (2005) highlighted the global scenario where resistance in P. xylostella is ubiquitous to synthetic pyrethroids, organophosphates, organochlorines and carbamates; in some cases more than 50,000 fold resistance has been reported in the pest. Various mechanisms of resistance operating in P. xylostella such as increased activities of microsomal oxidases, glutathion transferases, general esterases and knockdown resistance factors, have been discussed. It emphasized to delay the precipitation of resistance to newly introduced insecticides, its risk with respect to development of resistance in the target pest should be predetermined by subjecting the pest to continuous selection pressure under laboratory conditions so that the frequency of use of a particular insecticide be planned accordingly. This strategy can form a viable component of Insecticide Resistance Management (IRM) strategy of diamondback moth.

Goud et al. (2006) were of the opinion that the bio-efficacy of novaluron (0.01%), flufenoxuaron (0.01%) exerted superior control of cabbage leaf webber when compared with other treatments.

Nath and Singh (2006) concluded that two sprays of eco friendly bio – pesticides (NSKE 5 % and Nimbicidine) were found superior over one spray of bio pesticides in reducing the pigeon pea pod damage, grain damage and grain weight loss. Among the various treatments, pigeon pea + rice followed by pigeon pea + sorghum sprayed with NSKE 5% were found most effective in reducing the damage inflicted by gram pod borer.

Singh and Yadav (2006) investigated the efficacy of three modern insecticides, one conventional insecticide, two Bacillus thuringienesis base insecticides and three neem based formulation. Study revealed that, indoxacarb gave best result among all
treatments followed by spinosad and carbosulfan in reducing the crop damage. On the basis of two years study, it has been found that indoxacarb, spinosad and carbosulfan treated plots received 5.20, 7.0 and 9.40 per cent pod damage while 4.43, 5.45 and 7.63 per cent seed damage whereas 3.45, 4.69 and 6.60 per cent seed loss respectively. As far as grain yield is concern indoxacarb exhibited 1435.55, spinosad 1188.25 kg/ ha and carbosulfan 985.55 kg / ha. The increase in seed yield over control was observed 318.28 per cent in indoxacarb, 246.23 per cent in spinosad, 183.33 per cent in carbosulfan and 164.44 per cent in endosulfan.

Deivendran et al. (2007) conducted a field study to evaluate certain new insecticides against Plutella xylostella on cauliflower revealed that indoxacarb at 90g a.i/ha recorded the highest mean larval mortality (67%) followed by spinosad at 75g a.i/ha(62%) fipronil 75 g a.i(49%) thiodicarb at 750 g a.i(43%), nimbecidine at 75g a.i/ha(37%) and B.t at 1000g/ha(14%) one day after the first spray and all were significantly better than control. In general, there was an increasing trend in larval mortality with lapse of time. After two sprays at ten days interval, larval mortality was 100 percent in fipronil, indoxacarb and spinosad. The overall order of efficacy recorded was :indoxacarb>spinosad>fipronil>thiodicarb>Bt>dichlorvos>endosulfan>nimbecidine.

Jasmine et al. (2007) conducted three field trials to evaluate the efficacy of Abamectin in cabbage, indicated that abamectin 1.9 EC applied@15g a.i ha⁻¹ is more effective against diamondback moth when compared to the standard checks used. It is followed by abamectin 13g a.i ha⁻¹ and spinosad 45 SC75g a.i ha⁻¹. No phytotoxic symptoms were noticed in any of the treatments. Abamectin treated plots recorded the highest marketable yield in all the three experiments. Abamectin@15g a.i ha⁻¹ recorded a cabbage yield of 36.5-76.0 t ha⁻¹ as against 24.1-49.0 t ha⁻¹ in the untreated check.

Kumar et al. (2007) conducted a field experiment on efficacy and economics of insecticides and biopesticides against Plutella xylostella (L) on cabbage and concluded that all the treatments were found significantly superior over control in reducing diamond back moth population. Imidacloprid (0.01%) was most effective as it reduced the maximum larval population at each observational interval during first and second spray with the highest marketable yield (228.85q/ha). Cartap hydrochloride (0.05%) caused
58.8 to 60.1% reduction in larval population within 14 days of first and second spray. The treatment beta-cyfluthrin (500ml/ha) was found effective and economical and had maximum cost benefit ratio (1:20:02)

Ravi et al. (2007) evaluated biopesticides alone and in combination with newer insecticides for the management two keys lepidopteran pests’ viz., Spodoptera litura Fab. and Helicoverpa armigera (Hub.) on sunflower (CV.Co-4). Indoxacarb was the most effective chemical in reducing the larval population.

Sable et al. (2007) carried out a field experiment with 12 treatments viz., Bacillus thuringiensis @ 500g a.i/ha, endosulfan @ 350g. a.i/ha, spinosad @ 96.4g. a.i/ha flufenoxuron @ 26.70 +18.75 g. a.i/ha, thiodicarb @ 350g. a.i/ha cartap hydrochloride @ 375g a.i/ha, indoxacarb @ 73g. a.i/ha, NSKE % and quinolphos @ 150 g a.i/ha with one control replicated thrice for two years to study the efficacy of these insecticides against Plutella xylostella linn. The pooled data revealed that imidacloprid 17.8 SL + spinosad 2.5SC @ 26.70 +18. 75 g a.i/ha was recorded the lowest population of P. xylostella 2.33 larvae 10/plant on 3rd, 7th, 10th and 14th day after spraying which was followed by spinosad 45SC@ 96.4g a.i/ha (2.55, 1.00, 12.05 and 19.96 larvae 10 plants-1) and indoxacarb 14.5SC@ 73g a.i. ha-1 (2.73, 5.13, 13.45 and 22.51 larvae 10 plants-1) on 3rd, 7th, 10th and 14th days after spraying on 3rd and 7th days after spraying all these 3 treatments were at par with each other flower on 10th day after spraying imidacloprid 17.8 SL + spinosad 2.5 SC @ 26.70 +18.75 g a.i/ha was significantly superior over the rest of the two treatments and on 14th day after spraying it was found at par with spinosad 45SC@ 96.4g a.i/ha, the maximum larval population was recorded in untreated control 41.34, 54.45, 64.50 and 76.46 larvae plants on 3rd, 7th, 10th and 14th days after spraying respectively the highest yield of cauliflower curd was recorded 239.92 qt./ha in plot treated with imidacloprid + spinosad which was significantly superior over spinosad @ 45SC@ (2144.42 qt./ha) and indoxacarb @ 14.5SC (206.94 qt./ha). The lowest yield was recorded in untreated control 88.03 qt/ha.

Singh and Yadav (2007) studied the efficacy of indoxacarb, spinosad, thiomethaxam, endosulfan ,three Bt. Products and neem formulations. Indoxacarb caused maximum larval mortality after one week of two sprayings i.e. 99.4% and 98.3 %. The
maximum grain yield (1425 kg/ha) was recorded in indoxacarb with minimum pod damage (12.5%) and a C:B ratio of 1: 12.387 but greatest C: b ratio was recorded in spinosod (1: 15.45).

**Mane et al. (2008)** studied the efficacy of methanol extract of selected plant species against 3rd instar larvae of *Spodoptera litura* revealed that the treatment with 10.00% neem seed kernel extract (NSKE) was found the most effectively causing maximum mean percent larval mortality of 35.00, 50.00 and 75.00 at three and five days treatment respectively.

**Kang and Dhaliwal (2008)** determined the toxicity of some commonly used insecticides against population of *P. xylostella* in Punjab. The populations collected from Amritsar, Bathinda, Kapurthala, Patiala and Ropar were tested using leaf disc dip technique of bio assay. Based on the LC50 values obtained, cartap-hydrochloride was found to be most toxic against all the pest populations with LC50 values 0.045-0.162% followed by endosulphan and fenvalerate with LC50 values 0.117-0.473 and 0.147-1.936 respectively. Quinalphos was found to be least effective against all the populations with LC50 values ranging from 0.609-2.522%

**Bhavani et al. (2009)** conducted a field experiment for two consecutive years during Rabi, 2006 and 2007 to develop an effective and economic integrated pest management programme for the control of insect pest of cabbage at Regional Agricultural Research Station, Anakapalle. All the treatments were significantly superior over control in recording low population of the pest species studied. Module-5 comprising intercropping of cabbage +coriander (10:2), installation of pheromone traps(DBM and tobacco caterpillar), field release of *Trichogramma chilonis* @50,000/ha at 20 DAT, spraying of neemarin (300ppm)@2.5ml/lt at 45 DAT, spray of novaluron 10EC@0.01% 60 and 75 DAT recorded significantly less incidence of aphids(36/5 plants), tobacco caterpillar (1 larva/5 plants) and diamond backmoth (4.33 larvae/5 plants), head borer (0.83%) by recording highest percent reduction over control(88.9%), 97.3%, 92.7% and 98.8% respectively and registered highest marketable yield(14.75t/ha)when compared to all other modules during both the years of study. With regard to marketable yield also, all the IPM modules recorded higher yields(8.05 to 14.7 t/ha) and were significantly superior
over control while control (sole crop of cabbage) recorded lowest marketable yield of 3.38 t/ha.

**Dhawan et al. (2009)** conducted experiments to assess the toxicity of some new pesticides along with conventional ones against *Spodoptera litura* (Fabricius) on cotton in Abohar, Mansa, Muktsar and Sangrur districts of Punjab by leaf dip and direct spray technique. Irrespective of the bio assay technique applied all the four populations were most susceptible to emamectin benzoate followed by Novaluron in case of direct spray method only. The five new insecticides viz. emamectin benzoate, novaluron, chlorantraniliprole, pyridalyl and flubendiamide were more toxic than the conventional insecticides namely endosulfan, thiodicap and chlorpyriphos.

**Jayadevi et al. (2009)** studied the susceptibility of five populations of Diamondback moth (DBM), *Plutella xylostella* collected around from Bangalore to Indoxacarb, cypermethrin, spinosad, NSKE and Neemazal-F. The highest level of resistance was recorded to cypermethrin and all the field populations remained susceptible to NSKE and its formulation Neemazal-F. NSKE and Neemazal F selected populations indicated loss of proteins. In summary, considering all the above factors together, the low level of accumulation of resistance to neem might be due to multiple components of neem affecting insect behaviour, physiology and biology in a variety of ways, resulting in ‘physiological inability in the insect to recognise the stress (PIRS)’ leading to built in resistance prevention a safe bet for long term use in insect pest management.

**Kang and Dhaliwal (2009)** determined the toxicity of new molecules to multi resistant populations of *Plutella xylostella* Linn. in Punjab. Populations collected from Amritsar, Malerkotla, Mansa, Patiala and Ropar area were tested using disc tip technique of bioassay. Among the new insecticides, emamectin benzoate with LC50 values ranging from 0.00016 to 0.00056 % was found the most toxic to all the test populations followed by flubendiamide, indoxacarb and spinosad.

**Mandal and Mandal (2009)** revealed that cartap 50 SP @ 500 g a.i/ha proved to be most effective treatment against the pest and it was on par with triazophos 40 EC, carbosulfan 25EC both @ 300 g a.i/ha and profenophos 50 EC @ 100 g a.i/ha.
and weight of cauliflower heads ranged from 12.50 to 18.19 cm and 480.24 to 572.48 g respectively. The mean crop yield ranged between 184.91 to 201.76 q ha⁻¹ in the insecticidal treatment, the highest being in cartap (201.76 q/ha) followed by triazophos (192.35 q/ha) carbofuron (191.60 q/ha), profenophos (191.13 q/ha) and quinalphos (190.26 q/ha), which did not differ significantly among each other. The cost benefit ratio varied from 17.58 to 16.18 in different insecticidal treatments the highest in cartap with a record of maximum monetary benefit of Rs.23,067.00 closely followed by triazophos with its net profit of Rs.17,280.50 ha⁻¹.

Mandal and Mandal (2010) reported the efficacy of insecticides against mustard aphid, *Lipaphis erysimi* Kalt. Difenthiuron 50 WP@50g a.i/ha proved most effective in managing the aphids incidence and realizing higher yield of mustard (10.70 q/ha) followed by thiamethoxam 25 WG@25g a.i/ha (10.53 q/ha) and acetamiprid 25 SP@40 g a.i/ha (10.12 q/ha) Treatments viz. imidacloprid 200 SL@50g a.i/ha and betacyfluthrin 25 SC@25 g a.i/ha were comparatively less effective in reducing the pest population and they were statistically equally in realizing the yield of mustard but superior to achook 0.15 EC@800g a.i/ha (8.68 q/ha) and dimethoate 30 EC@400g a.i/ha (8.85 q/ha).

Satyanaryana et al. (2010) studied the incidence of *Spodoptera litura* in terms of larval population which showed non-significant relationship with maximum temperature, relative humidity wind speed spiders and coccinellid predatory beetles, but significant relationship with minimum temperature. The result of chemical control trials indicated that emamectin benzoate 0.00725% was the most effective treatment followed by indoxacarb 0.0145% and indoxacarb 0.00725%, novaluron 0.005% in reducing the larval population of *S. litura*.

Yadav et al. (2010) found out the efficacy of different neem based pesticides viz. neemazal, Bioneem, Neemgold, Nimbicidine and Achook was studied against diamondback moth *Plutella xylostella* Linn. infesting cruciferous crops. Neemazal was the most toxic photochemical amongst all the tested pesticides. Their relative efficacy on the basis of LC5 against diamond back moth, *P. xylostella* Linn. May be arranged in following descending order: Neemazal, Neemgold, Bioneem, Nimbicidine and Achook.
the relative efficacy of the different pesticides based on LC50 and LC90 values was computed.